The Semantic Sphere 1

Computation, Cognition and Information Economy

Pierre Lévy

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1 Information Economy Meta Language.

Chapter 1

General Introduction

A participatory digital memory common to all humanity is on its way. But at the beginning of the 21st Century, the use of this memory is limited by problems of semantic opacity, incompatibility of classification systems, and linguistic and cultural fragmentation. Lacking computable models, we are unable to automate most cognitive operations of analyzing, filtering, synthesizing and interconnecting information so as to take full advantage of the huge mass of data available. We do not yet know how to systematically turn this ocean of data into knowledge, and still less how to turn the digital medium into an observatory that reflects our collective intelligence. The primary goal of this book is to present to the scientific community and the informed public a new system for encoding meanings that will allow operations on meaning in the new digital memory to become transparent, interoperable and computable. This system of semantic coding is called IEML (Information Economy Meta Language). Its use could help eliminate the obstacles that now impede the optimal exploitation of the digital medium to serve human development in its social and personal dimensions. If a dynamic community of semanticists and linguists were to enrich and develop this language, a group of engineers were to program and maintain a collection of software tools exploiting its computational potential, and a critical mass of users and social media were to take possession of these tools, I believe we would have embarked on a new scientific, technical and cultural path leading in the long term to a significant enhancement of human cognitive processes.

In this book I will show that there is no scientific, technical or ethical reason preventing us from using a calculable symbolic system such as IEML on a broad scale. Just as there are *impossibility* theorems in mathematics (the most famous of which is probably that of Gödel), I will provide what I believe to be mathematical proof – accompanied by solid technical and philosophical arguments – that a new *possibility*, unsuspected by previous generations, is now opening up for the human mind.

IEML is one of many formal languages that exist today. Its originality and value lay in the fact that all its valid expressions model semantic circuits for channeling information flows. The IEML semantic sphere is a huge, coherent, calculable graph that connects all these circuits and can therefore be used as a system of coordinates for the common digital memory that is being created.

This general introduction is organized in three main sections. Section 1.1 presents the coherent vision that has gradually crystallized over the many years I have devoted to constructing IEML. Section 1.2 recounts, in the first person, my journey of discovery, the intellectual adventure that led me to develop the metalanguage. Finally, section 1.3 summarizes the result of that adventure, a result that I believe meets the challenges of my vision.

1.1. The vision: to enhance cognitive processes

In conceiving the IEML semantic sphere, I was responding to three closely interdependent challenges: a strictly semantic imperative, an ethical imperative and a technical imperative.

1.1.1. *The semantic imperative*

The immediate goal of IEML is to solve the problem of semantic interoperability – the "digital chaos" resulting from the multitude of natural languages, classification systems and ontologies. IEML functions as a "bridge language", an addressing system for concepts that is capable of linking different systems for classifying and organizing data that would otherwise be incompatible. I am well aware that the very idea of a universal system for encoding meaning can conjure up the worst images of totalitarianism, or at least the potential impoverishment of the diversity of meanings. I would therefore like to remind the reader that digital sound encoding and the use of universal file formats for recording music has in no way standardized musical messages, but rather has increased the diversity of productions, variations, mixes, exchanges and explorations in the world of music. In the same way, far from standardizing the world of icons, digital encoding of images by means of pixels[1] has stimulated computer-assisted production, automated processing and open creation

1 Generally speaking, a pixel is a set of five numbers: position on the X-axis, position on the Y-axis, quantity of blue, quantity of red, and quantity of green.

and distribution of images of all kinds. Finally, digital encoding of the letters of the alphabet is the basis of all word-processing programs, and no one has ever claimed that these programs limit the freedom to write. Using an open, collaborative dictionary, a set of basic recombinable operations and a practically infinite transformation groupoid, the IEML encoding should present any determinate meaning as a *moment* in a whole range of cycles of transformation, a *node* within a multitude of networks or a *figure* that only appears as such against a background that can be explored infinitely. That is to say, the inscription of a concept in the semantic sphere will have the effect of opening up its horizons of meaning rather than closing them.

The IEML semantic sphere is an intellectual protocol for expanding the possibilities for interpretive dialog around a common digital memory. This dialog should be understood as translinguistic, transcultural, transreligious, transpartisan, transdisciplinary and transinstitutional. This is why the semantic topology opened up by IEML welcomes all practical, ontological or philosophical points of view and considers them equally legitimate. The only attitude that is disallowed by this generalized perspectivism is denial of the legitimacy of another person's point of view, refusal of dialog, hermeneutic closure[2].

Its aim is to establish a space that accommodates *in a single system of coordinates* a capacity to make meaning that is virtually infinite in its diversity, so the semantic imperative essentially necessitates maximum multidirectional openness, or "equanimity". Thus it is not necessary to believe in the philosophical principles that inspired the invention of IEML in order to use it for your own purposes or to benefit from the enhanced individual and collective possibilities for creating and managing knowledge offered by the semantic sphere. But there is a caveat! I am not claiming that all semantic architectures that can be built in IEML are equally valid, or that everyone has to accept the perspectives of others. The semantic imperative assumes only two elementary dialectical principles: first, that all interpretations are in principle equally valid; and second that everyone must accept the right of others to hold points of view different from his or her own. Indeed, individuals and communities that decide to use IEML will be able to choose goals, objectives, sizes and degrees of transdisciplinarity or transculturalism that are as varied as they like. Only specialists in semantic engineering will have to be united by a common mission: to maintain and expand the hermeneutic equanimity of the semantic sphere.

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2 Hermeneutics is the art of interpretation. Hermeneutic closure (as opposed to hermeneutic openness) should be understood here as the *a priori* exclusion of other interpretations in favor of "the one true meaning" of an event, a phenomenon or a text.

1.1.2. *The ethical imperative*

The best use we could make of the contemporary infrastructure of memory, communication and digital processing would be to serve human development. The goal of human development is a reason of the heart, in the sense that "the heart has its own reasons, of which reason knows nothing"[3]. Rather than deal with each distinct aspect of human development separately (e.g. economic growth, education, public health, human rights, scientific and technical innovation), I propose that we focus our efforts on what a growing community of researchers considers its critical point: knowledge management through a free creative conversation. Knowledge management can be envisaged from two complementary perspectives: first, personal control of information flows with autonomous development of learning strategies; and second, collaborative use of data and sharing of knowledge. A multitude of creative conversations collaborating on indexing the digital data available in IEML and the subsequent use of the information thus produced would make it possible to initiate an autocatalytic virtuous circle between the two aspects – personal and social – of knowledge management. I invented the IEML semantic sphere in the hope of bringing about a socio-technical environment conducive to this creative dialectic.

I am certainly not able at this stage to rigorously demonstrate that a better technology for extracting and refining knowledge based on common digital data will have positive effects on human development. I do, however, sense that the scientific observation of its own functioning in the mirror of a digital Hypercortex will result in the maturation of human collective intelligence. I anticipate that new opportunities for collaborative learning and the expansion of individual intelligence will result from this new situation.

1.1.3. *The technical imperative*

As humanity is a social species with a highly developed ability to manipulate symbols, the availability of automata capable of increasing our capacity to process symbols, coupled with telecommunications and the large-scale storage of information, presages a huge transformation. The inevitable global cultural metamorphosis, of which we have only seen the timid beginnings as we enter the 21st Century, will necessarily extend over many generations. A philosophy that is concerned with fostering cultural creativity in this new technocultural environment thus has an interest in avoiding looking at the digital transformation through the wrong end of the telescope (sector by sector) or in the rear-view mirror of institutions and concepts suited to the era (now past) of static writing systems and one-way communication.

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3 Blaise Pascal, *Pensées*, 1670, fragment 277; translation.

The technical imperative of my philosophy may be formulated as follows: let us automate the symbolic operations that increase cognitive capacities as much as possible and thus in the end enhance the power and autonomy of individuals and communities. I would like to point out that the automation I am speaking of here is not limited to logical reasoning and statistical analysis. Ideally, it encompasses other cognitive processes, particularly those involving huge quantities of data: management and filtering of information flows, simulations of complex processes, perception of analogies, creative synthesis, discovery of blind spots, questioning of established models, etc. This technical imperative induced me to seek as much benefit as possible from the growing power of the automation of symbolic operations, even if this meant to some extent anticipating the calculation, memory and transmission capacities that will be available to future generations. In any case, the transparency of thought processes to calculation – in other words, the emphasis on computational models of cognition – is a cognitive scientist and programmer's ideal that users of IEML are obviously not obliged to share with me in order to take advantage of the practical benefits of the research program proposed here[4].

1.2. A transdisciplinary intellectual adventure

1.2.1. *The years of training, 1975-1992*

The IEML semantic sphere is the result of a long quest, the main stages of which I would now like to recount. I have decided to present this brief intellectual autobiography only because I think it may help my readers to better understand my purpose.

At a very young age, I was interested in the natural sciences, in particular cosmology. I was also fascinated by what was then called cybernetics and "electronic brains". I have maintained these two interests. I went into the human sciences, however, and after a short time in economics I took a university course in history. In the 1970s, Paris offered students a rich intellectual landscape. The French school of history, known as the Annales school, initiated by Marc Bloch and Lucien Febvre and so admirably exemplified by Fernand Braudel and Georges Duby, was at the height of its productivity. Structuralism in anthropology, championed by Claude Lévi-Strauss, was still a powerful intellectual current, and it was used by Roland Barthes to analyze the present. At that time the works of Michel Foucault, Gilles Deleuze and Jacques Derrida were already providing a stimulating counterpoint to

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4 To avoid any misunderstanding, I want to say that I do not believe it will ever be possible to make the entirety of human cognitive processes transparent to computation; rather, it is a question of slightly expanding the surface area of the rafts of discursive reflexivity and formal modeling that float on the vast chaotic ocean of reality.

structuralism. In the excitement following May 1968, all kinds of Marxist, Freudo-Marxist and Sartrian schools, as well as the Frankfurt school, were putting forward their points of view. To understand communications and the media, I read Marshall McLuhan, Guy Debord and Jean Baudrillard. Through Edgar Morin, I discovered systems theory, theories of self-organization and constructivist epistemologies. In the exact sciences, I had immense intellectual respect for the mathematics of Bourbaki. The young field of molecular biology convincingly explained the mechanisms of evolution and the functioning of organisms; I was particularly impressed by the "cybernetic" form that Jacques Monod gave to biology by bringing information theory into the heart of the living cell[5]. Debating with Jacques Monod, Illya Prigogine and Isabelle Stengers led me to discover in the *Order out of Chaos* (1984)[6] an evolving, complex, indeterminate and self-organizing nature, a thousand miles from a dead mechanism swinging between chance and necessity.

It was with Michel Serres, who was then teaching the history of science at the Sorbonne, that I really discovered the beauties of philosophy – and the freedom to think. During the many years I attended his seminars, Michel Serres made me understand the complexities and multiple resonances of theories of information and communication as well as the subtle – but profound – connections between the human sciences and the natural sciences. The author of a monumental thesis[7] on Leibniz's *Monadology*, he transmitted the living spirit of philosophy and Leibnizian encyclopedism to me.

