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## The Structure of Scientific Knowledge and a Fractal Model of Thought

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We begin with a theory of thought as a biocognition not precisely situated in the individual, and still less in the brain alone, but deriving from a shared field of bioinformation. The structure of associations among elements of speech may reflect the structure of this field. Then we demonstrate that the analysis of the structure of the scientific discourse applied within this logic shows the fractal structure of the field of bioinformation. We also show that scientific culture can be interpreted as a cultural model. So, scientific culture would be the elaboration of a cultural scenario in which each human being is another “myself” according to circumstances, an identification making a relationship of aid possible. This aid relationship is governed by an energy equilibrium defined by the cultural scenario, and may be calculated according to fractal theory. The result is a fractal model of consciousness and of the energies at work, whose equilibrium is necessary for the correct functioning of the human being. The consequences are determined concerning the reinsertion of the logic of the culture within the purely objective logic of medicine, in particular that of “giving–receiving” inherent in all cultures, even at the levels of giving birth in the context of modern medicine.

Keywords: biocognition, scientific knowledge, fractals

According to biocognitive epistemology (Martinez, 2001), “biocognition” is composed of thoughts, emotions and language, which develop within a historical culture from which these elements “co-emerge” or co-occur, rather than being the consequence of any one of them. No reality external to the

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subject exists, no objective perception.<sup>1</sup> The human subject is embedded in her environment. Biocognition is built out of associated events and the organization of the associations responds to a dual logic (Martinez, 2001): on the one hand is linear logic, related to the logic of Euclidean space and irreversible time, where the associations are organized by the brain through recovery processes to produce causal thought; and on the other hand is fractal, non-linear logic, where the associations are stored at every level, from cells to neurons, by way of the organs, but also through external, natural and artificial objects. In the latter case the context of an event is dispersed, distributed, and not local. Everything takes place as if these associations were erupting into what physicists refer to as a “field,” the field of “bioinformation.” This field may consist of information not really understood at present, like those of morphogenetic waves not included in the classical physics of weighted bodies.

Fractal theory, extended as a new principle of relativity (the scale relativity beyond the Galilean mechanical relativity — the speed of an object is relative — and Einsteinian electromagnetic relativity), suggests that we may observe the same (or build the same consciousness of) laws in physics whatever the observation scale (Nottale, 1996). In the frame of this theory, objects and the spaces in which they move are co-constructed.<sup>2</sup> Coordinates are fractal, which excludes differential computation of them. Time may be or may not be a dimension, depending on the scale involved. It not only can be abolished (case of space–time associated to a single object) but can be made reversible (case of certain small scales).

We may hypothesize that this could be the case in the bioinformation field to which the discoverer’s mind is linked. With scientific discovery, we will see in fact that a phenomenon like a drug effect can be described in terms of co-occurrences, like an idea emerging in a field where time is abolished, as well as in terms of causality, the consequence of real experimentation at the body scale where (according to scale relativity) time takes place.

### *From Gestalt Psychology to the Fractal Structure of Thought*

Gestalt psychology suggests that, in some cases, a human being may be perceived from just his face as well as from his entire body, as if what is perceived on his face is developed at every level of his body, and conversely

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<sup>1</sup>Mirror neurons, which react in an identical way, whether an act is performed by the subject or by a third party, make possible the elaboration of a single cultural scenario.

<sup>2</sup>Natural laws appear as geometrical laws like geodesic trajectories, thus linking space and objects as far as they take part in the space construction.

(Guillaume, 1937). Epistemology has already shown that an invention may be assimilated to a form, in terms of the gestalt. Kuhn (1970) held that science was evolving from new paradigms seen as perceptive structures, also in the manner of Gestalt psychology, according to which our perception is organized around global shapes. It is in this way that the same drawing can be perceived as being composed of black shapes on a white background (representing fish, for example), or as white shapes on a black background (representing birds, let us say).

What we would say in addition is that form (1) may be developed at different levels, (2) links the observer to the observed, and (3) may be assimilated to other forms such as those defined by connexionist psychology, i.e., as consequences of the existence of well-defined centers of convergence at the core of the network of associations stemming from perception (Feldmann and Ballard, 1982). A thought seen from this point of view is an associative structure. This structure would thus be fractal in type, organized around a repeated pattern at variable scales.<sup>3</sup>

*Networks of Associated Words as Surrogates for Associated Events: The Fractal Structure of Scientific Knowledge*

How can the heterogeneous associations and the structures involved in biocognitive epistemology be reached? Spoken words, consequences of thought, may be considered as pure sonorous events associated with the thoughts according to biocognitive logic. The words are then no longer considered from a linguistic point of view, as meaning something. Words sum up a relational thought, in which observer and observed are blended, context as well as text. Words correspond to what Vygotsky has called the whole set of subjective experiences linked to the preceding uses of a word for a subject (see Schneuwly and Bronckart, 1985). The analysis of the structure of the associations between words will then sum up the structure of the associations of the events which represents the thought itself.

