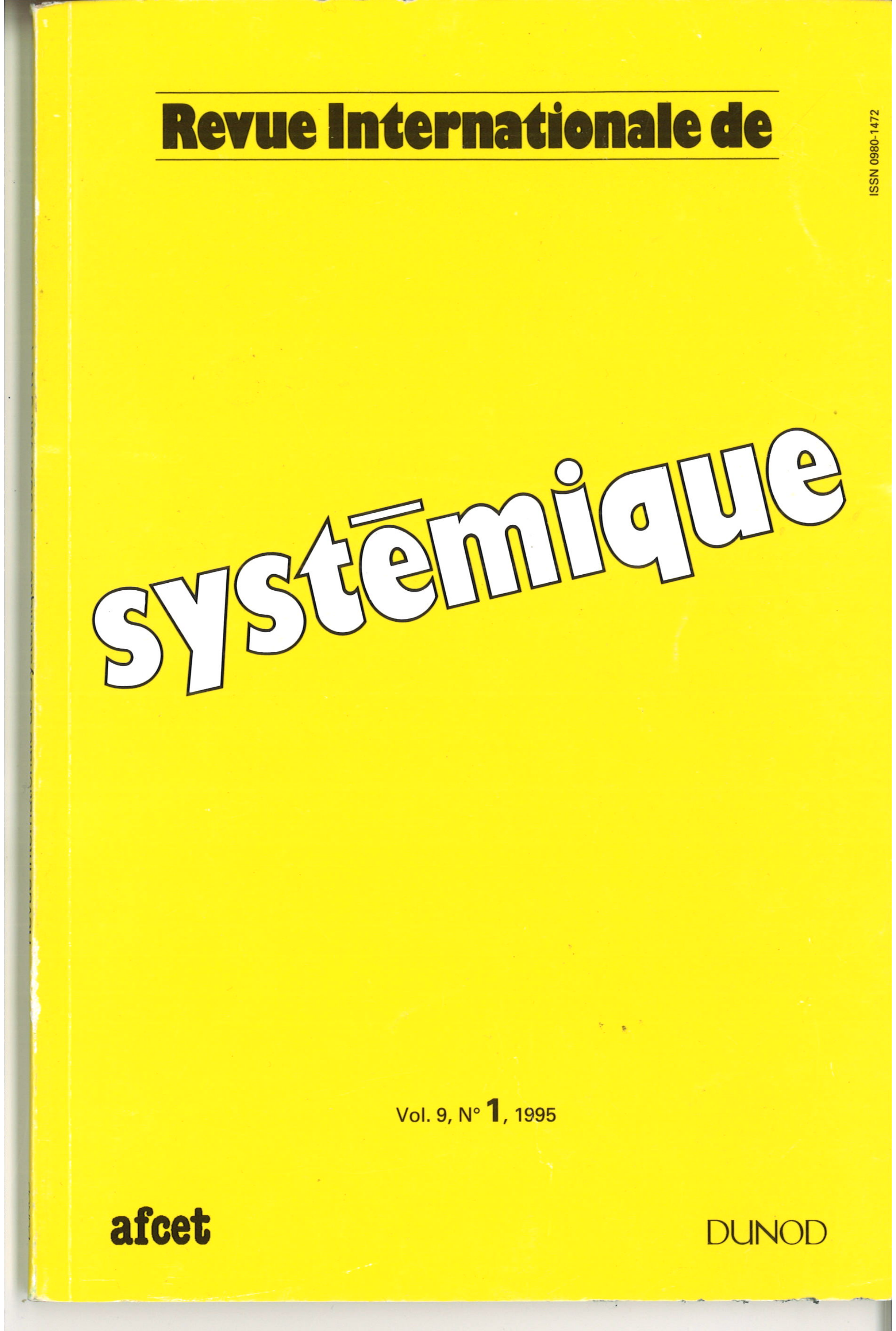

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Michaël Le Duc

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FROM SUFFIX TO PARADIGM. ELEMENTS OF CONSTRUCTIVIST SYSTEMICS

Michaël LE DUC [1]

Abstract

This paper is about relationships between mind, cognition and experience for multi-disciplinary scientific research and consultancy. I have chosen the term systemics, "a way of attack on life's problems as systems and by systems", for the guiding principles of a paradigm for thinking and acting within our complex world. Systemics takes the challenge of complexity as opposed to incomplex problems that can be treated with analytical or statistical means. Classical rationalism is contrasted to its complement constructivism as the paradigms of mapping reality and constructing realities, respectively. Descartes' four percepts in his "Discours de la Méthode" is used for a "Discours de la Complexité". Logical complements to Aristotelian logic are also presented. A discussion on what is to be considered scientifically rigorous is conducted.

Keywords: Constructivism, epistemology, ontology, cognition, systemics.

Résumé

Cet article concerne les relations entre esprit, cognition et expérience pour la recherche scientifique multi-disciplinaire et pour la consultation. J'ai choisi le terme de systémique, « un moyen de s'attaquer aux problèmes de la vie en tant que systèmes par des systèmes », pour définir les principes directeurs d'un paradigme permettant de penser et d'agir à l'égard de notre monde complexe. La systémique relève le défi de la complexité comme s'opposant à la non-complexité des problèmes étudiés par les méthodes analytiques ou statistiques. Le rationnalisme traditionnel se distingue de son complément le constructivisme, par le fait que le premier dresse une carte de la réalité et que le second construit les réalités. Les quatre préceptes de Descartes dans le « Discours

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de la Méthode » sont utilisés pour un nouveau « Discours de la Complexité ». Des compléments logiques à la logique aristotélicienne sont également présentés. Une discussion sur ce qui doit être considéré comme rigoureusement scientifique est enfin abordée.

INTRODUCTION

This paper discusses the relationships between mind, cognition and experience for scientific research and consultancy in complexity. This discourse is not set in any universal way but the thoughts put forth herein should receive acceptance in the "systems community" as a formulation of some of its prevailing basic concepts and principles.

I have chosen the term systemics for the guiding principles of a rising paradigm of thinking and acting within complex systems. The suffix "ics" suggests "a method of attack on life's problems", according to Rapoport (1952). I define **systemics** as "a way of attack on life's problems as systems and by systems". In other words, systemics is concerned with systems problems of experience ("reality") by cognitive structures belonging to systems categories. The French research in "la systémique" has influenced me and many of the references in this paper come from this movement.

