The Interfacing Approach for Investigation Beyond Boundaries

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abstract

My essay will tackle with the following issues:

1 – The urgent need of integrated studies for understanding the complexity of our current culture environment We are aware that science and humanities are no longer two separate spheres of knowledge but two complementary and integrated ambits. Science has to take into accounts epistemological and ethical issues, humanities need to face and be aware of scientific developments and new conceptualisations. 2 – The concept of «interface» that has been the working hypothesis of the European project Acume2 Interfacing Science and Humanities. We have started by questioning the very idea of 'influence' (or 'mutual influences') in favour of a more dynamic idea of 'interfacing'. Therefore, a fundamental point of departure is to acknowledge the isomorphism of the two fields, recalling that they have often developed new models and strategies of investigation into complex scientific and cultural (artistic, literary) phenomena at the same time, simultaneously responding to their own actuality and societal matrices. 3 – I will present the methodology and the scientific results of two cases studies carried on by scientists and humanists on: Memory and on Bio-complexity.

key words

Integrated studies; Interface/ interfacing; Travelling concepts; Complex Systems.

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> Science is that form of poetry (…)
> imagination and reason that act together synergistically
> (P. B. Medawar, *The Hope of Progress*, 1971)

INTRODUCTION

There is a clear consensus among progressive academics that the 'crisis of the humanities' is deep and far-reaching, as evidenced by the number of specialized and mainstream publications on the theme.[1] European and national research councils, as well as the ESF (European Science Foundation), are outspoken on the need to discuss the identity and purpose of the humanities today. At the same time, however, the neo-liberal, profit-oriented management style of universities has produced more negative consequences for the humanities than for other academic fields and tends to dismiss them as unproductive and uncompetitive. All the emphasis seems to be on entrepreneurship, research & development and endless research assessment exercises.

In dealing with the complexity of the phenomena that characterize our «planetary» society, comparatists (Bassnett, 1993) state the need to eliminate the fears

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1   cf. recent issue Martha C. Nussbaum of the *Times Literary Supplement* (April 30, 2010).

that have always haunted humanistic studies on the other disciplines, since perhaps these disciplines can furnish new interpretative models and heuristic tools. Since the 1980s, with the pressure caused by deep, complex migration problems, the accelerated processes of acculturation, movements of global capital and the diffusion of media and information networks, comparative studies have once again begun to question their own identity. Many comparatists realise that comparative literature needs new paradigms. The trait that all new comparatists share, despite their different theoretical approaches, is the awareness that, faced by this new scenario, they must not only accept the challenge of complexity, but also try to find theoretical and practical solutions for studying and teaching world literature.

The keywords that characterize the new strategies for overcoming the identity crisis in the humanities are: networking; new epistemological paradigms; new perspectives; intersections or interfaces between the traditional disciplines in the humanities and new emerging fields (gender studies, postcolonial studies, new media studies, the impact of technology on humanistic thinking and practice, etc.).

My paper will broach the following issues:

1. The urgent need for *integrated studies*. The deep crisis in the humanities was brought about by financial problems and awareness that the complexity of the world around us requires new approaches and methods. An integrated knowledge is necessary to understand the complexity of today's cultural environment. We are aware that science and the humanities are no longer two separate spheres of knowledge but two complementary and integrated fields. Science has to take into account epistemological and ethical issues, while the humanities must confront and integrate scientific developments and new conceptualisations. On the whole, this approach will end up being of reciprocal benefit and enhance both science and the humanities.
2. *The notion of interface* with regard to a number of studies, which has helped me to clarify this concept.
3. *Is the interface a metaphor or a methodology*? In our discussion of interfacing what we are interested in are the points of contact, since they represent the spearheads of a discipline. New cognitive paradigms arise from these contact areas, which can act as interesting fertile terrain, where contaminations and hybrids are generated.
4. The results that have been achieved using interface methodology and in

particular, two case-studies on memory and bio-complexity.

THE URGENT NEED FOR INTEGRATED STUDIES

In attempting to attain the target of integrated culture, one needs to go beyond the longstanding controversy involving the two cultures and deconstruct the stereotypes that characterise scientists and humanists. Reading C. P. Snow (1959/1998), one wonders whether, after almost fifty years, these stereotypes are still present in public opinion: scientists as optimistic, progressive, left-wing liberals who look to the future for inspiration; and humanists as pessimistic, right-wing conservatives who are inclined to dwell on the past.