It so happens that the fractal model, made calculable by the means of associated words, corresponds very well to the dynamics of the construction of scientific knowledge. For quite a long time now, using translation theory, we have developed and applied to the data bases of scientific articles a set of programs concerning the computation of an article's keyword associations (Callon, Courtial, and Laville, 1991). This set of programs has been called co-word analysis (the first software was called "Leximappe," and then by dif-

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<sup>3</sup>Speech works according to this fractal logic. For instance, words like "big" are obviously not scale dependent insofar as the meaning of big refers to some kind of relation between objects (Shanon, 1993).

ferent names in various countries, "Sampler" in France, "Copalred" in Spain, etc.). Current co-word analysis programs calculate the associations between keywords made by scientific articles. The associative coefficient retained between two words is the product of the probabilities of finding one word if the other is found in the same article. The program ranks the pairs of co-words in decreasing order. It then computes the strongest linked aggregate of  $n$  words, called clusters or themes. Each cluster is characterized by (a) its centrality, i.e., the sum of the links which join the words inside the cluster to words outside the cluster (external links), and (b) its density, i.e., the average value of the links between cluster words (internal links).

Let us consider, for example, the construction of scientific knowledge in the field of autism (Courtial, 2001, 2003; Courtial and Gourdon, 1999). In general, a new scientific idea is represented by a mechanism described by linear means. For example, the discovery of the role of endorphins in the case of autism will be described by the impact of an excess of endorphins on the tendency towards auto-mutilation, and the therapeutic role of a drug opposing the effects of the endorphin, such as naltrexone. But this is to forget that, from the viewpoint of the logic of discovery, the role of endorphins was revealed at extremely variable locations, from blood (analysis) to drug effect (symptoms) testing. Problems of autism and endorphins have thus been brought together at very precise levels of blood analysis, as well as at more general levels of therapeutic effects. In terms of networks, those associated at variable sites with autism, on the one hand, and those with endorphins on the other, are brought together in variable clusters, corresponding to the frequencies of variable events, rather weak concerning blood analyses, moderately high for therapeutic trials, and high insofar as a more general approach concerning autism is concerned, such as the chemical origin of it.

In fact, the researcher can readily imagine a link between the two networks: the network she associates with autism and the network she associates with endorphins.<sup>4</sup> She makes this association, for instance, because as a biologist, she has had the opportunity to approach animals displaying an excess of endorphins. Such an association is made because the researcher possesses two cultures: in this case a culture in biology, as well as a culture in psychology. She always poses the question of "self" and "the other": In what way am I not the other, and how, according to what mechanisms, might I be the other, in this case an autistic who mutilates herself? Here the fractal form characterizes both the object under study and the observing subject. It should be noted that in the absence of scientific theory the researcher may imagine self-mutilation as a kind of choice made by the autistic child, a strange

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<sup>4</sup>The following observations are derived from co-word analysis (Leximappe), using the PSYCINFO data base (Courtial and Gourdon, 1999).

choice, often summed up as a case of "mental retardation" and not further analyzed.

Having an hypothesis, the researcher develops this connection between different cultures, biological and psychological, at different levels of analysis. In order to do so, she goes through the associative network consisting of the representation she establishes of the body as object. In doing this, she builds what the sociology of translation calls an actor network, according to which the interactions among researchers and between researchers and nature consist of introducing sociocognitive equivalences (Callon, Law, and Rip, 1986).<sup>5</sup> It is as much a question of the associative network describing the action mechanism of endorphins, as that of the associative network describing the mechanism of self-mutilation, which may be observed, for example, at the level of the bites or the pulling out of hair. When the discovery is integrated into the researcher's culture as being true, when she can furnish a causal statement of it in a linear fashion, associative pathways in the mind link these elements in the manner of co-occurrences, as well as of causes.

Thus, a new idea has an impact at different levels of the actor networks it challenges. Let us again take the example of autism. According to the theory of mind (Baron-Cohen, Leslie, and Frith, 1985), the autistic child does not imagine what the other person is thinking, has no image of the other person's intentions (the other person's mind). What the other person thinks is usually derived from indications given by his body. In other words the other person is an object whose global "characteristics" (in this case what he expresses in his relationship with us) may be found at different levels of his body: (a) subtle movements, such as those of the eyes — a glance towards an object may show that one is thinking of that object, (b) the facial expression of emotions, and (c) the very general level of the thoughts expressed, opinions concerning people, an example referred to as "social cognition." These are the mechanisms observed at different levels which converge towards a new paradigm, constructing the actual idea of the theory of mind.