In a course on practical methodology devoted to the use of databases for historical research (taught by Jean-Philippe Genet), I was struck by the transformation of work methods and the increased intellectual rigor that using computers required[8]. I discovered that the computer was not "just a tool": it was above all an intellectual technology whose use transformed cognitive processes. Moreover, *The Computerization of Society* (1981), by Simon Nora and Alain Minc[9], which was launched at the same time as Minitel, opened my eyes to what seemed to me at that time one of the main cultural changes my generation – and the generations following!–would experience. This double shock made me decide to do my Master's thesis with Michel Serres on the subject of communication, teaching and knowledge in a computerized society (quite surprising for an apprentice historian in the late 1970s).

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5 For example, in *Chance and Necessity* [MON 70].

6 See [PRI 78].

7 *Le Système de Leibniz et ses Modèles Mathématiques* [SER 1968].

8 At the time, we were still feeding perforated cards into huge computers housed in refrigerated rooms, which after weeks of waiting gave us answers on almost illegible printouts.

9 [NOR 1981].

After my studies in history at the Sorbonne, I enrolled in a doctoral program in sociology at the École des Hautes Études en Sciences Sociales (EHESS), with Cornelius Castoriadis, whose book *The Imaginary Institution of Society* I had just read[10]. Castoriadis was a philosopher, economist and psychoanalyst. When I joined his seminar, he was doing a complete rereading of the Greek sources of Western thought. The first paper I did with him, which was published in part in the *Esprit*[11] journal, was a meditation on the cultural dimension of computers. When I think back to it today, two important ideas remain:

– first, that the automatic manipulation of symbols was the result of an ancient philosophical and scientific quest going back at least to Aristotle; and

– second, that the computerization of society and the global interconnectedness of computers – which were already becoming apparent in the late 1970s and early 1980s – showed that the movement of conquest of nature and exploration of the planet that had marked the modern era was turning back on itself and the new frontier was now the cognitive inner life of our species.

I knew then that these questions would occupy me for many years to come. But I did not feel ready to take them on without a solid philosophical education. That is why I decided to do my doctoral thesis (again with Castoriadis) on the idea of freedom in antiquity, which gave me the opportunity to do a close reading of the great Greek and Roman texts and the commentaries on them. Philosophically, that thesis, which was subtitled "L'un et le multiple" [The one and the many], centered on *the problem of open unity*. Was freedom essentially openness to multiplicity, or was it a unity forged in independence and autonomy? Or was it, rather, something like a dialectical balance between these two moments? And could openness to multiplicity be conceived outside a universality capable of containing it without constraining it?

At the beginning of the 1980s, shortly after I defended my thesis, I participated, with Jean-Pierre Dupuy, Pierre Livet, Francisco Varela and Isabelle Stengers, in a collective research project organized by the CREA (Centre de recherches sur l'épistémologie appliqué) of the École Polytechnique on the origins of the idea of self-organization. In the cybernetic area, I was specifically responsible for studying the work of Warren McCulloch[12], the first researcher to present a mathematical formalization of neural networks, and Heinz von Foerster[13], a pioneer of artificial

10 See [CAS 1998].

11 "L'informatique et l'occident" *Esprit*, July 1982, pp. 41-69.

12 McCulloch's main articles have been collected in *Embodiments of Mind*, [MAC 1965], see my article "L'oeuvre de Warren McCulloch" [LÉV 1986b].

13 The main articles by von Foerster have been collected in *Observing Systems* [FOE 1981]. See my article "Analyse de contenu des travaux du Biological Computer Laboratory" [LÉV 1986a].

life[14] and proponent of a radical constructivist epistemology. This was the beginning of my immersion in the cognitive sciences, connectionist models and artificial intelligence. *Neuronal Man*, by Jean-Pierre Changeux, came out in 1983[15] and the relationship between the mind, the nervous system and automata that manipulate symbols was being passionately discussed by a broad international community of researchers. Although I recognized the general relevance of the research program in cognitive sciences and the huge impact of the invention of the computer[16] on intellectual technologies, I was not able to convince myself that mechanisms operating step-by-step on the physical states of electronic circuits could reproduce, in the strong sense of the word, the inner experience of phenomenal consciousness, memory and linguistic meaning characteristic of human experience. My first book, *La Machine Univers* (1987)[17], looked at a tension between language and calculation that in many respects corresponded to the opposition between hermeneutic tradition in the human sciences and the pan-computational approach of the most extreme currents in cognitive sciences. The question of the *calculability of human language* was from then on present in the background of all my work and would not leave me until I found – in IEML – a satisfactory solution to it.

Shortly after the publication of *La Machine Univers* in the late 1980s, I spent two years in Montreal as a visiting professor in the communications department of the Université du Québec à Montreal (UQAM). It was there, thanks to the laboratory established by Gilles Zénon Maheu[18], that I discovered the nascent world of hypertext and interactive multimedia. While I was making a practical exploration of software for creating hypertext, I was rereading *A Thousand Plateaus*, by Deleuze and Guattari[19], and I was struck by the analogies between the philosophical concept of the rhizome and the new forms of network writing (of which Deleuze and Guattari were not then aware, as they later told me). I saw hypertext as a textual machine that could profoundly change writing, and therefore thought. In 1990, I began to dream of a hypertextual philosophical system illustrating the concept of open unity. In this ideal system, there was a graph of interdependent concepts in which any continuous path between nodes was accepted as legitimate. There was no longer absolute basis, foundation or beginning. Nor were there any final concepts or concepts converging toward an end point. Dictionaries, encyclopedias, indexes,

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14 As expressed in the name of his laboratory at the University of Illinois: the Biological Computer Lab.

15 [CHA 1983].

16 See my chapter on the invention of the computer in *Eléments d'Histoire des Sciences*, edited by Michel Serres [SER 1989] p. 515-535.

17 [LÉV 1987].

18 See http://www.medias-interactifs.uqam.ca/historique.html.

19 [DEL 1987b].

systems of pointers and open works[20] of all kinds clearly had not waited for digital hypertext to present free circuits of reading in documentary networks. I imagined a more systematic form, however, making maximum use of computational technology: a machine that generated hypertext. I also envisaged the hypertext universe generated by such a machine as an all-encompassing environment that would present every exclusive philosophy, every specific ontology, as a partial point of view that complements other viewpoints. The conceptual matrix for that machine remained to be found.

Two books were born of my first stay in Quebec. The first one, *Les Technologies de l'Intelligence* (published in 1990, before the Web!), predicted the merger of computer networks and hypertext networks. It also explored the concept of cognitive ecology, which I conceived as a self-organized emergence based on a combination of biological possibilities, cultural forms, social networks and intellectual technologies. This concept was very close to what, in 1994, I would call collective intelligence. The second book, *De la Programmation Considérée Commeun des Beaux-arts* (1992), was rooted in my own practice of knowledge engineering for the production of expert systems. My colleague at UQAM, management professor Jacques Ajenstat, had given me the opportunity to work with people in youth protection to develop an automated system for sharing their knowledge with novices. I had also worked with the Geneva entrepreneur and cultural activist Xavier Comtesse on a methodology of knowledge engineering based on several concrete cases of incorporating informal knowledge into software. At this time, there were still very few people talking about knowledge management[21]. I was thus able to experiment firsthand, and without too many theoretical prejudices, with the major reorganization of cognitive ecologies resulting from the partial automation and media encapsulation of tacit knowledge. Rather than the pair of opposites *implicit/explicit*, I used *procedural/declarative*, which was supplied by cognitive psychology and was also suggested by the *declarative rules* called for by the technology of expert systems. I mainly focused on the creative epistemological, cultural and social restructuring of knowledge architectures resulting from computerization.

When I returned to Europe at the beginning of the 1990s, Xavier Comtesse, Antonio Figueras and Eric Barchechat (who had a grant from the European Union) gave me the assignment of thinking about what a writing system designed especially for computer media could be. Alphabets, which represent the *sounds* of speech, were invented at the turn of the first millennium before the Common Era in a media

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20 See Umberto Eco, *The Open Work* [ECO 1989].

21 The famous book by Nonaka and Takeuchi, *The Knowledge-creating Company,* which was the basis of this new field and makes a distinction between tacit and explicit knowledge, only dates from 1995 [NON 1995].

environment in which audio recording did not exist. But in contemporary culture, which is dominated by interactive multimedia representations, instantaneous telecommunications and automatic manipulation of symbols, could we imagine something beyond the alphabet, a form of *animated writing* that would help us to share and collectively organize complex mental models? To draft the plan for *L'Idéographie Dynamique*[22], I had to learn about linguistics, the relationship between linguistic and cognitive sciences, and the complex connections between visual representations (iconic and animated) and language representations of mental models. It goes without saying that, at least in terms of my theoretical education, the invention of IEML owes a great deal to the work I did on dynamic ideography.

At the end of 1991, Michel Serres called on me to assist him with an investigation of open distance learning for the French Government. It was within this framework that, with Michel Authier, we imagined the system of *knowledge trees*[23]. One of our mandates was to validate the informal competencies acquired by individuals outside the education system and official curricula. We designed a software program that visually organized the competencies and knowledge of communities on the basis of people's real learning paths rather than predetermined patterns structured in terms of prerequisites and disciplines (again an example of "open unity"). Our proposition was not adopted by the Government and we decided to develop it in a private company, which was probably France's first start-up in network communications software specializing in knowledge management (KM). In 1992, the Web did not exist and KM was not yet a very established discipline. One of the most interesting results of our approach was the creation of a different knowledge tree for each community, showing the changes in the tree when people left or joined the community. The system could be used for exchanges of knowledge between people and for organizing knowledge management in schools, businesses and associations of all kinds. My experience in the conception and development of knowledge trees brought me closer to the dream of formalizing the world of ideas and knowledge in a computer model without locking that world into a closed, unchanging structure. The knowledge trees dynamically mapped the learning paths and current knowledge of a community, calculated contextual distances between areas of knowledge, and evaluated the knowledge according to various criteria. This calculable model was simply a reflection of the movements of a collective intelligence, allowing for the emergence of new knowledge or changes in the relationships among areas of knowledge. Even better, by giving all members of the community a common image of the knowledge space they created together, the trees allowed all of them to become aware of the collective intelligence in which they participated and their role in its evolution.

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22 See my book *L'Idéographie Dynamique. Vers une Imagination Artificielle?* [LÉV 1991].