This is a philosophical paper dealing primarily with **epistemology**, *i.e.*, "the branch of philosophy concerned with the nature, sources, and reach of human knowledge" (Bunge, 1980). It also deals with knowledge in its relation to ontic mind and ontic reality, *i.e.* **ontology**, which, according to Mario Bunge, stands for "the branch of philosophy concerned with the nature of reality. It studies, in particular, the general concepts of thing, space, law, causation, life, mind and society" (Bunge, 1980).

SYSTEMICS: THE SCIENCE OF COMPLEXITY

Mario Bunge used the term "systemics" in this Treatise on Basic Philosophy (Bunge, 1979) to mean the "set of theories that focus on the structural characteristics of systems and [systemics] can therefore cross the largely artificial barriers between disciplines". Bunge's definition covers what I mean by systemics only partly. Nevertheless Bunge captures the essence of systemics, as I see it, by saying that "Systemics has two related motivations,

one cognitive and one practical". The similarities between Bunge's philosophy and the view presented in this paper largely stop with this. I doubt that Bunge would adopt the principles of constructivism presented below.

Systemics takes the "challenge of **complexity**" (Bocchi, 1986). I define complexity as "a property of a system that is composed of a pluralism of subsystems that are interdependent, but not reducible one to another". "Subsystem" is seen here in its general sense, *i.e.* as a "selection of system parts and/or relations from one purposeful perspective". **Incomplexity** is "a property of a system that can be reduced to one subsystem". **Complication** is "a property of a system that can be reduced to one subsystem. Thus it is incomplex. Furthermore, a complicated system requires a relatively large amount, or a multitude of, logical operations to be understood, which distinguishes it from simple systems". **Simplicity** is "a property of a system that can be reduced to one subsystem and that only requires relatively few logical operations". These definitions are inspired by Edgar Morin (1977), Jean-Louis Vullierme (1989) and Jean-Louis Le Moigne (1984, 1990).

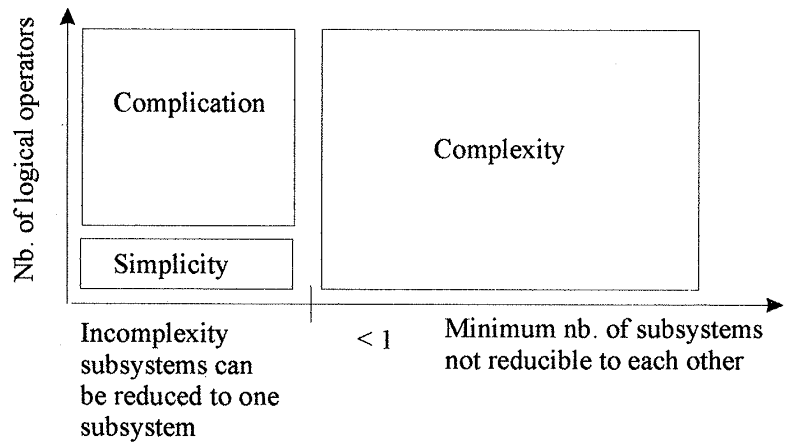

Figure 1. Complex and incomplex systems.

The systemics structures and methods used in a situation are always proprietary to the observer(s). The knowledge used in a situation can have been generated by other(s), or prior work from the observer(s), with complex, incomplex or any other methods different from the actual class used. The following transitions with example logic are possible:

Table 1. Transitions between system types.

	complexity	complication	simplicity
complexity	complex fit	top-down fit	top-down fit
complication	bottom-up fit	match	top-down fit
simplicity	bottom-up fit	bottom-up fit	match

The match and fit operations that are discussed further in the following have a similar relationship as the older discussion in the systems sciences on the relationship between homomorphy and isomorphy.

Systemics is to a large extent about these relationships. For instance, Morin states that "system" is the most simple of all complex concepts (Morin, 1977, p. 149). One reason for the reticent adoption by many scientists to take the challenge of complexity is that it is difficult to prove whether a method is better than another for these kind of problems by incomplex means. The verification of complication or simplicity is different from that of complex problems, if dimensions are not to be reduced one to another.

COGNITION

In this section I will discuss an area that is very complex, namely, cognition, cognitive structures and their relation to ontic mind (von Glaserfeld and Cobb, 1983) and ontic reality (von Glaserfeld and Cobb, 1983). The concepts and principles will lead to epistemological implications for scientific research, e.g., for the concepts of truth, objectivity and "validation".

Ontic mind and ontic reality are distinguished in the following from "mind" and "reality" in an epistemological meaning. When I put the concept "ontic" in front of another concept I mean the "thing" outside cognition. In this particular case "mind" and "reality" are cognitive structures and as such only approximations (you might say constructed models) of their ontic counterpart that are never completely accessible.

I have made a selection from The Concise Oxford Dictionary of Current English (eighth edition, 1990) to show the circular definitions of concepts related to cognition - cognition is not linear nor simple. **Concept**: "a general

notion; an abstract idea (the concept of evolution); (Philos.) an idea or mental picture of a group or class of objects formed by combining all their aspects". **Notion**: "a concept or idea; a vague view or understanding". **Idea**: "a mental impression or notion; a concept". **Cognition**: "(philos.) knowing, perceiving, or conceiving as an act or faculty distinct from emotion and volition". This last definition should have had an effect of clearing the fog for the reader by using a logical operator of systemics called "The Union of Opposites" (Heraclitus), "dialogics" (Morin) or "bi-polarity" (Kelly). The definitons prior to the last one were less meaningful by only using sameness as defining logic. With the rephrasing into "cognition is... *rather than* emotion and volition" a clear picture emerges where cognition, emotion and volition fit dialogically in a larger whole: mentation, *i.e.*, "mental action; state of mind..." which is the most comprehensive concept for the mind in action. The etymological sense of the word definition is "to cut out". A rich definition should complexly combine sameness and distinction, *i.e.* a system, its components and its environment.