The observations concerning eye movements form a cluster of words of associated events, forming an object of research (especially through the use of new devices which make possible the precise measurement of eye movements). This is also true concerning observations analyzing people's facial emotions and for observations concerning social cognition. The theory of mind is an associative intersection situated at the level of eye movements, facial emotions and social cognition, as an identical geometric pattern occur-

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<sup>5</sup>The concept of the actor network has been applied in several fields of psychosociology (Michael, 1996).

ring at different scales.<sup>6</sup> This pattern, however, when knowledge is in construction, can not be defined precisely as will be the case later when science is achieved. It only assumes its generally accepted name (the “game of pretending,” for example, more or less has expressed the same idea in an earlier time period) when the discovery is completed.

The work of Kuhn (science is in progress through paradigms) has led to the calculation of clusters of articles frequently referring to one another, calculations made by the [former] Institute for Scientific Information (ISI), in Philadelphia. These articles are interpreted by ISI in terms of “research fronts” linked to a precise paradigm. The ISI even published a cartography of these research fronts, for many years, under the title of “An Atlas of the Sciences” (Garfield, 1981). A research front consists of many articles citing a small set of “core” articles. Our approach hypothesizes the emergence of a new form linked in some cases to what could be called later a new paradigm, but the form is distributed to a number of sites in the network of word associations, and can not be simply attributed to the work of a small set of pioneers. This form or pattern refers to some fuzzy logic, as opposed to the language of experts when science is achieved and knowledge is stabilized. Rather, this form represents a new dynamic, scarcely visible, as long as the science it is linked to has not resulted in precise scientific statements. Experts in a given field, to whom networks of associated words are shown, are frequently confused when they read the maps computed through co-word analysis (Courtial and Remy, 1988). The latter do not propose the causal associations these experts are accustomed to, as expressed in conventional science. The variability of the words used to deal with a discovery makes the reading of associated word networks difficult. This is why calculations and quantitative predictions made possible by fractal theory is preferable to reading maps of associated words pointing out logical, linear links, like those that support simple paradigms, in the manner of research fronts.<sup>7</sup>

When a discovery is completed, the network of words associated to the discovery comes in the form of a stable structure, almost a regular arborescence (tree structure), with the name of the discovery at the root of the tree being referred to most frequently. The fractal dimension is weak, approaching, in a way, a rigid crystalline structure. This has been recently demonstrated, using

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<sup>6</sup>Connexionism tells us that a shape such as the written letter “s” — whomever the writer may be, the letter’s size, etc. — corresponds to a very exact node, activated at the core of a formal neuronal network.

<sup>7</sup>It is from the analysis of associated words that numerous prospective analyses have been carried out to date, in the field of research management (Callon and Courtial, 1995; Callon, Courtial, and Laville, 1991; Callon, Courtial, and Penan, 1993; Callon, Courtial, and Turner, 1991; Callon, Law, and Rip, 1986; Courtial, 1992; Courtial, Sigogneau, and Callon, 1997).

mathematical models derived from fractal theory, by Bailón–Moreno, in the chemical field of surfactants (Bailón–Moreno, 2003; Bailón–Moreno, Jurado–Alameda, Ruiz–Baños, and Courtial, 2005b).

In terms of the meaning of associations, a causal network surrounding an event is a network made up of associations, both centripetal and centrifugal, around the event. Heat induces swelling (a centrifugal link), and if there is swelling, there has been heat (a centripetal link). Scientific causal reasoning is therefore a particular case of biocognition.

Conversely, during explorative research, it is from the central regions of the fractal trees corresponding to previous discoveries and knowledge that the new idea, often under different names, appears. The fractal dimension is then very high, an expression, as Mandelbrot (1977) has shown for language, of the wealth of vocabulary: the idea is simultaneously expressed differently by various researchers. It is during these periods that scientific creativity is highest. The contributions by little known researchers is called the “Ortega effect” in opposition to the “Saint Matthew effect,” where the most well-known researchers make the biggest contribution to the advancement of knowledge.

Courtial and Gourdon (1999) demonstrated that causality attributed to an event (for instance, excess of endorphins in the brain) appears with associated keywords as an equilibrium between centrality and density rank value of the cluster associated to that event. More generally, it can be shown that cluster frequencies, centrality and density distribution, as previously demonstrated by Mandelbrot with language word frequencies, obey fractal logic (Bailón–Moreno, 2003; Bailón–Moreno, Jurado–Alameda, Ruiz–Baños, and Courtial, 2005b, 2005c). More precisely, everything takes place as if the dynamics within a field of research were the consequence of discoveries of an earlier type, entangled together, conferring upon the network of associated words a “transfractal” structure (Bailón–Moreno, 2003; Bailón–Moreno et al., 2005b). Hypotheses concerning endorphins and the theory of mind interfere with one another. So the dynamics of a field of research oscillates between a complex transfractal structure, whose centers are situated in intermediary zones in the network of associated words, within a simple fractal structure. All the laws of scientometry (the quantitative science of the development of knowledge) can be rediscovered from this model (Bailón–Moreno et al., 2005c).