Recently, the Italian mathematician Odifreddi, in a collection of essays, I *Classici e la Scienza,* claimed that «(…) the various cultures and paradigms are not nothing but the faces of an intellectual enterprise that transcends them all, and each one of them offers nothing but a structurally, socially and historically limited point of view» (2007, p. 53). The issue of integrated culture is intimately connected to the need to eliminate the dividing lines between disciplines; yet it is a fact that disciplinary barriers are still very strong at universities and in primary and secondary schools.

Ludovico Geymonat (1908-1991), the father of the philosophy of science in Italy, had little patience for artificial barriers and claimed that borders exist to be crossed. Nowadays, there is awareness that a parcelled type of culture no longer suits modernity and that excessively specialised knowledge does not seem appropriate when studying or attempting to comprehend the complexities of the modern world. The huge questions that technological and scientific development – from atomic energy to genetic engineering – have posed, require a clear analysis that only integrated knowledge can offer. Excessively specialised learning does not hold the answer.

The need to profoundly reform teaching in schools and universities is felt everywhere. Excessive fragmentation of knowledge only hinders young people who are being educated, because it portrays knowledge as a series of separate vessels that do not interconnect. This concept is underlined by philosopher Edgar Morin, and by Paolo Dario, an engineer interested in robotics. Morin (1999) states that our education system separates subjects and fragments reality, thus making understanding of the world impossible and preventing an awareness of fundamental problems that actually require a trans-disciplinary approach. As Paolo Dario asserts,

> Technology today must also meld with the human sciences, which should, in turn, proceed in the direction of innovation and open up, with curiosity and receptiveness, to the stimuli of technology. The model of engineering guided by science requires a high level of creativity and problem-solving capacity (2007, p. 263).

Since the 1970s, studies on the relationship between science and literature have striven to deconstruct this binary distinction, trying to highlight their affinities and identify possible cognitive paradigms common to both spheres. In these studies that have sought to find affinities between the two cultures, it has been noted that both are traversed by language. Not only literature, but also science is «a discourse», involving the same kinds of rhetorical strategies, literary tropes and unstable meanings as other forms of writing. L. J. Jordanova, an eminent science historian, in a beautifully written 1986 essay, stated: «Our primary object of study is language, that which mediates all thought, action and experience. We focus largely on the discourses common to science and literature» (p. 17).

There are many insightful pages in the works of Carlo Levi, a chemist, poet and great novelist, and in those of Italo Calvino, a writer fascinated by science, geometric shapes, symmetries, the *ars combinatoria* and geometric proportions, on how science and literature, far from being two separate activities, have many points in common. In a recent essay, Andrea Battistini (2008) asserted that the paradigm of bio-complexity was one that humanistic disciplines could also use. What links literature to biology is complexity, the complexity of subjects and of reality.

Another perspective is offered by Stephen Collini in his recent reediting of Snow's work, when he stresses how the notion of physics has changed since Snow's times from a subject considered:

> (…) as the hardest of 'the hard sciences', a discipline traditionally taken to exemplify how rigorously deductive analysis of a few general laws confirmed or falsified by induction from controlled experiment, provided predictive knowledge of the behaviour of the physical properties of the universe. The so called 'new physics' of the last twenty years has modified this model in two related ways. First, its actual findings on the nature of matter and the

origins of the universe appear to install unpredictability, open-endedness (Collini, 1998, p. XLVII).

This new view of physics greatly harmonises with the view of the world propounded by the humanistic sciences and literature.

In order to understand this contiguity, it is necessary to rethink some of the clichés surrounding scientific and poetic language: the former being denotative, transparent, and a class of language that refers more directly to what is spoken about; and the latter being connotative and inherently ambiguous. In order to show how many common elements these two types of discourse in fact possess, it is useful to start by analysing how metaphors are used in both cultures. The study of metaphors has indeed become one of the central themes in analysing the relationship between literature and science. Those who know how to use metaphors, or are capable of inventing them, possess a high level of creativity. Metaphors are a powerful instrument of knowledge that constitute an epiphany-like glimpse of reality. They are a means of semantic enrichment common to both scientific and poetic languages, that makes these languages productive and creative, capable of producing original views of the world and the things in it. In this respect, the scientist, the poet and the prose writer possess a capacity for «estrangement», an ability to look at reality through a stranger's eyes and consequently, discover unusual and hidden connections in the world that surrounds us. Many sciences, including immunology have actually used metaphors to explain the workings of natural phenomena.