23 See *Les Arbres de Connaissances*, by Michel Authier and Pierre Lévy, preface by Michel Serres [LÉV 1992a].

1.2.2. *The years of conception 1992-2002*

1.2.2.1. *The generalized trivium*

It was during the "Serres mission", when thinking about how to represent and organize the elementary units of knowledge or competency, that I had my first intuition of what would become the conceptual matrix of IEML. I was teaching in the education department at Paris-X Nanterre at the time. Exploring the foundations of education theory, I came across the trivium (grammar, dialectic, rhetoric) of Greek and Roman antiquity and the European Middle Ages, which I had already encountered during my classical studies. The trivium was for many centuries the basis of liberal education[24]. Grammar covered the basic abilities of reading and writing (mainly in Greek and Latin) and some familiarity with the corpus of authors traditionally defined as the "classics". Dialectic corresponded roughly to logic, the rules of reasoning and the ability to carry out a well-argued dialog. As for rhetoric, it consisted essentially of the art of composing, memorizing and delivering elaborate, convincing speeches suited to the circumstances and the audience's expectations. It seemed to me that this basic education, which was intended for the ruling classes of ancient societies and the clerics of medieval societies, excluded everything related to technology, the material world and what, in the Middle Ages, were called the "mechanical arts". In addition, the whole area of ethics and relationships among people was only dealt with indirectly, to be left (depending on the period) to philosophy, theology or law. The trivium was essentially only concerned with *signs* and their manipulation. After reading François Rastier's *La Triade Sémiotique, le Trivium et la Sémantique Linguistique* (1990)[25], it occurred to me that the semiotic triad could be used to design an expanded, or generalized, trivium.

The semiotic triad corresponds to the distinction made in modern linguistics between *signifier*, *signified* (for an interpreter) and *referent*. This division goes back at least to Aristotle[26] and it has been discussed and refined through the history of philosophy[27]. For my purposes, I renamed it *sign* (signifier), *being* (interpreter) and *thing* (referent). It should be noted that there can only be a signified or concept in the mind of an interpreter (being) or, from a Platonic perspective, in an intelligible world. The abstract concept is very different from the perceptible sign, since there are many signs (in different languages, for example: apple, *pomme*) that designate

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24 For a remarkable synthetic study on this fundamental matrix of Western culture, see Marshall McLuhan's thesis, *The Classical Trivium: The Place of Thomas Nashe in the Learning of his Time* [MAC 1943b].

25 [RAS 1990].

26 See *On Interpretation* [ARI 1972], p. 1.

27 For Medieval philosophy, see Alain de Libera, *La Querelle des Universaux, De Platon à la Fin du Moyen-âge* [DEL 1996a].

the same concept. It is clear, moreover, that a distinction also has to be made between the concept (a class or general category that can only exist for intelligence) and the referent: you can eat an apple (the referent, the thing) but not the concept of an apple.

In parallel with the classical trivium, which was a preparation for mastering the manipulation of signs, a trivium of beings and a trivium of things still had to be conceived. I thus developed a matrix of competencies with nine cells (with grammar/dialectic/rhetoric on one axis and being/sign/thing on the other axis). In Figure 1.1, the stars represent signs, the little figures represent beings and the cubes represent things, while single icons indicate grammar, double icons indicate dialectic and triple icons indicate rhetoric.

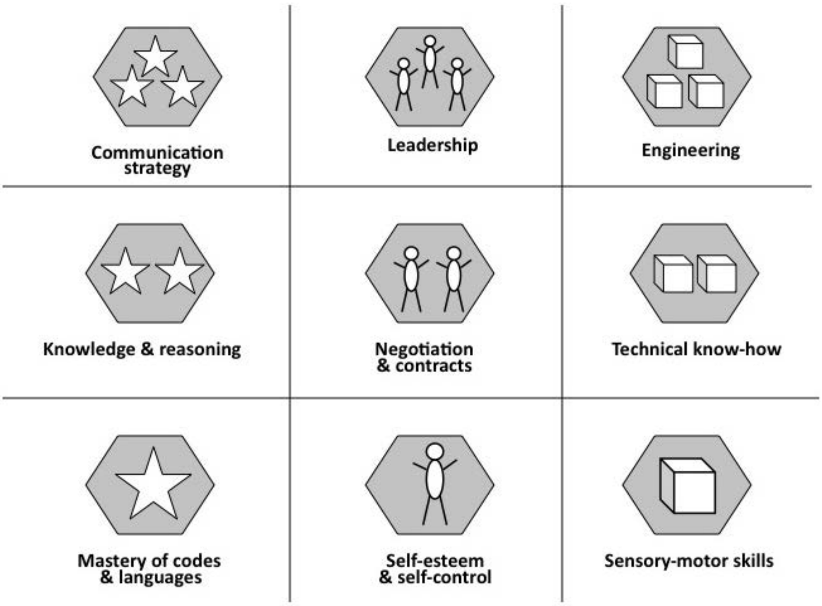

Figure 1.1. *The generalized trivium*

At the level of *grammar* we find fundamental capacities for action, “basic” competencies. But this does not necessarily mean elementary skills; there can obviously be very high degrees of linguistic competency, self-mastery or sensory-motor refinement. Grammatical competencies involve the self. They involve discursive or symbolic power with regard to signs, emotional or affective energies with regard to beings, and physical skills with regard to things.

At the level of *dialectic* we find interactional competencies. In the *signs* column, the grammatical mastery of codes serves knowledge of a wide variety of subjects, reasoning and dialog. In the *beings* column, self-esteem and self-mastery serve egalitarian, mutually respectful relationships with others. Conflicts and divergent interests are settled through negotiation, while agreements and promises are managed contractually. In the *things* column, sensory-motor competencies serve technical know-how involving the manipulation of tools and machines, and the ability to create and maintain concrete environments for life and work. Once again, dialectical competencies are not "medium" competencies between grammar and rhetoric. Each dialectical competency can be distributed on a scale of excellence from minimal to exceptional.

At the level of *rhetoric* we find the capacity to get things done. Communication strategies organize signs and messages so as to accomplish the work of persuasion, reframing (or even deception) as effectively as possible. Leadership, the ability to inspire or direct a group, acts on beings, in particular on their social cohesion. Finally, engineering involves having actions carried out on things, combining mechanisms for a particular purpose. Once again, rhetoric is in no way the "summit" of the competencies since there are obviously many degrees of strategic abilities, from weakness to maximum effectiveness.

My innovation was taking the three complementary functions of signification (the objective aspect) or interpretation (the subjective aspect) and using them for classification. The advantage of this approach is that it recalls the interdependence that is its basis: the clear separation of being, sign and thing is not allowed, since each of the three dimensions of signification necessarily refers to the other two. And grammar, dialectic and rhetoric are equally closely linked and complementary, especially in terms of the balance of competencies within a group. Thus, whenever an economic, social or technical change has a direct effect on one of the nine cells of the matrix, we can predict a reorganization of the eight others. In the knowledge trees, each special competency could be characterized by a certain distribution of intensity (which could be illustrated by degrees of grey) on the nine-cell matrix. This indexation using a generalized trivium made it possible to identify unexpected similarities, complementarities that cut across categories and systemic gaps – which a labeling system limited to the usual classifications of disciplines and occupations would not have brought out.

In addition to the purely empirical and local mapping of the knowledge trees, the generalized trivium made it possible to situate competencies, people and groups against a shared background that permitted comparative analyses. On the basis of an individual or collective diagnosis, it became possible to design learning or development strategies that were more well-founded because they took into account the absence or emptiness of certain areas of competency, while the trees showed only what existed. I had constructed a systematic conceptual structure in the form of a matrix that could be used for any field of knowledge or practice.

For the sake of regularity, this structure did not impose an *a priori* hierarchy or ultimate foundation. It did not dogmatically distribute the substantial and the accessory, or the infrastructure and the reflection. On the contrary, it permitted mapping of concrete situations while highlighting multipolar interdependencies. This was already the germ of the IEML semantic sphere.

1.2.2.2. *Archetypes*

Emboldened by these first discoveries, I wondered about the matrix that would result from placing the *being/sign/thing* triad on both the X-axis and Y-axis. The idea I had in mind was to start from the structure of signification itself in order to create a conceptual matrix that would produce an open, non-excluding hypertextual semantic space. Since all meaning is the product of an interpretation, the general form of the interpretation could not exclude any particular meaning. I then arrived at a new matrix of nine cells (see Figure 1.2).

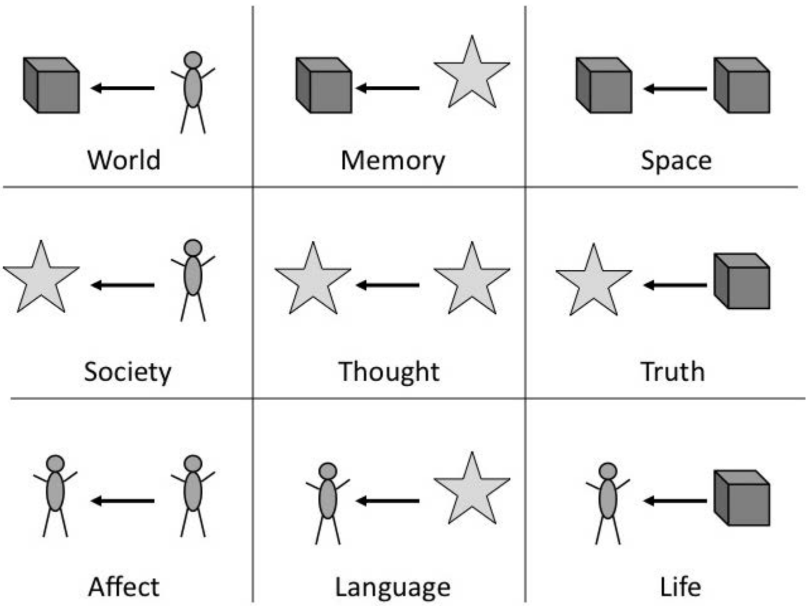

Figure 1.2. *Archetypes*

The signification attributed to these ideograms is the result of the real work of "deciphering". I first constructed my matrix, and only asked myself the question of the meaning of its nine cells afterwards. It was thus not a matter of illustrating concepts already conceived in natural language, but of interpreting in natural language an ideography generated using a combinatory algorithm (as "small" as that algorithm was at that time). To interpret the meaning of the ideograms, I had to first allow myself to be guided by the form and nature of the symbols. I then had to not lose sight of the need to exhaustively map the most varied dimensions of meaning, but in the mode of reciprocal implication or interdependence rather than that of separation. Finally, no concept could be "superior" or "more fundamental" than another.

The work of deciphering led me to think at length about the precise nature of the relationship between primitives that was presented by an ideogram. In Figure 1.2, there is an arrow connecting two primitives from right to left. The primitives read *being*, *sign* and *thing*. But how should the arrow be read? What is the relationship between the symbols? Figure 1.2 shows only one of the many representations I have used over the years. However, through the changes in representation, I have always read my ideograms as representing "implications", enfoldings or envelopments of one symbol by another.

1.2.2.2.1. Comments on the archetypes

In Figure 1.2, *World* must be read as an interpretation of the ideogram "the thing implies or envelops the being". This ideogram represents a small stage on which a universe of purely material things is infused with "human" qualities through naming, evaluation and work. It is this implication in the thing of qualities characteristic of being that constructs a world.

In the following ideogram, "the thing envelops the sign", we see the movement of inscription or recording that "makes" *Memory*.

Space corresponds to a reciprocal envelopment of things in things, i.e. to the construction of a topology or a material space in which every thing is situated in a universe of things.