The following two definitions are also dialogic. Concept: "In psychology, whatever is conceived rather than just perceived" (Bunge, 1980). "**Wisdom** is defined as... the ability to use knowledge not simply store knowledge... Wisdom is also about managing complexity not reducing it" (Eden, 1992). Systemics is in this sense synonymous with wisdom.

Cognitive structures are relatively stable knowledge in the mind. **Cognition** stands for the processing of these structures and is used here interchangeably with "cognitive processes". A **cognitive system** consists of all the cognitive structures and processes of a person as reflected upon in a particular situation. It has access to ontic reality through the **experimental system** that includes our five sensory channels (visual, auditory, kinaesthetic, olfactory, gustatory) and the processing of sensory data.

The purpose of systemics is not to gain complete knowledge about a system but sufficient knowledge for solving problems-at-hand (specific problems). The level of detail is set by a cognitive **grey-box** (Bunge, 1980, p. 262), which is a **black-box** where pertinent inner workings of the black-box are known. A black-box is only used to model input and output. With a grey box elements can be "popped-up" (added to a model) or hidden from a model. By doing either of these two operations one changes the resolution level of modelling, like when changing the magnification of a microscope - except systemics is more like a macroscope (de Rosnay, 1975). Since ontic reality has many more facets than we can ever hope to perceive, it is universally a grey-box to us. In parallel, the human mind is still dimly understood and can also be considered as a grey-box.

A graphical presentation of these relations can clarify the discussion further:

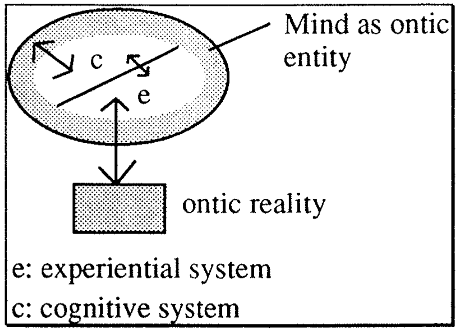

Figure 2. Experience, cognition and ontology.

Note: the shaded areas stand for grey-boxes.

Von Glaserfeld and Cobb share this constructivist view of ontic mind and ontic reality (von Glaserfeld and Cobb, 1983, p. 7). I discovered this after my initial formulation, which started by using a model consisting of Real World. Conceptual World and Mental World (Le Duc, 1992). The initial model posed some difficulties since I mixed ontology and epistemology.

To clear things a little more we can classify where different flows occur. Symbols, data and information flow primarily in the experiential system while knowledge is flowing in the cognitive system.

What we, in every day use, call **reality** is, according to constructivism, the structures in what I have called the experiential system and not ontic reality. In von Glaserfeld's words, reality consists of the "recurrent structures in the flow of experience" (von Glaserfeld and Cobb, 1983, p. 8) that are constructed from co-ordinated sense-data (von Glaserfeld, 1988, p. 109). The cognitive system cannot have complete accesss to ontic reality, only organise experience to approximate ontic reality iteratively (Piaget, 1970, p. 119).

There are **levels** of "reality" – some structures are more "real" than others. Glaserfeld and Cobb (von Glaserfeld and Cobb, 1983, p. 14) have explored the properties of some of these levels, which I sum up and extend in my

terms as follows. An experiential or cognitive structure is increasingly real (from an epistemological point of view):

– with repeated experience;

– with the confirmation from more than one sensory channel (this is not ontic verification; only correlation);

– with the association (assimilation) to previously known structures that match (logical truth) or fit (epistemic truth);

– with the corroboration of the structure by Other(s) (corroboration by consensus), *i.e.*, if I experience that Other(s) experience the same structure as I do, the structure is corroborated. An important comment here is that this form of validation does not confer any ontic status to the structure in question. However, von Glaserfeld and Cobb (1983, p. 14) note for this point that "With the corroboration by Others, one's experiences acquire the kind of reality that is usually called "**objective**". This view is close to phenomenology's intersubjective notion of objectivity (Husserl).

Classical scientific objectivity, at least in empirical research, values the first level. Repeated experience of simple, incomplex or complicated systems – in the controlled form of experimentation or using statistical methods – is more or less equated with objective knowledge. Other structures are seen as unscientific speculations. In contrast, to handle complexity we have to use all the levels above – and more. Interdisciplinary research is one way of achieving a higher level of intersubjective objectivity for complex issues than by monodisciplinary work. Many cognitive structures are organised into levels, some of which have emergent properties in relation to the next lower level. Systemics is a search for a kind of complexity management combining ordinary cognition with scientific epistemology.

In Kelly's Personal Construct Theory (1955), **hierarchy** is an important principle that reflects the most essential way of organising cognitive structures. The principle seems to be quite general according to the concept of chunking information into manageable parts (Miller, 1956). Chunks are composed of parts on a lower cognitive levels, e.g. stories and phrases, phrases and words, words and symbols, respectively. Hierarchy is a property of the cognitive system but we cannot confer some ontic hierarchy from that. This would lead to self-confirming laws since the only way to test the hypothesis is to experience it.

That we organise companies and government agencies into hierarchies reflects only that individuals on a certain level of management cannot interact *cognitively* with more than a certain number of persons or groups. Another interpretation is that executives who design organisations do it for their own cognitive effectiveness (Low, 1982) by chunking system components into hierarchies. Thus the combination of system, subsystems, suprasystem(s) and environment is just a formulation of a cognitive necessity, without ontological "necessity" "la causalité, loi de la nature ou nécessité de la raison" Piaget asks). This last point has ethical implications, e.g. the market is not something governed by natural laws but a complex system co-created by many decision-making agents in each transaction and in its institutions.

Systemics –by its concepts, principles and tools (including informatic tools) –is a search for increasing the cognitive effectiveness of managers, and other "knowledge-workers", to handle complex systems such as organisations. This would include increased effectiveness in managing several organisational levels in a complex way, *i.e.*, without reducing the properties of one level to another, to find an appropriate level of autonomy for each level, to increase the information processing capacity of components... and, in the end, to increase the fit to the environment and long-term viability.