It has often been claimed that «modelling» (mathematicisation) of the world aspires to absorb the universe's infinite characteristics, to achieve a model in which the qualities of reality are overlooked in favour of quantification. The artistic attitude on the other hand has been viewed as paying attention to details, to fragments, and to single factors. This opposition of positions is also questionable, because the description of singularities and fragments would possess no artistic/universal value without an underlying vision of the world, i.e. a model. Thus, upon closer inspection, one realizes that the modelling of the world is not only a feature of science, but of literary output. As Calvino reminded us in his *Lezioni Americane*, his lecture on exactness, «The formal choices of each artist always presuppose a cosmological model (…) Poetry is a great enemy of chance, although she herself is a daughter of chance» (1995, p. 69).

The other quality that both the poet and the scientist are endowed with is precision, the never-ending quest for the right word. In the author's case it

means precision in observation; in the scientist's case, the exacting description of natural phenomena. According to Calvino, exactitude – or precision – means three things:

1. A well-calculated and defined plan of the work.
2. The evocation of neat, incisive, memorable, visual images (in Italian we use an adjective that does not exist in English: *icastico*).
3. A language as precise as possible, both lexically and in conveying the nuances of thought and imagination.

Another important point is that today we possess a concept of culture and science that is more complex and less simplistic than the one discussed by Snow. For example, research carried out by the philosophers of science has led to a better understanding of the scientist's work method (see, for example, Thomas Kuhn's writings suggesting that scientific change does not invariably take the form of a steady accumulation of knowledge within stable parameters; anomalies in the evidence accumulate to the point where change takes the form of a «discontinuous jump» or «paradigm shift»). Furthermore, research done by sociologists in science has highlighted how the very constitution of scientific knowledge itself is dependent upon culturally variable norms and practices. Seen from this perspective, science is merely one of several sets of cultural activities, as much an expression of a society's orientation to the world as its art or religion and equally inseparable from fundamental issues of politics and morality. Science, then, is seen as a «social construct».

The third point to bear in mind is the discourse on creativity: those who have kept a close watch on the great watersheds in scientific thought and technological innovation cannot help but admit that the most creative developments have consistently torn down disciplinary fences.

In depth investigation into the relationships (links, affinities, differences, issues and problems) between the sciences and the humanities shows that there are mutual influences that favour a more dynamic approach toward interfacing. Therefore, the fundamental starting point would be to acknowledge the isomorphism of the two fields that, to respond to their own actuality and societal matrices, have often simultaneously developed new models and strategies to investigate complex scientific and cultural (artistic, literary) phenomena. This idea of isomorphism (Hayles, 1994) is no longer linked to traditional concepts of cause and effect, but instead implies simultaneousness, not consequentiality: one field does not influence or condition the other. Isomorphism implies

joint discoveries, as both domains simultaneously develop new investigative models which become, in turn, analogical mirrors of a world in constant progress. This idea leads us to view the sciences and the humanities together, because their mutual interfacing can trigger new dynamics in the various fields of knowledge.

In the last two centuries, theories of education were developed around ideas of distinctiveness and choice: with the humanities on one side and science on the other. However, today's students are asking for new educational models that reflect the complexity and interplay of a world characterised by a different understanding of knowledge and, especially, by the rapid development of new societal matrices. As a consequence, other paradigms that follow the development of new societal conditions have begun to emerge such as globalisation, changing political assets and new 'mediascapes'. In such a shifting context, the idea of «interface/interfacing» seems to offer a suitable paradigm that in turn triggers new, heuristic implications. Also, the very idea of interfacing leads to the interesting concept of 'complexity', which in itself is a metaphor that implies exchange, mutual interlinking and, above all, the concept of networking; that is, of new strategies for looking at and subsequently rendering a world in progress. The concept of networking implies not only a new way of carrying on transversal research among different disciplines, but also a new way of conceptualising and representing reality. Networking is at the basis of complexity: a new epistemological paradigm that is common both to humanistic disciplines and science.