In the case of the ideogram of *Society*, which shows the sign enveloping the being, we have to imagine a multiplicity of beings, such as a concert or a group of people playing music, with the musical sign playing the role of unifying envelope of the collectivity. This role of the envelope creating society can be played by many other types of signs: totems, flags, languages, laws, contracts, etc.

In *Thought*, the signs envelop each other in deductions, inductions, interpretations, narratives and associations dictated by the imagination.

Truth represents a small stage where the sign implies the thing, i.e. the proposition envelops the fact or the reference.

Affect represents the reciprocal implication of beings, each containing the other in its “heart”, whether in love or hatred.

Language represents the sign enveloped, or understood, by the being: the transformation of sign into message.

Finally, *Life* represents the assimilation of material qualities (the thing) by the being, suggesting incarnation, which cannot be separated from sensation, nourishment and breathing.

It is clear that someone else faced with the same problem of deciphering under constraint would have found a different solution, which would be expressed through other names given to the ideograms. But my interpretation of this matrix had the advantage that nine distinct philosophical points of view could be arranged on it without hierarchy or separation. *Space* could represent the materialist, physicalist or atomist point of view. *Thought* was obviously a good representative of the idealist point of view. *Truth* represented the positivist or logicist inspiration of analytic philosophy. *Language* was the place for the philosophy of language, communication and media. *Society* represented the sociological point of view in general and the interpretation of phenomena in terms of social relationships. *Life* could be the place for a biologistic philosophy and for empiricism (which is based on sensory experience). *Memory* could accommodate evolutionist approaches, but also anything based on writing and tradition. Finally, *World* would present an anthropological approach, in which human culture infuses the cosmos with its order and values. The ideographic matrix I conceived had the advantage of interweaving all these points of view symmetrically.

I had got into the habit of calling these ideograms “folds” and I called the language they made up the “language of folds”, since, as we have seen, the operation of composing the symbols was precisely one of envelopment. Since each of the three primitives could envelop the other two, the primitives could also be seen as envelopes, or at least “balls” of stretchy matter capable of enveloping other “balls”. I then started to refine my model in two directions: first I began to construct envelopments of three terms, and second I tried out envelopments of envelopments, or recursive folds.

1.2.2.3. *Triplication*

The following are three examples of three-term envelopment:

– the thing envelopes the sign in the mode of the sign, which gives the semiotic function *Mark*;

– the thing envelopes the sign in the mode of the thing, which gives the technical function *Container*;

– the thing envelopes the sign in the mode of the being, which gives the social role *Scribe*.

As shown in these examples, the *Mark*, *Container* and *Scribe* each project into their realm (semiotic, technical or social) the original intention expressed by the *Memory* archetype, which indicates conservation and duration. This is how I constructed the operation of *triplication*, or triple envelopment. The term on the *right* in Figures 1.3, 1.4 and 1.5 would be named *substance* at the end of my research. The substance corresponds to the core or the innermost membrane of the envelopment. The term on the left was later called the *attribute*. The attribute corresponds to the intermediate layer of the envelope. Finally, the term above the arrow was called the *mode*. It corresponds to the outside skin of the envelope or the semantic fold. The nine initial archetypes in Figure 1.2 simply have an empty or "transparent" mode.

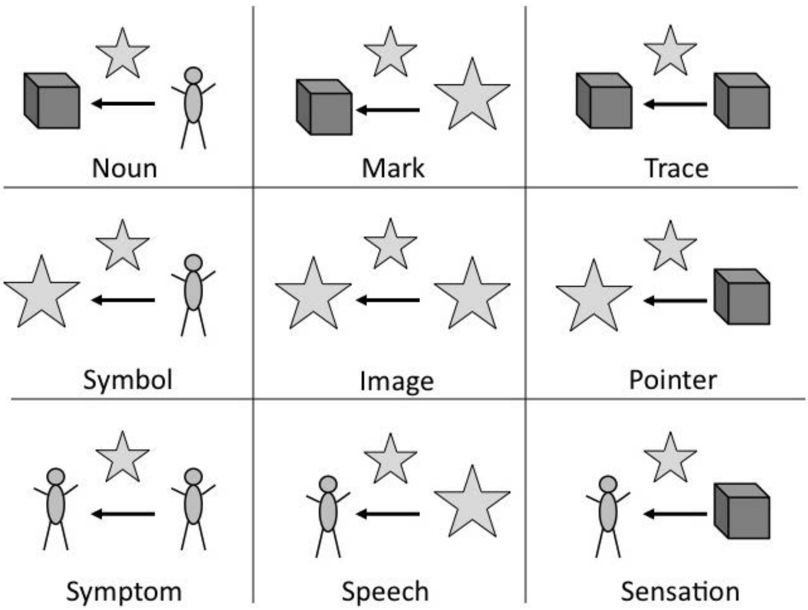

Figure 1.3. *Archetypes of semiotic functions*

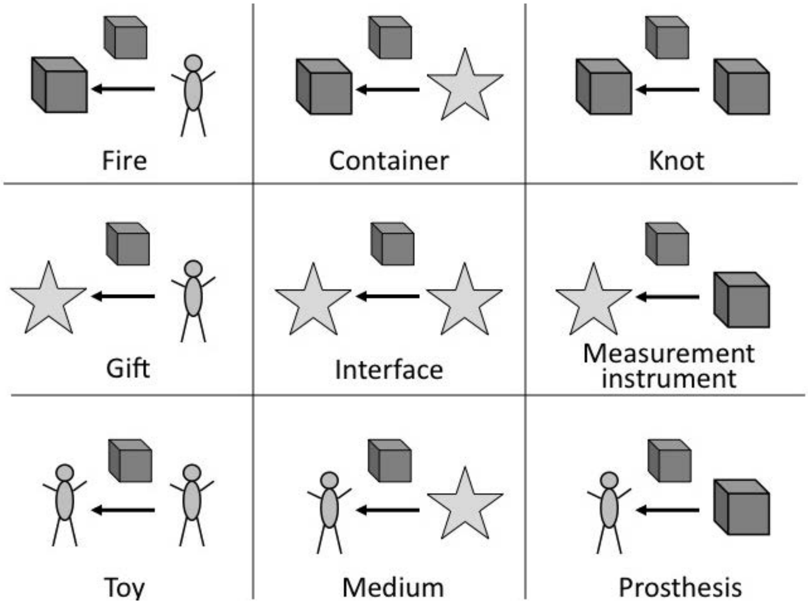

Figure 1.4. *Archetypes of technical functions*

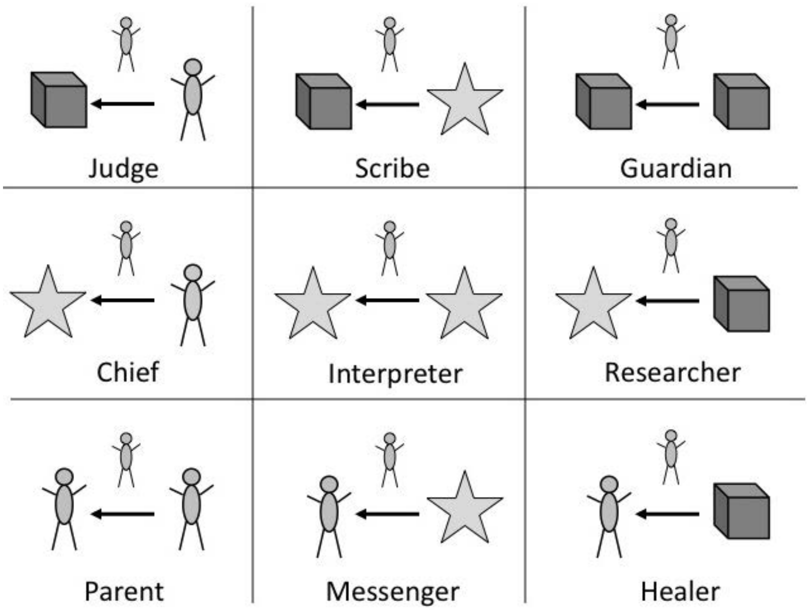

Figure 1.5. *Archetypes of social roles*

In examining Figures 1.2, 1.3, 1.4 and 1.5, the reader can observe that there are symmetries not only between the nine folds of each matrix, but also between the folds that occupy the same positions in different matrices, and between the matrices themselves. The key point is that these symmetries are not solely formal (in terms of the arrangement of the elementary symbols) but are also semantic because of the mode of interpretation or deciphering of symbols I had adopted. As in any good scientific ideography, there is thus an analogy between formal symmetries and the semantic symmetries. I will not go into a complete explanation of the deciphering of all these ideograms here, since this will be found – in its final form – in Volume 2 of this book. I will just comment on one last example in order to show the reader the logic governing the construction of IEML.

As a last illustration of the deciphering of the ideograms in this introduction, the general archetype *World* is projected in the realm of signs as *Name*, because humans cannot produce a cosmos without naming its elements. It is projected in the realm of social roles as *Judge*, which refers to the need to evaluate so as to construct an ordered world. It is projected, finally, in the technical realm as *Fire*, which here designates the mastery of a technique unique to humans, the hearth of warmth and light, the center of the home and the origin of all kinds of transformations and industries (cooking, pottery, metallurgy, etc.).

1.2.2.4. *The dialectic of address and message*

At the same time as I discovered triplication and the semantic symmetries it allowed me to explore, I began to construct matrices of reciprocal envelopment with the ideograms obtained through triplication of the primitives. For example, *Society* enveloping *Memory* gave *History*, and *Memory* enveloping *Society* gave *Tradition*. While the primitives represented degree zero of envelopment and the archetypes degree one, I could construct envelopments of degree two (the types), three, four, etc. The only constraint I set for myself was that the three operands of a triplication must always be of the same degree or the same layer. These successive layers of envelopment opened up two particularly promising perspectives. First, it became possible to construct ideograms representing concepts as precise and complex as I wished. Indeed, the lower the layer of triplication, the more general the concepts were. Conversely, successive triplications made the ideas increasingly precise (or complex). Second, I was beginning to glimpse a language whose expressions were in the form of envelopes containing envelopes, and so on recursively or “fractally”. From the point of view of the fractal enfolding of the envelopes within each other, this language could be seen as a regular, symmetrical *addressing system* – necessarily decodable by an automaton – since it was ultimately the recursive application of a well-defined operation to a small number of primitive symbols. From the point of view of the meaning of these fractal folds in successive layers, they were real messages. I thus had in my hands the core of a communication system in which the addresses were messages and the messages were addresses. The readable code on the external envelope summarized the internal folds of its content, and this numerical diagram of a fractal pleat was none other than the topological figure of a concept translatable into natural language.

1.2.2.5. *Toward a dialectic of virtual and actual*

From 1992 to 2002, I spent many hours combining in pairs, and then in triplets, the folds of my matrices of archetypes. At the time, I was not using the Roman alphabet, which I only came to many years later and which can be seen in the matrices in Volume 2 of this book. To rid myself of the mental habits that could have been imprinted in me by my knowledge of the living or dead languages I had studied, I always worked with icons, preferably using spreadsheets, database systems and drawing software rather than word-processing software. My matrices of types were becoming increasingly complex. I was beginning to dream of a system that could be used simultaneously as a general model of human collective intelligence and a computable language in the service of this collective intelligence: a symbolic mirror capable of reflecting the processes of social cognition in the digital medium. The "over-language" I spoke of in my 1997 book, *Collective Intelligence*, was a secret reference to this work in progress, although I had no guarantee that it would one day be completed[28].