#### *Scientific Knowledge, Collective Thought and Individual Thought, Self and Non Self*

Through the elaboration of scientific theory, the researcher acquires a new culture. For instance, that culture makes it clear that if the researcher had

shown an excess of endorphins, or if she had not elaborated the theory of mind, she would be autistic. This puts an end to explanations of the behavioral disorder of autists as being due to mental retardation. So, in this way, the theory of mind is placed between the educator and the autistic child as a social construct, an artefact, shaping the roles of each other in a new way.

The inventive process begins with a fusion of the researcher with her object of research, a fusion from which she escapes by producing culture (Mialet, 1994). All association clusters that will later distinguish scientific objects as distinct from subjective states are "mixed" during this step in the same way as child development is described in some combinatory theories (e.g., Kegan, 1982). The development of scientific knowledge thus contributes to the clarification of the rule concerning the attribution of associations occurring within us: an attribution of what is characteristically ours, or what is due to the environment (including culture). Of all the internal, motivating and iconic associations present within the researcher, only those connected to a shared, external culture can socially be attributed to nature.

The "programming" of the body assumed by biocognition is developed at all internal associative levels, both cognitive and corporal. Scientific culture is thus induced by all of our senses, by a mimetic, kinesthetic relationship with the environment, and not simply in an intellectual manner. This leads to a veritable culturally induced corporal diagram.<sup>8</sup> Someone who has been trained as an engineer feels the acceleration of a train because of an acquired awareness of kinetic energy, which comes to him more easily than to others — the body "retains the memory of continuous movements" as Galileo used to say when he set up the first principle of mechanics — an awareness of the need to dissipate this energy by running, when he steps onto the platform before the train has completely stopped. In a similar way, researcher self-awareness is elaborated by the culture.

Thanks to science, the educator of autistic children will be able to attribute the hostility of the child to external causes, and not to child awkwardness. This is a new culture, with increased possibilities (like the concept of "variety" in cybernetic systems), which means that identical representations give access to all situations. The unitary feeling of self-awareness through others is maintained, and culture may be seen as a vast scenario of the distribution of resources, at the core of which each actor, human and non-human, keeps her identity: the non-humans, because they behave according to human predictions, and the human beings, because they consciously have access to the universe. It is the abandoning of traditional

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<sup>8</sup>Mandelbrot (1977) used to say that before developing his theory of fractal curves, i.e., as continuous and non-derivable, they were considered to be monstrous.



behavior which leads the researcher to seek out other behaviors. From this viewpoint, science is a meeting with others in order to eliminate conflicts based on lack of understanding, as research into autism has shown. This approach emphasizes the generous side of science and therefore participates in what is referred to as bioethics (Martinez, 2001).

### *Scientific Knowledge and Energy*

All the social interactions imposed by science help maintain a coherent self-awareness, inscribed within a coherent scenario in which others participate. This scenario implies organizational growth, since it avoids conflicts, channeling the actor's energies in a more harmonious way than before. Coherent cultural action thus gives energy to the subject, who redistributes it to others in return. This scenario makes explicit the efforts of each person, making possible a fairer distribution of each person's contribution to life in society.<sup>9</sup>

This organizational growth functions all the better since, on the one hand (from an internal point of view), I, the educator, may often appeal personally to the theory of mind in order to explain the situations to myself and since, on the other hand (from an external point of view), others often share the same theory and find it adaptable to situations. In opposition to the classic physical view where objects are moving in a priori spaces external to them, the fractal field makes possible the construction of new spaces at any site. Consequently, as far as it is shared by many people, a new theory like theory of mind may be developed in several ways, building its proper space.<sup>10</sup>

### *Calculating the Increase in Organization and Energy Provided by the New Culture*

The sociology of science had established the foundations of the above model some years ago by way of the theory of translation (Callon, Law, and Rip, 1986; Courtial and Gourdon, 1999). A translation is a sociocognitive operation through which an equivalence between two problems (a complex one taking place in society and a more simple one that may take place in a laboratory) is suggested by the researcher, e.g., an equivalence between a problem of autism and a problem of endorphins, or of the theory of mind. Translation implies a change in culture, obeying a logic of organizational development, or

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<sup>9</sup>In the case of autism, identifying the suffering of the child by way of a biological test measuring stress allows us to make the child's suffering visible, thus also making visible the efforts of the educator to deal with this suffering.

<sup>10</sup>From the viewpoint of scale relativity, there is a co-construction of a fractal object, and of the fractal field of customs in which this object will be made to move.

of increasing organizational energy (Bailón-Moreno, 2003).<sup>11</sup> A translation proceeding from an event is precisely linked to the frequency of the event and to the fractal structuring to which this event may lead — according to the translation process — within a fractal space. It can be shown that the organization to which a cluster contributes is all the more complex when (1) the cluster occurs frequently and is structured internally, and (2) the environment of the cluster occurs frequently and is structured. The translation is thus at its maximum at the roots of the fractal trees. The result is that the total amount of energy incorporated within a cultural network is the sum of all the energy necessary for the construction of the culture, which includes the historical accumulation of all of the networks found at a given period.