We are facing a cultural context undergoing constant evolution. This is a fact that both domains have to acknowledge; and education is finding interesting ways to deal with these changes. There are new programs in medical schools, faculties of engineering and the other scientific branches that are offering courses in literature, the arts and philosophy, as well as courses to foster creativity. On the other hand, attempts have been made to apply scientific research and knowledge to the humanities. These involve the application of more practical approaches with the creation of new disciplines within the humanities such as humanistic informatics; the creation of new infrastructures such as e-archives and new databases; and new theoretical developments that combine theories of literature/criticism and scientific models of investigation (from field theory to chaos theory).

Other interesting examples come from the social sciences, which have been playing a pivotal role in developing new lines of research and new concepts to break down barriers and encourage interdisciplinary approaches. Anthropology has provided us with one particularly interesting example. In this disci-

pline, the scientific idea of «thick description» is applied to analyse *culture tout court*, a broad, complex concept that interfaces the two domains. Similarly, in the last two decades, scholars in the humanities have begun to reconsider the idea of «literary phenomena», with literature no longer perceived as a closed system, but instead as a complex manifestation, a network of events, thereby triggering a new understanding of *zeitgeist*. In such a shifting environment, the links between scientific discovery and literary and artistic experiments are inevitably being judged anew: not as linear, sequential phenomena but as manifestations that are convergent and interconnected.

THE CONCEPT OF INTERFACE

I shall now examine interfacing, the concept behind the working hypothesis of a European project dubbed «Acume 2 – Interfacing Science and Humanities», which I have coordinated.

The meaning of the term «interface» is easy to apprehend. The word is composed of the prefix «inter» or «intra», meaning «between two or more parties», and the root «face» – surface, face, point of contact. It is a term, however, which defies monolithic explanations. The semantic fields to which «interface» can be applied range from information technology (I.T.) geography and chemistry to metaphors.

The term was used first in I. T. and connotes not only a point of contact that allows communication, but also the methods of exchanging this information. We will use the term, which is a wide-ranging descriptor, and thus fascinating for its power to suggest rather than describe, and – in acting as more than a simple metaphor – convey a methodological point of origin. Let us, first propose a few definitions for the term «interface». In computer science and information technology, it is a circuit, a hardware component, that acts as a physical link to other components. The USB (universal serial bus) port of a computer is a good example of this. But an interface is also part of a computer's software; that is, a program enabling interaction, translation between two languages, thus allowing the user to interact with the machine.

In the strictest sense of the term, the «man-machine» interface is a program that allows someone to use his or her desktop or lap top computer. In other words, an interface is a knot, a minimum component that is part of a wider complexity. It is also the description of an exchange, a specification of the limits of a given activity. All information exchange implies, then, the

presence of an interface.

The utility of this notion is not then, that of naming something, but rather of making it visible. An examination of «human being – technology item» interfacing begs the question: Are we really facing an interface (excuse the artless redundancy)? If the answer is yes, then one must view the two systems as distinct and independent, since there are continuous exchanges between what is biological, what is human, and non-biological and non-human space. This last case is evident in artistic representations of artificial beings, and especially in medical technologies such as CAT scans and X rays, which allow human space to become readable, as it were.

Sickness or health are literally rendered by a tool that allows these renderings to become evident, visible, to the eyes of the doctor, who is then able to read them. So interfacing works, not only in those striking cases in which hybridization of the mechanical and the organic occurs, but also as a mediator, as a means of communication between two actors who are interacting with each other, and even as a new language invented for this communication. Likewise, in the CAT scan, a diagnostic, medical imaging technique that produces a 3D reconstruction of tissue through a tomographical analysis obtained by sweeping an X-ray beam over the patient, there are many «mediations» of messages: from the patient's symptoms to the diagnostician using an analysis instrument and customizing a final report on the basis of data obtained from the patient's body. In turn, the data are interpreted by the practitioner, who will then draw up a course of treatment. It is no mere diagnosis. Different levels are involved in the different stages of the procedure. The patient's body becomes a network, a multiple system comprising physiological, organic, psychological and existential dimensions. Interfacing lies at the core of the system of medical knowledge. It is the meeting of epistemology (all that is known about man and his functioning) and culture (the way illness is perceived by the subject himself and society and the way a particular illness is viewed by the patient and described to or by others). Interface is thus not a metaphor, but a methodological approach. It is a question of seeing how the two systems – man and technology – interact and at what level and how. From this observation, patterns may arise, that is, structures, continuities or discontinuities. The levels of interfacing can be analysed, in order to know if the two systems are really independent.