Independently of the success of my undertaking, it was becoming increasingly clear that the digital medium was evolving quickly – but in a non-linear fashion – toward an interconnected global memory. The diverse and motley community – tending asymptotically toward the totality of the species – that fed and used this memory that was being updated in real time was going to need a tool for managing the library of Babel[29]. It would need a language of metadata, a calculable metalanguage that would enable it to overcome its semantic separations. However, none of the symbolic systems invented by humanity had yet been designed to take advantage of a medium accessible through a ubiquitous network with practically unlimited storage capacity and constantly increasing calculating power. Spurred on by this vision, I continued to combine my icons in hypertext mode. After a few years, it became apparent to me that my ternary dialectic was missing an important dimension of reality. I was lacking a binary dialectic, which would be the counterpart of the *being/sign/thing* triangle. Many cultures and traditions have already expressed this binary dialectic in the form of an opposition and complementarity between Heaven and Earth, soul and body, form and matter,

28 "Transcending the media, airborne machines will announce the voice of the many. Still indiscernible, cloaked in the mists of the future, bathing another humanity in its murmuring, we have a rendezvous with the *over-language*", *Collective Intelligence* [LÉV 1997], p. xxviii.
29 See Borges, "The library of Babel" [BOR 1964].

extension and thought, yin and yang, form and emptiness. I represented this binary dialectic by a *virtual/actual* polarity and I recorded my meditations on the subject in the book *Becoming Virtual*, which was originally published in French in 1995[30]. Instead of three semantic primitives, I now had five!

1.2.2.6. *Further research*

In parallel with my main activity on metalanguage, in the late 1990s and early 2000s, I produced two reports, one for the Council of Europe[31] and one for the European Commission[32], on the foreseeable cultural and political developments connected to the rise of the digital medium. I continued to reflect on the concept of open unity, which I called "the universal without totality" in *Cyberculture* (originally published in French in 1997). In this book, I tried to dispel the Orwellian fantasies that clouded the view European elites had of the Internet by showing that, despite attempts at censorship by governments and at commercial control by big corporations, the digital medium was fundamentally participatory, welcoming of diversity and impossible to shut down, and above all, that it was a medium for collective creativity that we needed to learn to take advantage of. I also showed that cyberculture was not a marginal phenomenon of network geeks: with the Internet, a new cultural order was emerging, an event as important in its way as the invention of writing or printing. In *Cyberdémocratie* (2002), I foresaw the explosion of a new freedom of speech on the Net, the general acquisition of the power to send and receive, and the emergence, finally, of new forms of online deliberation and political communication. All of these became evident a few years later with the rise of the blogosphere and social media, not to mention Obama's victorious election campaign using the Web and the "Arab Spring" involving the use of Twitter and Facebook[33].

I also published two less academic books, *Le Feu Libérateur* (1999) and *World Philosophie* (2000). The first one relates of my practical exploration of various spiritual traditions, particularly Buddhism, which has developed both a very subtle philosophy of mind and refined techniques (contemplation and meditation) of self-observation of cognitive activity. The second book expresses my intuition about the evolution of humanity toward a form of open unity that transcends–without eliminating – its political, religious and cultural divisions. My work on IEML must obviously be evaluated only on scientific and technical criteria. Readers should

30 [LÉV 1995].

31 *Cyberculture* [LÉV 1997].

32 The book *Cyberdémocratie* [LÉV 2002] was not the text of my report (since the Commission refused either to publish it or to surrender the rights), but it was based on the work I had done for the Commission. This small contractual obstacle permitted me to extend my potential readership to the whole world rather than remaining confined to Europe.

33 The term *Web 2.0* was only coined by Tim O'Reilly in 2004.

however know, in order to fully grasp the nature of my undertaking, that I have not limited my efforts to understand the human mind to reading works in the contemporary cognitive sciences. Great thoughts are great thoughts, whatever centuries and places they come from. As such, they have something to teach us. I therefore *also* took my inspiration from the sources of Eastern wisdom and the kabalistic tradition of combinatorics using letters, as well as from medieval theology of the Aristotelian and neo-Platonist traditions. Certain theories of divine intelligence can be considered remarkable models – although very idealized – of human collective intelligence! On the other hand, I would certainly not have continued my work on metalanguage for so many years without any tangible results if I had not been moved by a profound faith in the capacity of the human species to become aware of its unity.

1.2.3. *The years of gestation, 2002-2010*

I was only able to bring my project to fruition – at least intellectually – as a result of obtaining a position as Canada Research Chair in Collective Intelligence at the University of Ottawa. This special position has permitted me to focus all my efforts in one direction for eight uninterrupted years.

1.2.3.1. *A model of collective intelligence*

I first worked to systematize and balance my ideography so that it would be capable of delineating the main dimensions of a collective intelligence conceived as the *principal engine of human development*[34]. During the first years of my work in Ottawa, I did not yet feel I would be able to create a potentially unlimited language that could reflect all the nuances of natural languages. At the time, I only envisaged something like a system of postal codes covering the main semantic zones required to define the "identity" or "address" of a specific collective intelligence.

I then arrived at the ideographic architecture presented in Figure 1.6. The top of the diagram shows the ideograms representing the virtual qualities of a collective intelligence, while the bottom shows the ideograms representing the actual qualities. Each of the two main groups of ideograms is divided into three subgroups, corresponding respectively to sign (on the left), being (in the middle) and thing (on the right). Each of the six branches is organized as follows: a main ideogram represents the general semantic orientation of the branch, and nine *archetypes* present the main distinctions (which are interdependent) in the branch. Eighty-one *types* are systematically connected with each of the archetypes in the *actual* part and correspond to more complex structures in the *virtual* part. The "social roles" branch requires no comment; the "documents" branch corresponds to an analysis of

34 On this point, see section 5.1.

semiotic functions; the "equipment" branch corresponds to an analysis of technical functions; and the "wants" branch corresponds to a range of cultural values. The "powers" branch involves a classification of competencies, of which the nine *archetypes* correspond to the generalized trivium and the *types* to the application of these competencies to the *actual* archetypes. Finally, the "knowledge" branch is organized as a reflection of collective cognition on its different parts – as represented in this six-branch model – and their interactions[35]. As we will see in Volume 2 of this book, all this was kept, with minor modifications, in the IEML dictionary.

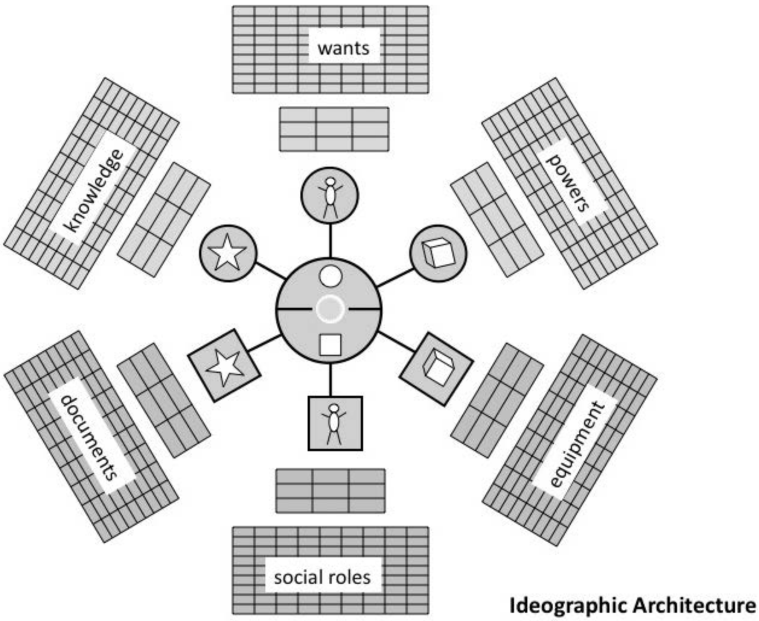

Figure 1.6. *A six poles model of collective intelligence*

The next step consisted of analyzing in detail the support provided by each of the six branches to the functioning of the five others and what it received for its own functioning in return. I went through several models in turn, but I am only showing one here (see Figure 1.7) so as not to overburden the reader. My thinking gradually shifted toward an *information economy* that measured flows in channels, attaching a value to various kinds of "capital" (corresponding to the six poles of my model) and

35 The reader will note the analogies between this type of representation and the rhetorical tradition of memory theaters. See, for example, Frances Yates, *The Art of Memory* [YAT 1974].

suggesting pertinent decisions with respect to desirable developments and useful alliances among different collective intelligences.

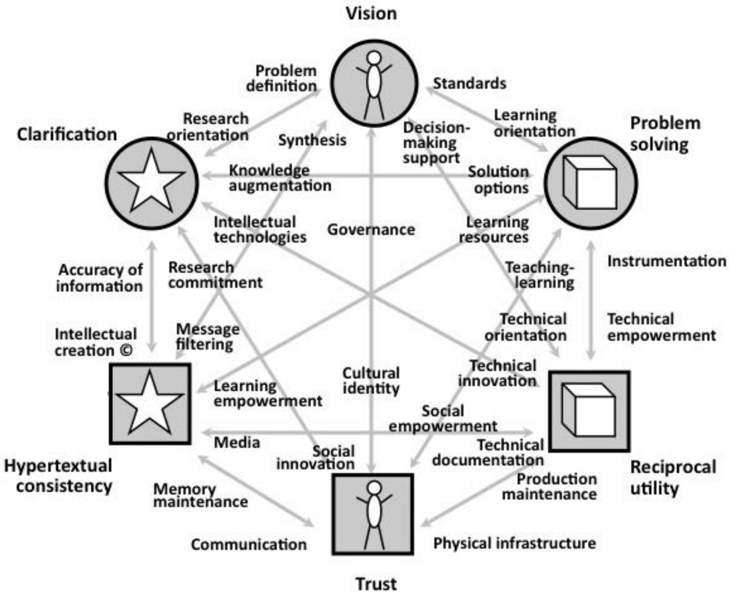

Figure 1.7. *Information transfers among the six poles of the model of collective intelligence*

My model gradually became more complex, resulting in an increasingly large repertoire of ideograms. I even took lessons in graphic design from my wife, Darcia Labrosse, to help me represent abstract ideas visually. Through constant work with the visual symmetries and the almost physical manipulation of the icons over the years, I developed a sensory-motor intuition of the mathematical group structure I would finally reach. However, after working on an increasingly unwieldy repertoire of ideograms, I finally realized that the images represented a phase that, while probably necessary, was not the definitive solution. Shouldn't future users (even though they were only a small number of experts) be able to directly manipulate this writing, using their keyboards? I therefore decided to work on a more abstract representation of my language, even if it meant letting users choose for themselves the visual form it would take, since the connotations of the images can vary according to contexts and cultures.