The elaboration of knowledge may thus be analyzed from the point of view of energy, in the sense of the channeling of individual energies within the framework of the scenario prescribed by knowledge. The organization inscribed in the scenario is made exactly equivalent, through the notion of entropy, or, more precisely, of its opposite, neg-entropy. The sociocognitive construction of the theory of mind perfectly demonstrates that organizational growth. In this case, energy is embedded within new concrete behaviors, new neural connections induced by the theory of mind as if matter was created from thought.

#### *Unifying Physics of Inert Bodies and Laws of Culture: A Global Model for Body Insertion within Culture*

The energy equation may be calculated from the organization of networks of associated events. Everything takes place as if our bodies were obeying the laws of the development of an expanding organization, making human behaviors compatible, because they are inscribed within a scenario in which everyone is a model of a human — or supra-human — entity, unique in construction. The laws of science are thus inscribed in a wider logic, which is that of the culture, insofar as it controls science.

The fractal theory allows us to calculate the organizational energy incorporated in a fractal structure, according to the laws of information. This theory includes both the energy of classical physico-chemical associations included in the map — for example the chemical mechanism by which naltrexone is opposed to endorphins — and the organizational energy linked to bioinformation. So the laws of the physics of inert bodies and the laws of the culture

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<sup>11</sup>We know that there is a relationship between fractal structure and organizational energy, linked to the elaboration of the structure. For example, a glass breaks into pieces of different sizes, connected by a fractal structure which disperses maximum energy in minimal time.

— of the organization created by humankind — are to be found in the same model, in accordance with the unifying theory of entropy–organization.

It is the fractal hierarchical model of the functioning of the body which may replace the former cybernetic models of the hierarchy regulating the cell, the organs and, finally, the body, the objectives of each of these elements being controlled at the higher level (Anderson, 2000). The functioning of the body is controlled by a fractal logic, distributing tension and relaxation within different preceding elements, in order to respond harmoniously to nature and to other people. Is it not possible to consider health as a state of well-being, a consequence of the harmonious circulation of organizational energy? In our model, the functioning of a cell or of an organ, according to the laws of medical science, is simply a subgroup of the system. This subgroup has to do with that aspect of the functioning of the body which may be isolated from the rest, “translated” into what Latour (1987; Latour and Woolgar, 1979) calls a laboratory (a simplified society).

#### *Beyond Causality: Logic of Abolished Times and Chaos*

An event can be analyzed in the same way at many levels of precision which in physics is known as degree of resolution. We have seen that with fractal relativity time can be put aside according to the scale. Causality in science attributed to an event (for instance, excess of endorphins in the brain) may thus appear with associated keywords as an equilibrium between centrality and density rank value of the cluster associated to that event, regardless of time. We may postulate that fractal modelling could be the ideal tool for linking micro-processes at the scale of the thought to macro-mechanisms at the scale of the human body. Such micro-processes were formerly attributed to quantum mechanisms or were sometimes studied in the frame of Einsteinian (not fractal and not compatible with quantum mechanics) relativity in which hypothetical particles such as “tachyons,” “mindons,” or “psytrons” having no weight, travel faster than light, as if time was abolished. The fractal linkage allows the same explication at micro and macro levels without having to choose between quantum mechanics and relativity or leaving the boundaries of certified science. Within definite space time, for instance the space time of any object taken here and now and as an isolated object, time is abolished (Nottale, 1998).

The logic of the fractal model is very different from the logic of classical causality. It is a logic of chaos. A small object linked to an event can have great consequences if it activates the same form at different levels. Love at first sight is an example of this kind of process. Advertising campaigns preceding and following movies for children where the same figures appear as toys, as book heroes, and on food boxes are other examples of fractal pro-

cesses. But since the materialist conception of health does not take into consideration the self-realization of the subject *via* the cultural responsibility for illness, the human subject protests, as some of the following research shows.

### *A Fractal Model of Unconscious*

Consciousness, as it could be described through this model — the kind of self constructed through scientific knowledge — would be composed of fractal associations moving in the fractal space of associations created by other human beings.<sup>12</sup> The “fractal unconscious” expresses the same organizational dynamic. It constantly projects giving–receiving roles according to human experience at every level of the fractal trees, including their rooting, thus moving back and forward in time. Dreams may be witnesses of this logic: they represent the integration conflicts of our actions within the vast anthropological scenarios of the culture in which they would normally belong. This way of thinking does not define the unconscious as the place where our instincts are strictly repressed, to such an extent that our dreams would represent unsatisfied desires, with no cultural interaction other than that of finding signifiers. Dreams are complex constructions, the consequence of interactions between different cultural structures, one assimilated by the subject, and the other governing the global culture, without the subject’s being aware of this.