Remember that mentation (mental action) comprises cognition, emotion and volition. We should not underestimate the importance of emotion, beside cognition, for effective action, e.g., according to George Kelly's Personal Construct Theory (Eden, 1983). Systemics is action-oriented and we should keep this in mind when reading this paper that is concentrating on cognition. To accomodate the other two components of mentation in a cognitive context we can ask the following kinds of meta-question: "Did I *know* what happened to come to this result? What did I *feel*? For instance, was I committed? Did I *want* it to happen?"

Modelling

Modelling is the purposeful processing of cognitive structures from two systems, where one system is more complex than the other and the less complex one is used to increase the understanding of the more complex one. The less complex system is frequently designated as "a model of" the more complex system, for which I adopt Stafford Beer's notion of "system-in-focus" (SIF; Beer, 1985). By selecting dimensions in the SIF through the grey-box metaphor, the model is defined – but not directly. A conceptual framework (CF) is used to assimilate or accommodate the SIF into model(s). The conceptual framework is used to make a many-to-one fit of the elements in the SIF. In a second step, these mappings are reformulated (remodelled) into one or several models that are suitable for the purpose-at-hand.

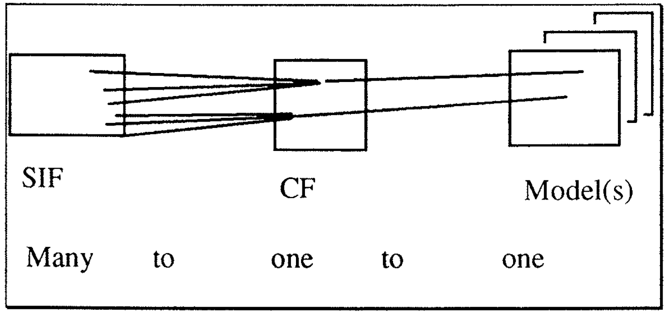

Figure 3. The modelling process. Adapted from Le Duc (1992, p. 409).

A **model** is a snapshot of the less complex system at a specific moment in time. It should be seen as one version that is being changed in the modelling process of going back and forth between the SIF and the models. In systemics, the emphasis is on the modelling process and not a particular model (Le Moigne, 1984, p. 25). Le Moigne has further a similar model to the one in the figure. Modelling is frequently performed to understand structures in the experiential system.

Again, models are used in cognition due to our limited capacity to consciously process more than a few dimensions at a time. A text, a drawing or a formula are used to manage aspects of more complex systems. Complex systems can be cognitively approached in this manner *only* by jumping between models in a round robin manner, *i.e.* by pair-wisely relating models. This point is extremely important. Successive approximation (Piaget) or I would prefer the term successive approaches of complexity is the way this paper or any academic document work. Knowledge is a stable structure of this round robin game between models, while competence is the effective use of a set of models in a situation type (modelisaction as Morin would put it).

Truth

To define truth, constructivism, instead of equating it with a true picture of ontic reality – a mapping or re-presentation of reality – the concept of viability is borrowed from the theory of evolution. Cognitive viability follows the same principe as biological viability. "**Viability**... [is ascribed to] a cognitive structure which will *fit* a certain type of experiential situation". (Glaserfeld and Cobb, 1983, p. 10). If viable, the problem solver's "know-how is functionally *adapted* to the constraints of unknowable ontic reality". Knowledge fits reality epistemically rather than matching ontic reality. Causation is replaced by adaptation to constraints (von Glaserfeld, 1983, p. 11) or the sense-making process (Piaget) and I would add the cognizing subject's creation of opportunities. Indeed the environment comprises both constraints and possibilities for the individual.

I define two principal types of **truths**:

(*a*) the degree to which cognitive structures **fit** with experiential structures and processes, with a specific purpose in mind and for a particular situation, or the degree to which cognitive structures on different levels fit. A satisfying fit is not only cognitive but also emotional and volitional – dimensions that are suppressed in scientific documentation, maybe since they are paradigmatic, *i.e.* ubiquitously necessary but silent. A professional opinion uses all these dimensions. On the long run, fit structures can be viable or not for a class of situations, *i.e.* by the process of abstraction. Experimential structures include past ("memorised") and present ones. They can have different levels of reality (see discussion on "realness" above), including intersubjective objectivity by relating them to other persons. Some cognitive structures, usually labelled as "theoretical", can not be related directly to experiential structures but require the use of "vicarious" structures on lower conceptual levels (Bunge, 1977).

(*b*) the degree to which cognitive structures **match** each other on the same level of abstraction. This is the realm of classical logic (see section on logic) and the full range of analytic and statistical tools. Aristotelian logic as used by classical science emphasises the notion of closure, consistency and completeness whereas constructivist logic emphasise fit between logical levels and meta-levels.

In sum, logic is used to handle the relationships between cognitive structures on the same logical level (b: **logical truth**) whereas epistemology is used to handle the relationship between different logical levels (a: **epistemic truth**). One important problem in classical science is due to its reduction of epistemic truth to logical truth, of fit to match. The emphasis on proof (or disproof as recommended by Popper) has metaphorically used the match concept for different levels of abstraction, but the metaphor has not been seen as such.

The construction of new structures

In some cases, true structures show up to be less fit/viable even after incremental modifications of the structures in adaptation to changes in the stream of experiential data. In those cases, and if the individual wants (volition), new structures can be created by combining old ones in the form of a synthesis that might be more fit/viable. This is what is usually called learning. A basic assumption of constructivism is that new knowledge can only be gained by re-organising previous knowledge into emergent structures. The learning paradox must be solved for this to fit, which is approached on the next page.

The process of assessing truth and creating new structures (to be subsequently tested) are fundamentally different. Piaget distinguished between assimilation and accomodation, while others have suggested matching terms for this dialogic relationship. This leads us straight into one cornerstone of constructivism, namely the processes of **adaptation and learning**. "... constructs and construct systems may be "permeable" or "impermeable" [in Kelly's Personal Construct Theory]. Man is in a process of change, "adapting" and "adapting to" or, according to Piaget, "assimilating and accomodating"." (Low, 1982, p. 230). The essence of systemics lies in the balance between creation (accommodation) and verification/action (assimilation).