1.2.3.2. *A regular language*

While I was modifying the notation of IEML, I was starting to lean toward creating a complete metalanguage of indexing, with nouns, verbs, cases, conjugations, adverbs, prepositions, etc. All these elements are now part of the IEML dictionary.

At that time, I had only five primitives. These primitives were finally designated by capital letters: U (virtual), A (actual), S (sign), B (being), T (thing). The move from icons to letters of the Roman alphabet occurred gradually, with an intermediate step in which my five primitives were represented by little bars, as shown in Figure 1.8. The three-position bars represented the elements of the dialectic sign (left)/being (center)/thing (right), while the two-position bars represented the elements of the dialectic virtual (left)/actual (right). Bars that started with an element of the binary dialectic were verbal in nature, while those that started with an element of the ternary dialectic were nominal. In order to simplify things for users, I decided that verbals would be represented by vowels, and nominals would be represented by consonants. Since my combinatory ended up with 10 vowels and the Roman alphabet only has six, I adopted long vowels (wo, wa, wu, we) to avoid causing problems for users whose keyboards had no accents.

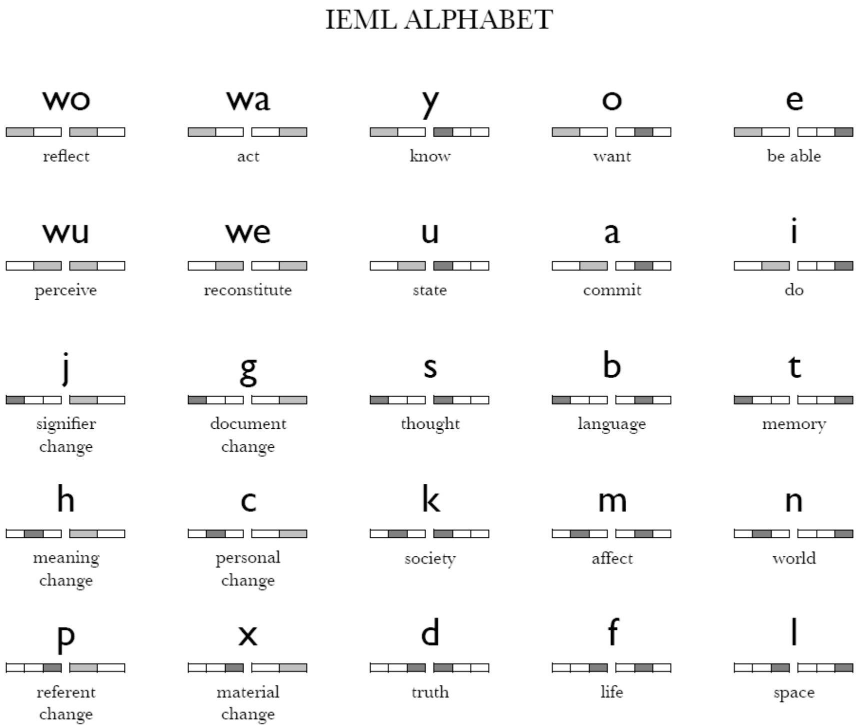

Figure 1.8. *The 25 lower case characters of IEML*

Figure 1.8 shows an ideographic alphabet. Each of the 25 lowercase letters represents one of the possible arrangements of the five primitives U, A, S, B, T (represented by five distinct bars) on the two syntactic positions *substance* and *attribute*. It is clear that this "alphabet" is not phonetic and is independent of natural languages. The English expressions explicating the ideograms can be replaced with equivalent expressions in any other natural language. I envisaged the possibility, through a dictionary establishing the correspondence between each ideogram and its explanations or descriptions in the various natural languages, of automatically translating IEML expressions into natural language, and even translating expressions from one natural language into another through IEML.

In Figure 1.8, it can be seen that my lowercase "letters" (which were in fact ideogrammatic words) were composed based on two syntactic positions. At this time, I was still allowing myself folds with two operands. To compose words and now sentences at layers of higher complexity, however, I still needed three syntactic positions (substance, attribute, mode), with each of them playing a different role in the construction of the expression. In order to simplify and standardize, I decided to systematically adopt triplication in all the layers. In addition, each of the three distinct syntactic positions would have to play the same semantic role, regardless of the layer. I then found myself with situations where I had only one or two elements to occupy three standard syntactic positions. All the expressions had to be unambiguously recognizable by an automatic syntactic analyzer (*parser*). So how could we know whether ba meant (1b 2a 3), (1b 2 3a) or (1 2b 3a)? Since this was a positional notation, I was obliged to reinvent zero. I therefore introduced a sixth primitive, which I called *emptiness*, indicated by E. My six primitives were indicated by capital letters: E for *Emptiness*, S for *Sign*, B for *Being*, T for *Thing*, A for *Actual*, and U for *Virtual* (I did not use V in order to remain faithful to the rule that the elements of the virtual/actual dialectic had to be represented by vowels). So b meant SBE, a meant ABE and ab had to be notated as abEEE or ABESBEEEE.

To avoid having to explicitly notate all the empty spaces, which in some cases could be very numerous, I adopted the convention of terminating each syntactic triplet with a punctuation mark indicating its layer. Using the arrangement of the punctuation marks, it was then possible to automatically reconstitute the implicit empty spaces. A colon (:) indicated layer 0, a period (.) layer 1, a hyphen (-) layer 3, and so forth. This led me to the distinction between IEML, a formal language consisting of mathematically describable abstract structures in the form of chains of symbols, and STAR (Semantic Tool for Augmented Reasoning), a notation that made it possible to manipulate IEML in a practical way. For example, instead of writing SBEABEEEE (in IEML "mathematics"), we could write *A:B:.S:B:.-** or *a.b.-** (with the stars marking the beginning and the end of the expressions in STAR-IEML). The parser that is now available is capable of checking the correctness of expressions in STAR and "reading" them, i.e. translating the lowercase letters into capital letters, reconstituting the implicit empty spaces, attributing each symbol and group of symbols to a specific syntactic position and transposing everything into XML format.

This work on notation was done in collaboration with Michel Biezunski and Steve Newcomb, who programmed a preliminary hypertext version of the IEML dictionary and the successive versions of the parser. These researchers gave me the benefit of their experience in the development of computer standards; they are, among other things, the fathers of the *Topic Maps* standard. They are the ones who developed the XML version of IEML, which explicates the layers and syntactic positions of all the symbols and groups of symbols.

Thus I had arrived inadvertently at a regular language (in Chomsky's sense), one that could be represented by chains of characters. I gradually improved this language by adding operators permitting algebraic manipulation (union, intersection, difference) of sets of chains of characters and allowing the construction of expressions containing many sets of sequences from different layers. A valid expression in IEML is now called a USL (Uniform Semantic Locator) and consists of sets of sequences from different layers. The mathematical formalization of IEML began in 2003, but it was only completed in 2010. Starting in 2008, I worked almost exclusively on developing functions for the construction of semantic circuits between IEML expressions and proving their calculability. These functions use the properties of symmetry (group structure) and the possibilities of algebraic calculation inherent in metalanguage as much as possible. I would never have produced the semantic topology[36] presented in Volume 2 without the generous collaboration of Andrew Roczniak, an engineer with a gift for mathematics whose computer science thesis at the University of Ottawa I co-directed (with Prof. Abed El Saddik). Roczniak patiently assisted me in formalizing my thoughts, version after version, for almost seven years.

1.3. The result: toward hypercortical cognition

Now that I have discussed the goal of my research – to increase collective cognition – the three challenges (semantic, ethical and technical) involved and the long road I have travelled to reach a result, I will, as briefly as possible, describe the tool I finally arrived at so as to allow readers to grasp it at a glance. The following is a summary of what I intend to justify and explain at length in the rest of this book. As readers now know, I only discovered the complex structure of the metalanguage gradually over many years of trial and error. It should also be noted that this metalanguage is intended to be developed and used collaboratively. Indeed, my own

36 See online http://www.ieml.org/spip.php?article152.

invention only concerns the mathematical syntax and the initial core of the IEML dictionary. This invention established the irreversible existence of a semantic automaton – an abstract machine for "calculating meaning" – opening up new possibilities for human cognition. In practical terms, much still remains to be done. Research and development using the IEML semantic sphere as a fundamental calculation grid for the digital information of the future will have to involve huge multicultural and multidisciplinary teams.

1.3.1. *A system of coordinates*

My long-term goal for IEML is that it should become the addressing system for a shared semantic sphere in which human cognition will be able to:

– organize its memory and its knowledge according to an open multitude of commensurable perspectives and

– represent and observe its own self-organizing processes.

IEML is a formal language, in the sense that its syntactically valid expressions can be generated and recognized by a finite automaton. The number of valid expressions with distinct meanings is finite, but immense, since there are more of them than there are photons in the universe, by several orders of magnitude.

There are obviously 2^6, i.e. 64, distinct subsets of the set of six primitives T, B, S, A, U and E. At layer 0, there are 64 – 1 = 63 meaningful ideographic characters. The number 63 corresponds to *the set of parts* of the set of primitives minus the null set. The null set – to be distinguished from the primitive "empty" – is only used for operations: it has no interpretation in the dictionary. At layer 1 (the first triplication), there are 63^3, i.e. more than 250,047 distinct semantic sequences. At layer 2 (the second triplication), there are 63^9, or 15,633,814,156,853,823 sequences. At layer 3 (after three triplications), we get 63^{27} sequences, which gives 3,821,156,589,287,986,284,580,441,367,887,410,055,869,435,352,767 distinct semantic sequences. At layer 4, we get 63^{81} distinct semantic sequences, which gives 12,913,993,997,549,750,548,748,951,390,525,129,485,166,487,876,965,953,696,70 1,312,933,401,663. Layer 5 is made up of 63^{243} distinct sequences, and layer 6 of 63^{729} distinct sequences. It does not seem useful at this stage to cover entire pages with lines of numbers that no one will read just to illustrate these huge numbers. But these are only the numbers of sequences! It should also be recalled that the USLs are made up of *sets* of sequences belonging to the seven layers (from 0 to 6). Thus, the number of distinct USLs exceeds the number of elementary particles in the known physical universe by many orders of magnitude. It seems that there is sufficient capacity in IEML metalanguage to express all meanings!

Every valid text in IEML metalanguage – every USL – can be considered the address of a node of the semantic sphere, because IEML comes with an automaton that is capable of tracing semantic circuits between USLs and interpreting them in natural languages, as long as it is properly programmed with a dictionary. This semantic automaton connects the nodes of the IEML sphere by means of two types of links: paradigmatic links, which connect expressions considered as *concepts*; and syntagmatic links, which connect expressions considered as *utterances*.

1.3.1.1. *Paradigmatic links*

Paradigmatic links themselves belong to many families: they may be etymological, taxonomic, symmetrical or serial.