### *Development of and Access to the Cultural Scenario*

The elaboration of scientific knowledge, within the framework of biocognition, provides us with a model for the construction of culture in general, when culture is built upon mutual understanding, and not upon coercive law. Each human being manages her resources in energy according to a global cultural scenario, based on the fragments she has access to.<sup>13</sup> Just as the researcher’s curiosity leads her to give up her own culture in order to construct another culture, one more complex, the child can not remain structured simply by the culture she shares with her mother, in relation with the primitive harmony of their bodies. According to biocognitive epistemology, the psychophysical functioning of the mother and child is in relation with an integrated bioinformation field. The functioning of the bodies is regulated by synchronized phases of tension and relaxation, of which breast feeding pro-

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<sup>12</sup>This is similar to the theory of waves of forms, where the form underlying every event makes the repetition of this event more probable.

<sup>13</sup>Mirror neurons precisely make possible the elaboration of a single cultural scenario.

vides the model, a mechanism which, at the emotional and cognitive level, is sometimes referred to as "attunement." So, childhood attunement prefigures the language and thought to come.

The undifferentiated thought of the child within the bioinformation field is going to become differentiated. This differentiation is made necessary by the development of the body's autonomy, by its difference with the mother's body: subjective states and objects will be distinguished in the same way as the researcher produces new knowledge by separating objects from himself. For example, toilet training (a "clean body") will thus be acquired through articulating internal sensations induced by digestion with the mother's behavior and the meaning she attributes to this cleanliness — either a step towards autonomy, or, to the contrary, an annoyance produced by the child, reminding the mother of her own difficulties with her body when toilet training was imposed too soon on her.<sup>14</sup> A general form or relational pattern may thus lay behind this process, like gift and counter-gift interaction or educative coercion, etc.

Nevertheless, it is the absences of the mother which lead the child to develop the idea of the mother existing. This construction, analyzed by Piaget as a way for the child to build reality, may be analyzed in an opposite manner as a way for the child to build identity and permanence whatever the context (Varela, 1979). In the same way, sickness and death may be regarded not as accidents to be eradicated some day, but, on the contrary, as contributing to the realization of the self (Van Eersel, 1997). Sexual differentiation is also acquired, along with the question of seductiveness, which transforms this difference into complementarity, and puts something at stake. In order for "one person's desire to be identified as such by the other person's desire" a cultural scenario must be shared. We develop our personalities through what we think others think of us.

We develop a representation in order to change a cultural theory according to which the fusional relationship within the bioinformation field moves within a (cultural) imaginary scenario. The fusion of bodies will once more join the fusion of minds in adulthood, with the advent of genital sexuality. The functioning of our body, in its interactions involving giving and receiving, is henceforth regulated, according to an educational logic, by cultural rules. The economics of energy (eating, feeding, dressing, etc.) concerning physical exchanges are inscribed within a social organization. Each adapta-

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<sup>14</sup>It is in this way, according to Françoise Dolto (1981), that a child, toilet trained, but without mastery of his sphincter, may have acquired this ability under hypnosis, i.e., by identification with his mother. In this case the muscles called upon for the elimination of intestinal waste relax under the influence of supervision and are imagined to be the mother's, and so interiorized. This deprives the child of a part of his own body.

tion supposes a transfer cost in energy: inhibition of an acquired behavior (until that moment in energy equilibrium with the environment), to the benefit of a new behavior, corresponding to a superior energy equilibrium.<sup>15</sup>

In the same way when, as an adult, one adapts oneself to a new culture, voluntarily assuming a new role supposes a cost in energy, which varies as a function of the difference between this role and the formerly acquired roles within the frame of the economics of energy in both cultures. It is the simultaneous awareness of several possible cultures to create this shared awareness, as well as social roles from this awareness, based on a logic of gifts and counter-gifts, which account for a common humanity.<sup>16</sup>

To adopt a culture is therefore to gain access to a common representation of the laws of the world and of humanity, each of us being a model of the same person. The doctor helps her patient to fully recover his capacities for life, as an individual, another model of himself. In the same way, the patient permits the doctor to give much more than what may be given by an ordinary citizen. In this way, culture, or what more strictly speaking may be termed scientific culture, increases our creative possibilities through action on nature and other people. We may be rewarded for our actions according to the laws of market or we can reach gratification in a more subjective way, through gift transaction mechanisms which involve identification with the others while at the same time conserving of one's own identity. This logic of gift and counter-gift, observed in many traditional societies, leads to many rich possibilities — to increased creativity, increased meaning of life.<sup>17</sup> Since we have increased capacity to help others in more versatile ways, others gain the capacity to help us in return. This provides a growth of alternative biocognitive associations ruling the body and consequently an increased probability to maintain correct working of the body in general. Lastly, the

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<sup>15</sup>When the culture is coercive, energy accumulates in conflictual nodes in the associative network.