The seminal studies by Katherine Hayles, *The Cosmic Web, Scientific Models and Literary Strategies in the 20th Century* (1984), and Edward O. Wilson, *Consilience, The Unity of Knowledge* (1999) are vitally important. The first was written by a

scholar who moves in humanistic circles (and now also in ITC) and the second by a biologist. Both authors affirm the need for cooperation between the two fields and propose new methods and paradigms of knowledge. Therefore, a fundamental starting point is to acknowledge the isomorphism of the two fields that, to respond to their own actuality and societal matrices, have often developed new models and strategies simultaneously while investigating complex scientific and cultural (artistic, literary) phenomena.

In the work mentioned above, Hayles links literary sign/signs to scientific theories, and proposes the idea of 'field theory' or 'field concept' as the epitome of the new way of observing and perceiving contemporary reality that characterizes both scientific research and artistic and literary endeavour. What makes Hayles' book interesting and characterises her line of research is the fact that the author doesn't limit herself to simplistic, even predictable, remarks such as «science influences literature and opens it up to new imagery» or «new scientific discoveries offer literature new models of expression». Rather, Hayles offers a deeper examination and subscribes to a new concept of field within a more complex context. She observes that between the end of the 19th and the beginning of the 20th centuries, apologists of both the humanistic and scientific spheres of knowledge, started proposing similar modes of investigation that were less connected to the atomistic (Cartesian) idea of knowledge and increasingly linked to a holistic idea that Hayles defines, as «field theory». Science and humanities have come up with new investigative methods within field theory that Hayles herself espouses, that are built on two fundamental assumptions:

1. All things are connected – not by a tidy, hierarchic logic – but simultaneously by their joint presence.
2. For this very reason, the language expressing them is, inevitably, self-referential.

These conditions make observation more complex, because it cannot be carried out in a traditional way: all differences between the observer and the observed are eliminated (both actors belong to the same field of observation, and mutually influence each other). One of the fundamental differences contained in atomistic (Cartesian or linear) observation is that

(…) in the atomistic view, the gap between subject and object is not 'contami-

nated' by the circular paradoxes of self-referentiality, because it is assumed that reality can be divided into separate, discrete components. Consequently, it is assumed that language can be used to define the relation between subject and object in a formally exact way. But the field concept assumes that these components are interconnected by means of a mediating field. When language is part of the mediating field (i.e., the means by which the relation between subject and object is described), it participates in the interconnection at the same time that it purports to describe it. To admit the field concept thus entails admitting that the self-referentiality of language is not accidental, but an essential consequence from within the field (Hayles, 1984, p. 41).

'Field concept' is thus a way of observing (viewpoint) that underpins both scientific and artistic research and that, as previously said, can no longer be explained in terms of a simple cause and effect relationship, precisely because it is perceived simultaneously by the two fields. Rather, Hayles stresses how important it is to read this new idea in the light of a complex and ever-changing cultural context:

(…) a comprehensive picture of the field concept is more likely to emerge from the literature and from science viewed together than from either one alone. (…) A more accurate and appropriate model for such parallel development would be a field notion of culture, a societal matrix which consists (…) of a 'climate of opinion' that makes some questions interesting to pursue and renders others uninteresting or irrelevant (Hayles, 1984, p. 10, p. 20).

In turn, the idea of «consilience» that Wilson investigates in his studies proposes the union of the two cultures in order to grasp, holistically, the cultural processes and those of the natural world. The definition of consilience is thus unequivocal.

Consilience [is] a jumping together of knowledge by the linking of fact and fact-bases theory across disciplines to create a common ground-work of explanation (Wilson, 1999, p. 8).