CLASSICAL RATIONALISM AND CONSTRUCTIVISM IN A DIALOGIC

In the first version of this paper (Le Duc, 1992) I dichotomised a few different epistemological "isms" but the task was difficult. There are many labels in epistemology that mean different things to different authors and communities. Rationalism, empiricism, realism, idealism, nominalism and constructivism are labels forming an intricate web. To fray a way in this net is the task of professional epistemologists. I have tried here to find a proper resolution level for the grey-box of systemics by limiting the discussion to classical rationalism and constructivism. These two complementary and antagonist schools of thought are revealing for understanding constructivist systemics. The constructivist Personal Construct Theory (Kelly, 1955) says that the relation of a concept to its opposite pole determines its meaning in a specific context (Low, 1982, p. 229). Furthermore, I conjecture that dialogics (Morin, 1991), is a fundamental logical operator for understanding complexity by focusing on complementary and antagonist dimensions.

Knowledge as mapping... knowledge as creating viability

At a fundamental level, classical rationalism postulates the possibility of mapping ontic reality into more or less isomorphic cognitive structures. In other words, the position assumes the possibility of mapping ontic reality into epistemic reality in a potentially complete way – it is only a matter of time and resources. Constructivism defines knowledge as the construction of cognitive structures out of experiential data and/or previous knowledge. There is no mapping of ontic reality in the sense of classical rationalism. The following presentation evolves around two protagonists of classical rationalism and constructivism – René Descartes (17th century) and Giambattista Vico (18th century), respectively.

Is constructivism a form of solipsism or a more moderate form of idealism (anti-realism)? Clearly no. The mind-body problem that stared by Cartesian Dualism is solved as follows. There is no dichotomy between mind and matter and mind is not a "substance" in its own. "Mind" is a concept for the mental structures and processes in individuals. Some incomplex properties of the mind are possible to experience in scientific experiments such as its data processing capacity (Miller, 1956; Simon, 1974; Miller, 1978; Warfield, 1988). However, for higher mental levels, recurrent structures are difficult to validate by experimentation. These levels are complex (rich in dimensions) and require a more subjective experience to be understood. The works of Heinz von Foerster (e.g. von Foerster, 1984) and others (research on neural networks; Lawson and Staver, 1989; Pitts; MacCulloch; Maturana; Varela) show that a dualist stance towards mind and body is not necessary for a constructivist. The constructions of the mind are essentially neurological. They are just simply difficult to observe and measure at high mental levels because they are complex (involve many neural functions and structures). Higher-levels are possible to understand in a more intuitive way, a more philosophical way. Yet this does not change my position that even the highest levels are concrete neural processes organised in a complex way.

The **learner paradox** has been put forth as a fundamental problem of constructivism. The paradox lies in the statement "how can a simple [cognitive] structure generate a more complex structure?" (Lawson and Staver, 1989). If the paradox is not satisfactorily resolved, constructivism is unfit (or falsified in Popper's terms) in the sense that knowledge then cannot be created by re-organising previous knowledge. Also the position of seeing complexity as an ontic entity learned by the individual and/or that there must be some *a priori* cognitive structures to build upon win. Lawson and Staver (1989) propose to resort to the concept of emergence in neural nets. By a re-organisation of the neural system new knowledge is created from the *same* parts. Complexity increases not by increasing the number of neurones but by the number of connections. The field of neural nets has

shown that complex behaviour can emerge from relatively simple structures (see references above).

Methods, Methodologies and Methodolatries

Philosophical discourses on scientific universal principles abound in the literature – those philosophers against any method (e.g. Feyerabend) also fall into the category of seeking universals since they claim the generality of anti-methods. The underlying assumption to this quest is that there might exist some universal rules or anti-rules abstracted from the work of expert scientists to learn from sequentially by less expert scientists. But, a cook book does not make a chef, or, "... un discours de la méthode sera toujours un discours de circonstance" (Bachelard in Le Moigne, 1984). Debates in academese on the order in which methodological steps should be followed is askin to methodolatry. What really matters in a investigation is which basic concepts and general principles are fit for that work.

The most elaborate "method" of all, cognition, is still only partially understood. Yet, it is the most effective means to solve problems and take appropriate action inside and outside academies. The existing methods to experiment analytically or calculate statistically are supportive to the real challenge of reality: complexity management. These useful methods should not be unrigorously generalised to systemics hoping for the same success. Instead, "ordinary" reasoning supported by concepts and principles from systemics should be used contingently with traditional scientific means without hoping to ever reach a crisp and unique method for dealing with complexity. Some tools that build upon systemics concepts and principles are presented in this paper.

The percepts of classical rationalism and constructivist systemics

From the basic distinction between "mechanical" mapping and "organic" construction follows a number of dialogic dichotomies. French systemists have used Descartes' four precepts for wisely conducting one's own reason in his *Discours de la Méthode* to discuss the shortcomings of classical rationalism and dialogically propose precepts for constructivism (Le Moigne, 1984, p. 43; Vullierme, 1989, p. 109; Durand, 1990, p. 8).

My own critique is not be seen as an attempt to win rhetoric points against a great mind from the seventieth century but as an effort to model the gist of classical rationalism in relation to constructivism. It would be difficult to make a precise account of Descartes' method in this context, so I will simplify his work. Descartes himself warned us against the selective use of citations: "Je serai bien aise que ceux qui me voudront faire des objections ne se hâtent point, et qu'ils tâchent d'entendre tout ce que j'ai écrit, avant de juger d'une partie: car le tout se tient et la fin sert à prouver le commencement." (Lettre à Mersenne, cited in Morin, 1977).

In his time, Vico was a fierce critic of Descartes. His main argument was that Descartes overemphasised reason as compared to creation. One possible interpretation of this is that Descartes followed Aristotelian logic (see section on logic) which is good for matching but not as good enough for creating fit.

The following dichotomies are proposed by Le Moigne (1984, p. 43) and Vullierme (1989, p. 109), respectively. I have made a selection and modifications in the last column.

Table 2. The four precepts of Descartes and constructivist complements/alternatives.

Descartes	*Le Moigne*	*Vullierme*	*Le Duc*
1. Evidence	Pertinence	Modelling	Pertinence
2. Reductionism	Globalism	Emergence	Emergence
3. Causalism	Teleology	Causal loops	Teleology
4. Ontic completeness	Aggregation	Black-box	Grey- box

The Precept of Evidence... The Precept of Pertinence

"... ne recevoir jamais aucune chose pour *vraie*, que je ne la connusse évidemment être telle... de ne comprendre rien de plus en mes jugements, que ce qui se présenterait si *clairement* et si *distinctement* à mon esprit...", Descartes.