<sup>16</sup>The result is that a “reprogramming of the self” is scarcely possible simply through intellectual effort, since mental activity has inhibited precisely all the paths which would have resulted in a different program. This reprogramming supposes that the subject has had a chance to find himself concretely in situations contrary to his programming, so as to modify his bodily make-up, to be able to make the functioning of his body slowly change, according to a fractal logic. This is the case, for example, in paradoxical therapies, where the symptom is prescribed (Watzlawick, Helmick-Beavin, and Jackson, 1967).

<sup>17</sup>Unless taking part in the market or creating a new market may mean creating real social links as *culture* in the spirit of free enterprise. Culture may be defined as the realm of gratuity like arts, gift and counter-gift. For a theory of impossible market without preceding culture, see Rifkin (2000).

same law of increasing organization could account for the growth of scientific knowledge and personal health.<sup>18</sup>

*An Application: Healing in Modern Societies*

According to the model, healing can be regarded as cultural as well as natural. Attributing an illness to a natural accident, as posited by medical science when it transforms a body into an a-relational laboratory event, is restrictive. The placebo effect demonstrates the role played by the senses. Instead of considering the placebo effect as a parasite on the mechanisms observed in the laboratory, it would be more judicious to consider the effect as complementary to these mechanisms.

In order to show the cultural influence on giving birth, we analyzed the discourse of pregnant women in the same way as the scientific articles in the field of autism: we identified the actor networks structuring the women's feelings (sensations) about birth by studying the logic of keyword associations in their discourses. Our study concerned 26 pregnant women, some of whom were "fragile" women (defined by several indicators like feelings of ambivalence, couple difficulties, little mention of baby, etc.) and we interviewed them before and after childbirth (Courtial and Le Dreff, 2003). Among other results, the actor network structured around the use of an ultrasound scanner showed that women in a fragile condition experienced more anxiety than comfort from its use. The women required intense reassurances from their physicians. More generally, through the medicalization of childbirth, a surprising actor network appears: although feeling secure, the mother is at the center of so many "orders" that she no longer feels she created her child.

According to biocognitive logic, as interchangeable human beings, subject to the same laws, we are exposed to the same associations.<sup>19</sup> We desire what the other desires and therefore the other becomes both model and obstacle leading to mimetic rivalry and mimetic violence, processes that religions have tried to control (Girard, 1996). We still have one resource not possessed by the animals: through/in our minds we are able to imagine ourselves in the place of others. This leads to the creation of culture and scientific knowledge which may be considered as a particular form of culture.

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<sup>18</sup>If it happens that we succeed at a given time to create this organizational structure of the total compatibility of the self with all, the associations may immediately extend to infinity. We may have, with this fractal speed involving so many associations, a feeling of time abolished. Love brings us nearer such sensations, as well as do certain social rituals, such as religious ceremonies and commemorations.

<sup>19</sup>Namely as a consequence of mirror neurons.

### Conclusion

Analyzing the construction of scientific knowledge with fractal tools within the framework of biocognitive epistemology and recent works in the sociology of science has lead us to suggest a model for science as culture and for the construction of culture in general. Words are at the nodes of a model of association from which natural laws and cultural consciousness of human beings flow. It is within the framework of this model that natural laws embedded in the social context of their construction can be regarded as organizations. Simultaneously, a co-construction of our self and context emerges.

Elaborated by the culture creating a shared awareness of the world, an encounter between humans is possible. This dynamic is thus cumulative from one human being to another, and gives access to the sum of human experience. We participate in a cultural scenario in which we can play all the roles, but we have to create a singular role for ourselves. So it is up to us to create this singular role, feeling at the same time that we could also be all others, according to circumstances. A culture based on these principles like scientific culture may be very strong in relation with its complexity, leading to a great variety of roles according to circumstances. We can then derive an extraordinary creativity or organization (form of energy opposed to entropy) capacity from others, far superior to that resulting from medical and psychological theories based on the economy of the isolated subject. We can fight against cancer by our relationship with others, just as we can let ourselves be vanquished by it, as a consequence of too great a relational solitude.

### References

- Anderson, C.M. (2000). From molecules to mindfulness. *Consciousness and Emotion*, 1, 193–226.
- Bailón-Moreno, R. (2003). *Ingeniería del conocimiento y vigilancia tecnológica aplicada a la investigación en el campo de los tensioactivos. Desarrollo de un modelo cientimétrico unificado*. Doctoral Thesis, University of Granada, Granada, Spain.
- Bailón-Moreno, R., Jurado-Alameda, E., Ruiz-Baños, R., and Courtial, J.P. (2005a). Bibliometric laws: Empirical flaws of fit. *Scientometrics*, 63, 209–229.
- Bailón-Moreno, R., Jurado-Alameda, E., Ruiz-Baños, R., and Courtial, J.P. (2005b). The unified scientometric model: Fractality and transfractality. *Scientometrics*, 63, 232–257.
- Bailón-Moreno, R., Jurado-Alameda, E., Ruiz-Baños, R., and Courtial, J.P. (2005c). Analysis of the scientific field of physical chemistry of the surfactants with the unified scientometrics model: Fit of relational activity indicators. *Scientometrics*, 63, 259–276.
- Baron-Cohen, S., Leslie, A.M., and Frith, U. (1985). Does the autistic child have a “theory of mind”? *Cognition*, 21, 37–46.
- Callon, M., and Courtial, J.P. (1995). La scientométrie au service de l'évaluation. In M. Callon, P. Laredo, and P. Mustar (Eds.), *La gestion stratégique de la recherche et de la technologie* (pp. 177–235). Paris: Economica.
- Callon, M., Courtial, J.P., and Laville F. (1991). Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemistry. *Scientometrics*, 22, 155–205.