1.3.1.1.1. Etymological links

Etymological links connect compound concepts (of layer *n*) to more elementary concepts (of layer *n*–1). They show that the meaning of the compound concepts can be derived from more elementary concepts. Typically, the meaning of a word can come from one or more roots. To take an example from natural language, the word *hypothesis* comes from *thesis*, meaning "placing", and *hypo*, meaning "under", in Ancient Greek. In IEML, as shown in the matrices in Figures 1.2, 1.3, 1.4 and 1.5, the meanings of the ideograms of layer 1 are derived from the triplicated ideograms of layer 0. I outlined above (in section 1.2.2.2) an etymological analysis of the matrix in Figure 1.2. I want to point out immediately that not all the meanings of the words in the IEML dictionary can be derived from their components (there are primary concepts, just as there are prime numbers). On the other hand, the meaning of all sentences and all complex propositions can be deduced automatically from the meanings of the words that make them up. The etymological links are obviously traced by the semantic IEML automaton *only* when the meaning of an expression of layer *n* is derived from an expression of layer *n*–1.

1.3.1.1.2. Taxonomic links

Taxonomic links connect concepts, some of which are subsets of other concepts, as in the case of *generosity* and *virtue*. To give an example from IEML, there is an expression corresponding to the union of all the sequences (all the ideograms) of the matrix in Figure 1.3, and the descriptor of this expression in natural language is "semiotic function". The reader will easily understand that the expressions in the cells of the matrix in Figure 1.3 are subsets of the "semiotic function". The IEML semantic automaton traces taxonomic links between each of the concepts in the cells of Figure 1.3 and the concept ("semiotic function") corresponding to the set of the matrix.

1.3.1.1.3. Symmetrical links

Symmetrical links connect concepts that can be substituted for each other to exhaust a field, for example, the concepts of the different colors. Symmetrical links are also used to indicate complementary concepts, such as *teach* and *learn* or *professor* and *student*[37]. If we refer back to Figures 1.2, 1.3, 1.4 and 1.5, we see that each matrix shows a small system of permutations among the contents of its cells. All the cells in the same matrix are thus symmetrical to each other. I noted in section 1.2.2.3 the symmetrical relationships between the ideograms meaning "memory", "mark", "container" and "scribe": their substances and attributes are identical (respectively, *thing* and *sign*), while the primitives *emptiness*, *sign*, *being*, and *thing* can be substituted for each other in their modes. I also spoke of the IEML words that are translated into English as *history* and *tradition*. They are currently written in IEML as *k.o.-t.o.-'** (*history*) and *t.o.-k.o.-'** (*tradition*). As we see in this example, the substances and attributes are reversed in these two expressions, and this formal symmetry corresponds to a semantic symmetry.

1.3.1.1.4. Serial links

Finally, there are serial links, marking before/after relationships between concepts, relationships that result from the automatic arrangement of concepts according to linear gradients, such as more abstract/more concrete. For an example in IEML, let us examine the matrix in Figure 1.8. We will first check that all the rows have the same substance (first role) and all the columns have the same attribute (second role). The rows and the columns are ordered according to the principle of increasing reification or concreteness: virtual, actual, sign, being, thing. Virtual/actual come before because they mark processes (verbals), and sign/being/thing come *after* because they mark reified entities (nominals). In the virtual/actual dialectic, the virtual is obviously more abstract than the actual. In the being/sign/thing triad, it is clear that thing is more concrete than sign, with being playing an intermediate role. Thus, in the set of the matrix in Figure 1.8, the least concrete is at the upper left and the most concrete at the lower right. The cells in each column go in descending order from most to least abstract, and those in each row decrease in abstractness – or increase in concreteness – from left to right. It will be understood that this alphabetical order (which is also a semantic order, unlike the phonetic alphabet) can be used to automatically sort IEML expressions.

1.3.1.2. *Syntagmatic links*

Syntagmatic links form rhizomes that break IEML texts (USLs) down in complexity – into compound propositions, and from compound propositions into

37 The matrix O:M:.O:M:.- from the dictionary provides a good example of these complementarities; see Volume 2.

sentences, sentences into words, and words into morphemes. It goes without saying that the relationships between the morphemes in a word, between the words in a sentence, between the sentences in a proposition and between the propositions in a text (USL) are also represented by explicit links. These are rhizomes and not trees, because the connections are not only hierarchical or genealogical. The nodes that come out of the same "bulb" (and that are therefore of the same genealogical degree) are connected through horizontal "capillaries". For example, the words that make up an IEML sentence are automatically broken down and connected by capillary links that indicate their grammatical relationships. In addition, as a general rule, the same node can enter into many transverse relationships with other nodes, with these relationships always corresponding to automatable functions.

1.3.1.3. *A computational topology*

Syntagmatic and paradigmatic circuits may be seen metaphorically as "meridians" and "parallels" of the semantic sphere. The semantic topology based on IEML generates an immense closed structure of syntagmatic and paradigmatic channels that intersect at nodes (valid IEML expressions), each of which is a distinct variable in a groupoid of symmetrical, calculable transformations. We can imagine the syntax of IEML as a stationary machine capable of computing the vast, fractally complex network of the semantic sphere. This syntactic machine needs to be provided with a dictionary that establishes the correspondence between IEML expressions and natural languages and governs the details of the connections. The dictionary functions as a "semantic program" that weaves together the sphere (an evolving, perfectible program) and realizes the potential of the computational machine that is the syntax of the metalanguage.

Each node of the IEML semantic sphere is at the center of a multitude of calculable pathways of transformation. Each step from one node to another along these pathways is the variable of a discrete function. Step by step from one node to the next, these paths connect each node to all the other nodes. In the centrifugal direction, a node is thus the singular origin of a star of transformation that generates the entire sphere. In the centripetal direction, a node functions as a universal vanishing point of the sphere, since there is a calculable path of transformation that leads to it from any other node. In short, the IEML semantic sphere is a sphere whose center is everywhere, whose circumference is nowhere and whose every singularity organizes an immense semantic circuit in an original way.

1.3.2. *An information economy*

The directional links between two nodes are called *channels*. Each channel of the semantic sphere may be associated with an energy flow that can be defined by a pair of numbers: a cardinal number (*quantity* of energy: positive or null) and an ordinal number (*quality* of energy: negative, positive or null). The energy associated with a channel is an *information current*. The functions of the information economy have input current flows and output current flows. They use only calculable transformations on the numbers and on the channels. The information economy based on IEML is thus founded on a group of calculable transformations of the semantic sphere. It would therefore be possible to model all kinds of economic functions, drawing, for example, on ecosystem, neural, social, psychosocial or economic (in the sense of the monetary economy) models. It would also be possible to explore some original dynamics of the circulation of the information current in the semantic sphere, using models especially designed to show various forms of collective intelligence or personal cognitive strategies. In short, the semantic sphere is the shared transparent computational field of a large number of games, each game corresponding to a set of economic functions involving certain specific circuits. I note in conclusion that the semantic topology presented in Volume 2 proposes various functions for the calculation of *semantic distances*, distances that can be weighted according to the intensity and value of the current circulating in the channels[38].

The IEML information economy provides a tool for computable modeling of symbolic cognition that can be used to simulate, represent and observe cognitive phenomena at both the individual and collective levels. In practical terms, the effective use of the semantic sphere is obviously dependent on the existence of indexing programs that transform multimedia data from the Web into information flows in the semantic sphere, and in turn transform the dynamics of information currents in the semantic sphere into interactive multimedia data. Ultimately, human intelligence – as invested objectively in the data of the Web – would become capable of reflexivity[39] in the mirror of a digital medium coordinated by the semantic sphere, which I call the Hypercortex[40].

1.3.3. *A Hypercortex to contribute to cognitive augmentation*

At the time that I am writing these lines, the IEML semantic sphere is a philosophical idea, a theoretical mathematical – linguistic construct. But since this abstract mechanism has been fully formalized and its calculability has been demonstrated, I can state that – in the reality in which abstract machines exist–the semantic sphere *exists*. Now, sooner or later the implementation of open-source software and collaborative use of the IEML semantic sphere will permit us to meet three major challenges of cognitive augmentation: that of the scientific modeling of

38 Readers will find details on these functions in Volume 2.

39 I.e. scientific self-referentiality.

40 I capitalize Hypercortex, just as we capitalize *Internet* and *Web*.

symbolic cognition, that of perfecting the collaborative production of knowledge using data from the Web, and finally, that of increasing individuals' capacity to autonomously organize their learning and navigate information flows.

1.3.3.1. *A scientific model of human cognition*

The Hypercortex based on the IEML semantic sphere will make it possible, first, to have a scientific model of symbolic cognition whose complexity will be of the same order of magnitude as its object and that will take into account its sociocultural dimensions. The model of the information economy in the Hypercortex does not reduce thought to the operation of neurons (or of any natural material system) or to a few rules of automatic reasoning in a micro-world of elementary propositions. It is nevertheless scientific insofar as it can be explicated in terms of calculable functions and can be manipulated automatically in a transparent, reproducible and shareable way. Representing the complex phenomena of the life of the mind by means of graphs or mathematical quantities is clearly not original. The originality of the IEML semantic sphere does not so much lie in the topological representation in network form: almost all contemporary scientific models of complex phenomena use graph theory[41]. The novelty and relevance of my theoretical proposition come from the fact that the vertices and edges of the IEML semantic circuits are the variables in a unique system of symmetric transformations, which makes all aspects of the graph transparent to computation[42]. As I said above, in the IEML semantic sphere, the addressing system and the content expression system are one identical (and huge) system of algebraic transformations.

1.3.3.2. *Knowledge management that respects cultural diversity*

Beyond the strictly theoretical issues around the modeling of symbolic cognition, the implementation of the IEML semantic sphere will make it possible to gradually advance toward a better integration of the heterogeneous multitude of knowledge traditions for the benefit of human development. The information economy modeled in the IEML semantic sphere provides an accounting of knowledge flows created, exchanged and evaluated in the ecosystemic circuit of human collective intelligence. Knowledge from a profusion of cultural disciplines, traditions and communities that are not currently well interconnected on the Web could be explicated and coordinated much more effectively using the IEML semantic sphere. The key point is that this practical integration would not take place at the cost of a reduction in diversity or a leveling of differences but, on the contrary, would be accompanied by

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41 See for example, Albert Laszlo Barabasi, *Linked, the New Science of Networks* [BAR 2002].

42 Tim Berners-Lee's Giant Global Graph, or Web of Data, obviously does not meet this requirement, since its basic addresses, URIs (and the same is true of URLs), are opaque in construction; see http://www.w3.org/DesignIssues/Axioms.html#opaque.

the expression and enhancement of the diversity of universes of discourse. The practically infinite and radically multicentered nature of the semantic sphere should reassure those who fear that, on the pretext of explication and sharing, codification will impoverish knowledge or that a few dominant points of view will impose their reductive imperialisms.