This precept is about cognition and does not cover the experiential system (Huisman, 1981). The precept of evidence states that one should accept a cognitive structure as true only if it is evident: it must be clear, that is, all elements are covered; it must be distinct, that is, it cannot be confused with any other cognitive structure. We could have a long discussion about the shortcomings in this precept for modelling complexity, but I will limit it to central themes.

In modelling systems, it is always difficult to draw precise boundaries. For example, even a "purely" theoretical model's components have more or less strong, often implicit, relations to cognitive structures outside the specific model and it is often difficult to know what to include and exclude for the problem-at-hand.

It is seldom the case that boundaries are "evident". I will return to the logic underlying this precept later. It suffices here to mention the works of Gödel (1931) who demonstrated by theorems that in all advanced logical systems there are propositions that are undecidable, *i.e.*, they cannot be determined as true or false by the logical system's own means. Classical rationalism tries to constitute a system by starting from first evidences (axioms) and then build true propositions via rules of inference. Gödel showed that these propositions cannot prove the truth of the first evidences and thus there is no evident foundation to build upon.

For systemics, it is not necessary to limit the components of a model to clear-cut ones, it is not even advised. In fact, many valuable insights into complexity can be gained by exploring models with variables that can jump between states without us knowing *evidently* how (chaotic behaviour, catastrophe models, fractals, qualitative variables, etc.). There is also increasing legitimacy for multi-valued logic where model components can belong to several categories (I will for instance approach dialogics later; see also fuzzy set theory). Truth is circumstantial and to model most complex systems several perspectives, often *difficult to clearly distinct*, are necessary to make them intelligible.

The Precept of Reductionism... The Precept of Emergence

« ... de diviser chacune des difficultés que j'examinerais, en autant de parcelles qu'il se *pourrait* et qu'il serait *requis* pour les mieux résoudre ». Descartes.

"Since all things are caused and causing, supported and supporting, direct and indirect, and all things are interdependent by a natural and stable link that relates the most distant and the most different things, I hold it impossible to know parts without knowing wholes, neither to know wholes without particularly knowing parts". Blaise Pascal, éd. Brunschvicg, II.

The shortcomings of reductionism was the main reason for the start of the systems movement. Thus, there is a large body of literature on reductionism vs. systems thinking and I will not discuss the theme extensively.

The reductionist recipe is a guarantor for the academic success of all scientists who adopt it. The recipe is simple: if the problem you are trying to solve is too "stubborn" break it apart into its "constituent" parts. If one of the partial problems is difficult to solve break it also down. Continue like this until you have solved all the problems on the different levels of analysis. Make a synthesis and the original problem is supposedly solved. Heinz von Foerster's first Law treats this phenomenon in a humorous way: "The more complex the problem which is being ignored, the greater are the chances for fame and success", (von Foerster, 1972, p. 1). A corollary to this precept is that scientific research can be organised into increasingly specialised fields and subfields without losing the whole picture.

This precept has been difficult to explicit in a method. To date, nobody has conceived a general, teachable and explicit method for partitioning problems (Jean-Louis Le Moigne about Jacques Arsac). Analysis is an intuitive process that a competent scientist has learnt by experience. If you walk into a hospital or a university, knowledge and crafts about parts have progressed tremendously since Descartes, but the backlash is that many take the part for the whole (Paul Valéry).

In contrast, the constructivist recipe is to accept emergent properties, *i.e.* that the whole has some properties not found in its parts. In other words the whole is more than the sum of its parts by the process of *emergence*. At the same time the parts have some properties not found in the whole, *i.e.* the whole is less than the sum of its parts in the form of *constraints*, e.g., antagonism, standardisation, etc. There is a hierarchy of cognitive levels, where each level may have some properties that cannot be reduced to the properties of another level. In short, we should not abandon analysis but be aware of that some level properties cannot be analysed, yet they can be understood and controlled. We should manage the complex relation between wholes and parts systemically.

A detail here is that the concept emergence refers to some of the organisation of the parts into what gives rise to new properties not found in the parts, *i.e.*, creation. A corollary to the principle of emergence is that when we design a system its components do not necessarily have to be viable for the system as a whole to be viable (Ackoff, 1976, p. 10). With systemic organisation a system can be viable/sustainable in spite of weak components, if left in isolation – an important property of life.

Design and creation are central to systemics. However the English word does not cover the other side of creativity that is embraced by the French word "conception", which combines modelling and design in the English sense. It would be better to use conception or "**to conceive**" instead of design. If we turn to Vico, he complements Descartes precept with "**ingenium**": « faculté mentale qui permet de relier de manière rapide, appropriée et heureuse des choses séparées » (Pons, 1981, p. 131).

Much of systemics lies in taking the challenge of complexity (Bocchi, 1986) – in combining the Cartesian precept of reduction with Vico's *ingenium*. It is a matter of pertinent analysis and synthesis. The discussion on wholes and parts has sometimes been naive such as in holism where everything is mysteriously not possible to analyse. But systemics should adopt complex thought and rigour is not a classical rationalist prerogative. Leonardo Da Vinci was proclaiming obstinate rigour even in artistic creation (Le Moigne). Universal reductionism is rejected as well as universal holism, which sees wholes everywhere and parts nowhere. In fact, holism and reductionism belong to the same paradigm of categorically choosing either wholes or parts (Morin, 1977, p. 124).

Classical science in the light of the need for knowledge from decision makers and the public is often accused to lead to *paralysis by analysis*. The major reason is contradicting results from separate studies and the sheer amount of narrow scientific results. On the other extreme holism, e.g. as formulated by Pascal in the citation above, leads to *paralysis by systems analysis* by never leading to any conclusion since no principle for closure is included. So the *satisficing* principle of Ackoff is prevailing outside academies somewhere in the middle of these extremes. The principle can be formulated as "it is better to know a little at the right time than all too late". Systemics tries to help improve this strategy toward a better handling of complexity – by combining classical analysis, creative synthesis and the acceptance of intention in every study.