- Callon, M., Courtial, J.P., and Penan, H. (1993). *La scientométrie*. Paris: P.U.F.
- Callon, M., Courtial, J.P., and Turner, W. (1991). La méthode Leximappe: Un outil pour l'analyse stratégique du développement scientifique et technique. In D. Vinck (Ed.), *Gestion de la recherche* (pp. 207–277). Bruxelles: De Boeck.
- Callon, M., Law, J., and Rip, A. (1986). *Mapping the dynamics of science and technology*. London: MacMillan.
- Courtial, J.P. (1992). *Introduction à la scientométrie*. Paris: Anthropos Economica.
- Courtial, J.P. (2001). Cognition in language use: Pointing out relational structure of scientific texts. *Metalinguistica*, 9, 93–112.
- Courtial, J.P. (2003). Analysis of scientists social representations in action based on words associated by scientific articles. *European Review of Applied Psychology*, 52, 221–230.
- Courtial, J.P., and Gourdon, L. (1999). Mapping the dynamics of research on autism or the cultural logic of science. *Theory and Psychology*, 9, 579–604.
- Courtial, J.P., and Le Dreff, G. (2003). Analyse de récits de femmes enceintes. *Santé Publique*, 16, 105–122.
- Courtial, J.P., and Remy, J.C. (1988). Toward the cognitive management of a research institute. *Research Policy*, 17, 225–233.
- Courtial, J.P., Sigogneau, A., and Callon, M. (1997). Identifying strategic sciences and technologies through scientometrics. In W.B. Ashton and R.A. Klavans (Eds.), *Keeping abreast of science and technology* (pp. 337–372) Columbus: Battelle.
- Dolto, E. (1981). *Au jeu du désir*. Paris: Le Seuil.
- Garfield, E. (1981). *ISI atlas of science: Biochemistry and molecular biology*. Philadelphia: Institute for Scientific Information.
- Girard, R. (1996). *The Girard reader*. New York: The Crossroad Publishing Company.
- Guillaume, P. (1937). *La psychologie de la forme*. Paris: Flammarion
- Feldmann, J.A., and Ballard, D.H. (1982). Connexionist models and their properties. *Cognitive Science*, 6, 205–254.
- Kegan, R. (1982). *The evolving self*. Cambridge: Harvard University Press.
- Kuhn, T. (1970). *The structure of scientific revolutions*. Chicago: University of Chicago Press.
- Latour, B. (1987). *Science in action. How to follow scientists and engineers through society*. Cambridge: Harvard University Press.
- Latour, B., and Woolgar, S. (1979). *Laboratory life: The construction of scientific facts*. London: Sage.
- Mandelbrot, M. (1977). *The fractal geometry of nature*. New York: Freeman.
- Martinez, M.E. (2001). The process of knowing: A biocognitive epistemology. *The Journal of Mind and Behavior*, 22, 407–426.
- Mialet, H. (1994). *Le sujet de l'invention*. Doctoral Thesis, University of Paris I (Sorbonne), Sociology Department, Paris, France.
- Michael, M. (1996). *Constructing identities*. London: Sage.
- Nottale, L. (1996). Scale relativity and fractal space–time: Applications to quantum physics, cosmology and chaotic systems. *Chaos, Solitons, and Fractals*, 7, 877–938.
- Nottale, L. (1998). *La relativité dans tous ses états*. Paris: Hachette.
- Rifkin, J. (2000). *L'âge de l'accès*. Paris: La Découverte.
- Schneuwly, B., and Bronckart, J.P. (1985). *Vygotsky aujourd'hui*. Lausanne: Delachaux et Niestlé.
- Shanon, B. (1993). Fractal patterns in language. *New Ideas in Psychology*, 11, 105–109.
- Van Eersel, P. (1997). *Réappropriation la mort*. Paris: Albin Michel.
- Varela, F. (1979). *Principles of biological autonomy*. New York: Elsevier.
- Watzlawick, P., Helmick–Beavin, J., and Jackson, D. (1967). *Pragmatics of human communication: A study of interactional patterns, pathologies and paradoxes*. New York: W.W. Norton.