INTERFACE AS A STRATEGY: A NEW METHOD
OF APPROACHING LITERARY STUDIES

In her study, Katherine Hayles offers up a new method of literary analysis that is founded on the use of mathematical models applicable to texts. Hayles' fundamental working hypothesis is that the 20th century's change in the scientific paradigm determined a change and a new conceptualisation of reality, which necessarily affect the scientific, social, cultural and artistic milieus. However, it is not a simple exchange of influence between the scientific and the artistic or social domains. A revisiting of the concept of comparison thus becomes necessary. It is no longer a case of adapting a scientific methodology to literary studies; it is no longer a case of using metaphors, but rather seeing the two spheres of knowledge as indissolubly linked, as part of the «cosmic web» that connects a holistic, multi-stratified universe to man, science, technology and art. According to Hayles, the chaos theory and the theory of complex systems of the 20th century have supplied investigative models and brainframes[2] which can be applied to all the fields of human studies. In other words, the old notion of cause and effect has given way to concepts embracing a simultaneity of non-consequential relations and to areas of isomorphism, where the different levels and materials interact simultaneously.

Hayles invites us then to a reformulation of the concept of «comparison». It is no longer a question of putting two or more texts on the same level, but rather keeping the borders of texts fluid to permeable thematic constructions, languages, structures, all part of contemporary «discourse» in which human beings, technology and art overlap each other in a continuum.

In the European Project Acume 2, starting off with specific «case-studies», we have attempted to understand how some concepts, metaphors and narrations, migrating from one discipline to another, have acquired new meanings. Consequently, they have sparked new knowledge configurations and have opened new frontiers of understanding. Words such as «appropriation», «translation», and «reassessment» have become key words in understanding the reconfiguration of the processes of knowledge that occurs when there is a migration from one discipline to another. Another important point that emerged was that, in this process of migrating from one discipline to another,

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2   A brain frame is a structure for the physiological, cognitive and sensory reception and interpretation of reality, created and determined by information technologies. According to this model, the means of communication change the mental configuration of those who take part in the communication. Derrik de Kerckhove, a pupil of M. McLuhan, developed this concept and it is used here, modifying its application somewhat. All the technologies and sciences together, with their paradigms are in fact considered agents of changes in the mainframe.

the different historical and national contexts must be kept in mind.

Not only are concepts, metaphors and narratives the most important theoretical and analytical tools of academic discourse, but they also provide critical interfaces between science, literature and the humanities, enabling debate, research and dynamic exchange on the basis of a common language. However, more often than not, the meaning and operational value of concepts, metaphors and narratives, even of those which appear to be self-explanatory, differ between the various disciplines, different academic and national cultures and historical periods. Concepts such as 'communication', 'code', 'complexity', 'life' and 'system'; metaphors like 'crisis', 'network', 'body' and 'text'; and cultural narratives such as 'evolution', 'ageing' and 'digression', which are at the core of both sciences and humanities, are not univocal and firmly-established terms. Rather they are dynamic and interchangeable as they travel back and forth between academic contexts and disciplines. Hence, they constitute what Mieke Bal has felicitously called '*travelling concepts*' (Bal, 2002).

With the move towards greater transdisciplinarity, the dynamic exchange of concepts between different disciplines, as well as the translation of concepts into metaphors and narratives has surged. Through constant appropriation, translation and reassessment across various fields, concepts, metaphors and narratives have acquired new meanings, triggering a reorganisation of prevalent orders of knowledge and opening up new horizons of research. This has happened to such an extent that their meanings must, be constantly renegotiated between the different disciplines' travelling concepts, metaphors and narratives in order to foster a self-reflexive approach to the transdisciplinary study of culture.

THE NOTION OF TRANSDISCIPLINARY STUDIES

I would like to mention two books *Memory/Memories: Transdisciplinary Routes* (Agazzi & Fortunati, 2007) and *Bio-complexity at the Cutting Edge of Physics, Systems Biology and Humanities* (Castellani, Fortunati, Lamberti & Franceschi, 2008), which are the result of our efforts to test interface as a strategy for approaching possible common epistemological paradigms both in science and humanities. Both of these books were born from the fecund idea of transdisciplinarity. While in interdisciplinary studies the various disciplines operate alongside each other with each one tackling the same problem from its own field of competence, in transdisciplinary studies the research methods them-

selves are re-envisaged and, consequently, so are the disciplinary boundaries. The idea of transdisciplinarity is built on the reasoned and dynamic combination of verticality (macro-areas) and horizontality (common keywords).

Our first book investigates the state of the art of studies on memory in six disciplinary macro-areas: Social Sciences, Biomedical Sciences, Arts and the Media, Humanities and Religious Studies. These are crossed by 'keywords' present in the conceptualisation of memory that has developed during the last twenty years. This means that every section must confront the keywords that constitute a sort of thread running through the various disciplines.