The Precept of Causalism and Linearity... The Precept of Teleology

« ... de conduire par ordre mes pensées, en commençant par les objets les plus simples et les plus aisés à connaître, pour monter peu à peu, comme par degrés, jusqu'à la connaissance des plus composés; et supposant même de l'ordre entre ceux qui ne se précédent point naturellement les uns les autres ». Descartes.

Cause-and-effect relationships are only one type of possible cognitive structures. Cognitive structures can be conceived as components and relations. In general, relations are teleological to the observer, e.g., the goal can be to solve a scientific problem. That some structures are strongly correlated to each other does not prove that there is some causation involved in ontic reality since we have no other contact with ontic reality than through the experiential system. The correspondence of realist causation in constructivism is that two structures are correlated *and* that one is varying before the other one – the "cause". Vico: "If true means to have been made, then to prove something by means of its cause is the same as causing it" (von Glaserfeld, 1988, p. 207). Causality in behaviour is not in ontic reality. What the observer knows is that an experienced behaviour fits the model as expected in the causal sense defined above.

In a scientific context, instead of confining the selection of theories and models for a study to causalist ones one should use the theories, models and intuitive hunches that can help make sense of experience in accordance with the purpose of the observer. This results in purposeful selections of background material, methods, etc., without unnecessary restrictions.

Cause-and-effect relationships are a special case of recursive relationships. In a cycle, portions of it can be modelled as causal relationships. If the boundaries of a causal relation are widened enough, a cycle can frequently be uncovered.

The Precept of Ontic Completeness... The Precept of the Grey-Box

« ... de faire partout des dénombrements si entiers, et des revues si générales, que je fusse assuré de ne rien omettre ». Descartes.

The Precept of Ontic Completeness can be simply put: do not forget anything. The question is: when do we know that? Everything in the universe is so interrelated that one could lump in factors indefinitely in a study (see Pascal citation in second precept and Gödel's Incompleteness Theorem). Here again the recipe does not add very much to the quality of the researcher. Unfortunately, a field of research closely related to ours has not contemplated its own epistemological foundations by incritically adopting this precept: computer science. Computer professionals have decreased organisational effectiveness, efficiency, and safety by overly formalising information flows (Le Moigne, 1984, p. 41) with expensive machinery. If they had remembered one of computer science's foundations, the principle of the black-box, more pertinent database systems would have been built. The negative consequences are now indisputable: the computer industry has a serious downturn world-wide and major structural changes are undergoing since the clients now require systems that really support their specific organisations and not expensive systems to replace cheaper information processing. Now, large database systems are partially distributed on personal computers and workstations (client-server architecture) and the end users are increasingly participating in the informatics design process. The clients have by hard experience learnt that you only need just as much detail as is pertinent, *i.e.*, a grey box. Object-Oriented Design (OOD) and Object-Oriented Programming (OOP) follow this principle by the concepts of abstraction, modularity, encapsulation and polymorphism. Comparisons of systemics and OOD/OOP are further discussed elsewhere. In my own early experience with OOP, behind the terminology there are viable structures for designing complex informatic systems.

The (epistemic) Completeness Principle for Systemics is as follows: Knowledge about reality can never be ontologically complete but epistemic completeness should be sought, *i.e.* a pluralism of pertinent perspectives, rather than a reduction of perspectives – (changer de point de vue... multiplier nos points de vue; Morin cited in Le Moigne, 1991, p. 48).

Note that the four precepts are interrelated. There is also an additional common pattern in the precept pairs, namely a dialogic between the domination of rationality over other mental and sensory dimensions and a strategy of facilitation (faire avec) all human dimensions.

Aristotelian Logic in dialogic with logic for systemics

Aristotelian Logic – also labelled Disjunctive Logic, Formal Logic or Deductive-Identitary Logic – laid the ground for a logical system that dominates scientific discourse and ordinary thinking in the western world. It has been important for the elaboration of many scientific theories by being extremely useful for developing a large body of knowledge fragmented into incomplex categories/theories. However, the principles of Aristotelian logic do not help us to handle multi-dimensionality, *i.e.* complexity. Aristotle did not intend them to do so either. Some complementary logical principles are thus pertinent to use for systemics.

Many thinkers now accept that Aristotelian logic is not sufficient for understanding man as a complex system of psychological, social and biological components (individu, société, espèce is a triad underlying Morin's project "La Méthode"). Though useful for grasping parts of complexity, it is too constraining to model from several perspectives that in relation to each other often do not follow Aristotle's rules.

Aristotle constrained the validity of his logical principles to one time and one relation (Morin, 1991). This has been disregarded by his successors in classical science. The time is ripe to replace his principles in context and identify complementary logic that can help us structure complexity in multiple perspectives. This has been excellently performed in Edgar Morin's latest volume of "La Méthode" (Morin, 1991, chapter on logic).

The three axioms of Aristotelian logic or Disjunctive Logic

Aristotelian logic has three closely related axioms (or basic principles): (1) The Axiom of **Identity**. What is, is. "A is A". The axiom states the impossibility of one object existing and not existing at one time and under one relation (Morin, 1991, p. 174). (2) The Axiom of **Non-Contradiction** "B cannot be A and non-A". A thing cannot be and not be at the same time and under the same relation. (3) The Axiom of the **Third Excluded** (*tertium non datur).* Assuming that all propositions must be true or false, if two propositions are contradictory, only one can be true: "B is A or B must be non-A".

As soon as one changes relationship or time the axioms loose in sense. In certain circumstances, they help us in processing propositions without checking reality in a matching logic. Yet, we need alternative and complementary logical principles to help us process complex problems for fitness and viability.

Some logical principles of constructivism or Conjunctive Logic

The Principle of **Recursion**. The best example is given by Piaget who says in my terminology that the cognitive system organises the experiential system/reality by organising itself (Piaget, 1973, p. 311). The Principle of the **Third Included**, or the Principle of **Dialogics** (Morin, 1977). Often, truth is a dynamic process of two opposing and complementary cognitive structure. « La dialogique, c'est justement le tiers inclus, deux propositions contraires sont nécessairement liées tout en s'opposant. Chacune est à la fois vraie et fausse dans sa partialité; tout en tendant à s'exclure l'une l'autre, les deux deviennent vraies dans leur complémentarité. C'est bien cette dialogique que nous avons vue à l'oeuvre non pas toujours ni n'importe où, mais partout où il y a complexité. » (Morin, 1991, p. 201). Dialogic strategies are increasingly used in a wide variety of fields. Sabelli's process theory of personality (Sabelli, 1989) identifies a dialogic between psychological priority and supremacy. Elie Bernard-Weil (1988, 1991) uses dialogic strategies for cancer therapy. By dosing cortisone (agonist agent) alternatively with vasopresine (antagonist agent) in a process mitose can be controlled – consequently mitose's uncontrolled type cancer. Stafford Beer's Viable Systems Model (Beer, 1985) for management defines viability as a dialogic along two dimensions: 1) autonomy of sub-systems versus integration of the system as a whole; 2) stability versus adaptation. Heracleitos' Union of Opposites and the two-valued symbol of the I Ching are other formulations for dialogics.

The Principle of **Truth by Action** (Piaget, Vico) that follows a fitting strategy. Vico put it best. Truth is the same as the made (*verum ipsum factum*). A mental construct is true if it has been proven effective in action and effective action elicits truth. Systemics is a process that constantly goes back and forth between experience, cognitive structures and mental structures. This has been symbolised in Stafford Beer's method to make management and science communicate by the Yo-Yo metaphor (Beer, 1984). Beer used this metaphor to develop his Viable System Model, where scientific knowledge was transferred to the management field by going up and down an epistemological hierarchy like a Yo-Yo. Some French systemics have similar ideas: allers-retours; va-et-vient. For mnemonic reasons, we could also call the principle of truth by action as the **Yo-Yo principle**.

SCIENTIFIC RIGOUR REDEFINED

Classical Science has emphasised cognitive domination over all other human faculties. Experience has been constrained to deterministic experiments or statistical streamlining. Scientific reports hide as much as they can emotions and volition that are part of scientific life. The creative side of science is further difficult to document outside anecdotes if the only logic accepted is Aristotelian and classical rationalism is the only approved epistemology. Dogmatic rationalism leads to sterile *rigour mortis*.

Even if constructivism is not able to prescribe how to be creative, it sheds some light in a *post factum* (von Glaserfeld) mode on scientific creation. Systemics is about complex action and reflection, which necessitates creation in larger magnitudes than specialised sciences (the *ars combinatoria* between dimensions). The creative side lies for the most part in the need to combine established perspectives. By creating new paths, systemics takes risks. The endeavour should be performed in a new form of rigor – *rigour virtuosis* is about questioning (remettre en question) on meta-levels:

(1) Questioning the questions.

Is the defined problem, the right one? Can we add value by asking additional questions – e.g. by brainstorming first and then make a selection? Is it relevant to reformulate, add perspectives, change the level of modelling?

(2) Questioning the foundations.

For every problem-at-hand we have to assume principles and axioms to build upon. The standard points of departure should be questioned, especially in the social sciences. Are there more pertinent assumptions? Further, the concepts and definitions used in a study are important. Should concepts be adapted narrowly to the available measurement apparatus and disciplinary survival strategies? This point is difficult since paradigms are largely taken for granted.

(3) Questioning ourselves as individuals and the scientific system as a whole.

We are only human and subject to group-think (Janis), taboos, dogmas and rigid doctrines.

The important thing for science is the use of this questioning to a greater extent than in other realms of life. Politics is limited by the conceptually acceptable structures of the electorate, institutions and other structures of power – and mostly debate (the opposite of scientific discourse). Corporations are limited by the market's acceptance. Journalism [1] is also subject to market forces and increasing time pressure due to its technical development.

Truth is biodegradable (Morin). There are no universal "first evidences" or foundations set once and for all. Some cognitive structures are more stable and general than others in practice but not universally (e.g. categories in relation to concepts, codes in relation to data in investigations).

One question is why western science has led to the domination of cognition over experience and mind, with its search for incomplex structures that are general, or even universal. Generalisation from analysis seems to dominate – generalisation as assimilation over rigorous accommodation. One conjecture is that in generalisation we are constantly testing the limits of a particular cognitive structure in action and reflection. To do this we must first "hypothesise" a larger domain of fit for the structure than we know from earlier experience, we use the "hypothesis" in action and then assess it

1. Except maybe investigative journalism that can be of greater depth and breadth than many academic investigations (on a comparison of qualitative research and investigative journalism, *see* Gummesson, 1991, p. 124).

for its positive and negative consequences in reflection. In other words, we must cognitively dominate experience by the process of generalisation and subsequent action in a search for sense and control. We cognitively assimilate experience to maintain a reasonable level of cognitive stability as long as possible before accomodating significant deviant structures into new cognitive structures. Accommodation is vital for adaptation to a changing environment but we avoid it as long as we can. At the deepest level of science, this dynamic stability resulting from the complex relationship between assimilation and accomodation, is mostly denominated as the relationship between paradigms and paradigm shifts.

CONCLUDING REMARKS

A relevant summing up would be to ask if systemics is scientific or not? Systemics aims at creating strategies to act intelligently according to its principles (pertinence, emergence, grey-box, etc.). In that respect any knowledge is pertinent, be it scientific or "ordinary", expressible in words or "tacit". For some classes of problems scientific knowledge is outdoing "ordinary knowledge". If science is equated with testing hypotheses by analytic or statistical means then systemics is something more than that. If science is defined in a broader view as the pursuit of knowledge by openness (as opposed to dogmatism) and intellectual rigour then systemics is scientific.

The final word is for Edgar Morin who is one of the principal sources to the thoughts in this article, also by his aesthetic sensitivity: « La sensibilité systémique sera comme celle de l'oreille musicienne qui perçoit les compétitions, symbioses, interférences, chevauchement des thèmes dans la même coulée symphonique, là où l'esprit brutal ne reconnaîtra qu'un seul thème environné de bruit » (Morin, 1977, p. 141). My translation: "Systemic sensitivity is like that of the musical ear that perceives the rivalry, symbiosis, interference and crossing of themes in one and the same symphonic flow, where the brutal mind only recognises one theme surrounded by noise".

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