- Evolution
- Individual and collective memory/memories
- Memory and trauma
- Memory as a dynamic process
- Memory and information
- The context
- Memory and oblivion

The idea of trans-disciplinarity is built on the reasoned, dynamic combination of verticality (macro-areas) and horizontality (common keywords). Thus, traditional disciplinarity remains a compulsory touchstone (both for writers and the readers) but it is 'revisited' by means of common keywords that acquire marked heuristic relevance.

Work we are jointly carrying out with a number of scientists led to a book based on a seminar aimed at investigating the paradigm of 'bio-complexity' as a possible heuristic model for the interpretation of complex systems in other disciplines. The book discusses biological complexity as a challenge and a possible paradigm for other fields of knowledge whose objects are non-biological complex systems (i.e. literature). The working hypothesis is that the bio-complexity model could be used as the paradigm for the observation of complex systems in both fields of human and scientific sciences: from biology to economics and from literature to physics. This is the thread that runs through the book and connects the articles of its various contributors who are pursing a variety of objectives and referring to a number of disciplines.

Fundamentally, the book stresses that there are concepts that can highlight the characteristics shared by a series of complex systems, despite

their apparent diversity and their belonging to different fields of knowledge. For example, we have to verify if the theories of biological complexity can be useful in examining literature, which is seen as a complex system. In the humanities, the paradigm of bio-complexity has revealed itself to be a useful analytical tool, because from a global perspective of literary systems, the view of European and Trans-European literatures and cultures as complex systems that interact within a system of networks is now being explored in comparative and post-colonial studies. Because of its complexity, the study of literature at the global level requires models created in other fields of research, such as quantitative historical graphs, geographical maps and the genealogical tree of evolutionary theory. Only in this way can relationships, structures and forms be identified in literary macro-systems (Moretti, 2005).

The most advanced conceptualizations of biological complexity have underscored the following characteristics shared by living organisms:

- They are made up of a very high number of elements that mutually interact and organize themselves in functional, dynamic *networks*.
- They possess different *levels* or *strata of complexity*, from molecules, to sub cellular organelles and *the cell*. This fundamental unit of living organisms is not only a complex system in itself but the building block of higher levels of organization that can generate a whole series different tissues and organs that finally constitute a unique body.
- The different bodies (organisms) organize themselves into *societies* which in turn constitute their own ecological systems which are even more complex and in which hundreds or even thousands of different species coexist or cohabit in a dynamic balance.
- They are systems possessing their own *evolutionary history*, which has conditioned their structure and their functional capacities, and as such, entails a series of *constraints*.
- They are the result of a *fitness* selection, which optimises the networks from a structural and functional point of view, and occurs at all the above-mention levels of complexity, from molecules and cells to organisms.
- They are organized into *modules*: aggregations of networks with a defined function. Modules are organized by means of *links* amongst them in order to form supra-modular organization.
- The systems are *dynamic*, *open* and *non-linear* and are dominated by *stochastic*

fluctuations and noise.

- They are characterized by *the emergence of wholly unexpected properties and functions* (symbolic language, awareness, etc.).
- They possess the ability to *learn* and remember (*memory*), which occurs from the molecular to the highest level of biological organization and includes the most sophisticated, cognitive functions.
- The behaviour of every given element is determined by its *context*, that is it is conditioned by all the others together, in a continuous interactive and dynamic system.

The two books show how fertile an approach that combines traditional disciplinary distinctions is and demonstrates how such outwardly different subjects share similar methodological problems that can be examined using the same instruments. It is not a trivial lesson for scientific institutions such as universities that are still organized according to visions that do reflect today's concepts regarding the dynamics of knowledge. Memory and bio-complexity are fields that have shown the rewards of challenging time-honoured, traditional disciplinary divisions that have still not incorporated the heuristic, epistemological potential of the transdisciplinary method.

I would like to end my contribution by citing two authors who have so aptly summarized the working hypothesis of my research on complexity in literature and science: Italo Calvino and Prigogine:

> The function of literature is communication between what is different, not dulling but exalting the difference (Calvino, 1995, p. 668).

> While classical science used to privilege order and stability, today we recognize the primal role of fluctuation and instability at every level of observation, [associating] multiple choices with the horizons of limited predictability (Prigogine, 1996, p. 14).

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