1.3.3.3. *A writing that makes the intellectual mastery of information flows possible*

We know that reading and writing are not only used for the communication of words and information. They are also a *cognitive technology* that permits thought to be accumulated, classified, reflected on and observed critically from a distance and enables it to take forms unknown to oral cultures (lists, tables and systematic theories). The practice of writing by communities of experts led to an uninterrupted series of symbolic innovations: ideographies, phonetic alphabets, mathematical notations, etc. Literacy and education certainly meet economic goals. They are also necessary conditions for the political and cultural emancipation of societies, however, the basis of a certain individual freedom of thought in relation to tradition and in learning.

IEML is a new kind of writing that opens up the possibility of reflecting thought no longer in static texts on material media, but as information flows in the context of a digital memory coordinated by the semantic sphere. By providing elaborate tools for measurement, categorization, collection, filtering, transformation and exchange, this "writing of circuits" would give people a new intellectual mastery of digital data flows. IEML could thus serve as the basis of personal knowledge management environments, which we urgently need in order to survive the deluge of data and organize the growth and refinement of our memories. We have to think of the true medium of this writing not as paper, hard disk or screen, but as the ever-changing ocean of data online: it is a writing of metadata, a semantic channeling of the movement of information. I should note that IEML would have to be manipulated using interfaces in natural languages or interactive sensory-motor devices, and that the direct relationship with the code would probably be reserved (at least for the next generation) for professionals in formal modeling. The fact remains that a new literacy is in sight that should not only facilitate the collaborative creation of knowledge but also enable people to increase their autonomy and control over their destiny.

1.3.3.4. *Humanistic openness or post-human singularity?*

If the turbulent digital medium of binary electronic flows constitutes a kind of planetary fractal brain, IEML provides the symbolic system – the metalanguage of computable explication – that makes it possible to give that brain something like speech, and therefore reflexive consciousness.

The new means of recording, communication and processing that have become available to us through digital technologies in a mere generation (the Web dates roughly from the mid-1990s) can and should be used to explore new cognitive powers by and for humanity. I emphasize humanity, because authors such as Ray Kurzweil and Vernor Vinge have announced the imminent coming of a “singularity” whereby human civilization will supposedly be transcended by machines. Beyond this singular point, progress would become the work of artificial intelligences capable of perfecting themselves or a kind of quasi-immortal cyborg that would no longer be human but would evolve through nanotechnology, genetic engineering and electronic coupling. The perspective presented here contrasts radically with that hyper-materialist vision. I maintain that our evolution will be first and foremost cultural, founded on the advancement of our capacity for symbolic manipulation in favor of multidimensional human development. By making the symbolic representation of categories possible, articulated language has opened the way to the reflexivity of human thought and forms of collective intelligence of a power unknown in the animal kingdom. In the future, the shared symbolic representation of the processes of collective intelligence in the mirror of the Hypercortex[43] will take us toward a technically enhanced symbolic reflexivity. In the situation of global interdependence of which we are now aware, this technically enhanced reflexivity of our collective intelligence is the condition of a sustainable control of human development. This is not a promise of some Heaven on Earth[44] or magic solution to all problems, but of a path to wisdom and responsibility in the long term that it is up to our generation to inaugurate. Far from subjugation to some supposed non-human intelligences or the mirage of a society of immortal cyborgs, the direction for cultural evolution should be sought in a symbolic openness: toward a parallel expansion of our knowledge and our freedom.

1.4. General plan of this book

This book is being published in two volumes:

– Part 1 of this first volume, entitled “Philosophy of Information”, presents the philosophical, scientific and practical problems that the IEML metalanguage will solve. All these problems are related to one central question: how can we enhance human cognitive processes by making optimal use of the digital medium’s memory, ubiquitous communication and calculating power? This part is particularly intended for readers interested in philosophy, the human sciences, the information and communication sciences and knowledge management.

43 A Hypercortex that, I must emphasize, will be able to play its role as mirror of collective intelligence only if it is coordinated by the IEML semantic sphere.

44 And even less, a promise of Earthly immortality as envisioned by Kurzweil.

– Part 2 broadly outlines the structure of the IEML semantic sphere and shows how it can be used as a system of coordinates for the digital medium. Thanks to this additional layer of metadata addressing in the form of a transformation group on a topology of concepts, the "global brain" can provide access to a reflexivity of collective intelligence. That is why the digital medium will metamorphose into a Hypercortex capable of solving the problems of cognitive augmentation presented in Part One. The Hypercortex, coordinated by the IEML semantic sphere, will enable us to shift from the current state of distributed social computation, which is still too opaque and fragmented, to a transparent, public mechanism for the scientific observation of phenomena of social cognition. The second part of this first volume, entitled "Modeling Cognition", can be considered the basic theory of the research program I am proposing here. It is especially intended for readers interested in the cognitive sciences, linguistics, the "global brain", collective intelligence and artificial intelligence.

– Volume 2 will present the mathematical syntax of IEML and the operations that trace the circuits of the semantic sphere in detail. It is here that I will systematically present the semantic primitives of the metalanguage and the principles of the dictionary, with many examples. Volume 2 functions as a proof of the theory presented in Part 2 of Volume 1. It shows that the metalanguage is not only a hypothesis, but that it actually exists. All its important aspects are already available, for example the grammar and the core of the dictionary. I also provide a complete mathematical demonstration of the calculability of the semantic sphere. Volume 2 will be more specifically intended for the computer engineers and future semantic engineers who will have to augment the metalanguage and construct the tools that will be used to manipulate it.

A multidisciplinary bibliography of nearly 400 scientific books and articles in Volume 1 provides all the references required for readers who wish to read further on the subject.

PART 1

The Philosophy of Information

“Ah! very great tree of language, peopled with oracles and maxims, and murmuring the murmur of one born blind among the quincunxes of knowledge…”

Saint-John Perse, *Winds*, Pantheon, New York, 1953

“It was with pleasure that he saw himself in this eye looking at him. The pleasure in fact became very great. It became so great, so pitiless that he bore it with a sort of terror, and in the intolerable moment when he had stood forward without receiving from his interlocutor any sign of complicity, he perceived all the strangeness there was in being observed by a word as if by a living being, and not simply by one word, but by all the words that were in that word, by all those that went with it and in turn contained other words, like a procession of angels opening out into the infinite to the very eye of the absolute.”

Maurice Blanchot, *Thomas the Obscure*, D. Lewis, New York, 1973

“It is evident, therefore, that the differentiating characteristic of humanity is a distinctive capacity or power of intellect. And since this capacity as a whole cannot be reduced to action at one time through one man, or through any one of the societies discriminated above, multiplicity is necessary in the human race in order to actualize its capacity in entirety. […] With this belief Averroës (Ibn Rushd) accords in his commentary on the treatise *Concerning the Soul*.”

Dante Alighieri, *De Monarchia*

Part 1 of this book explores the concept of open unity, i.e., a unity that is neither closed nor uniform. Chapter 2 presents the scientific quest for the unity of nature. Chapter 3 discusses a definition of humanity based on symbolic cognition. Chapter 4, entitled “Creative Conversation”, discusses the unity of human knowledge and argues in favor of the general semantic interoperability of its online management. Chapter 5, “Toward an Epistemological Transformation of the Human Sciences”, calls for a unifying transformation of the humanities and social sciences. Chapter 6, finally, entitled “The Information Economy”, explores the unity of the information flows in the most varied ecosystems of knowledge. Each chapter suggests the role the IEML semantic sphere could play in the open unification of the area in question.

Chapter 2

The Nature of Information

This chapter aims to establish a unity of nature based on the concept of information, and in particular to show the ultimate unity of mind and matter. It is organized into five sections. Section 2.1 presents a synthetic image of this "information nature" as a general orientation. Section 2.2 presents the information paradigm and provides a history of the scientific concept of information. Section 2.3 describes the hierarchy of levels of complexity in information nature: the physical, biological and cultural realms are interpreted in terms of layers of encoding. Section 2.4 deals with evolution through the successive appearance of different layers of encoding. Section 2.5 concludes the chapter with a discussion of the unity of nature. It shows how a system of calculable semantic coordinates would make it possible to include human culture in a unified nature that lends itself to scientific investigation.

2.1. Orientation

The purpose of this section is to situate the semantic sphere on a general map of information nature and thus introduce the reader to this concept. Precise definitions will not be provided here – they will gradually be added subsequently – but rather, a preliminary reconnaissance, an overall orientation. As I see it, the nature of information is structured in successive layers: from quarks to atoms, molecules to organisms, nervous systems to phenomena, and symbols to concepts. But instead of starting from atoms to arrive at concepts, climbing up layer by layer through the interfaces of transcoding, I start from the center. I begin with the organizing middle[1]

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1 As Gilles Deleuze says, we should draw lines rather than make points. "What matters on a path, what matters on a line, is always the middle, not the beginning or the end. We are

of nature, the human mind. Let us therefore consider a division of nature into three strata: that of phenomena, in the southern hemisphere; that of the human mind, in the intertropical zone; and that of symbols, in the north.

Here the mind is not a substance, as in Cartesian philosophy, but an equator. A multitude of moments of thought (more or less conscious) in interaction: this is the distributed medium of experience. It is only one part of nature, but a paradoxical part that contains everything, because what can we know outside of human experience? Not only perceptions imbued with emotions, but even abstractions that seem farthest away from perceptible matter, are collected, recorded and thought about in this medium of human experience, experience that is inevitably immersed in time, second by second.

Every moment of the present interprets its legacy of past moments while influencing future moments that will interpret it in turn in different situations. Since we are social beings, our moments of experience are connected: we reciprocally imply cognitive processes that fecundate each other, carving networks of shared memory in communities. As we think and communicate using symbols, and because a symbol connects a sensation to an idea, each moment of thought connects a phenomenal complex (an interlacing of sensory-motor images) to a semantic complex (relationships among concepts). Between the signifying phenomenon and the signified concept circulates a stream of emotional intensity: binding energy. There is no cognition without affect, no connection between signifier and signified without a specific strength and quality of connection. The strength is variable and its qualities are subject to a thousand nuances – from anger to tenderness – that express the practical context and the intensity of the thought. The etymology of the Greek *psyche*, "mind", and the Latin *anima*, "soul", like the Hebrew *ruach* (both breath and spirit), evokes this current of attraction between the image and the concept, these forces of repulsion or gravitation among ideas and percepts. Between the southern hemisphere of phenomena and the northern hemisphere of ideas lies the world of minds, the intertropical zone of moments of thought where the winds of human intelligence blow.

Now that we have identified the equator, which is both connection and source, let us examine the two hemispheres of the natural globe. In the *phenomena* part, the south, I distinguish a temperate zone, close to our subjectivity, and a polar zone that is less familiar, that of the cold, rigorous procedures of the exact sciences. The temperate zone, which we may call the *biosphere* for short, includes our bodies and the biological environment in which they interact. It is here that ecosystems evolve, that organisms devour one another, reproduce, live in symbiotic relationships, and

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always in the middle of a path, in the middle of something", like grass. The more one takes the world where it is, the more chance one has of changing it [DEL 1987b], p. 28.

exchange bacteria and viruses. The biosphere contains the “real” economy, where raw materials are extracted and processed, heavy freight is shipped at high cost in hydrocarbons, and garbage is thrown out and recycled. It is in the biosphere that people gather together in villages, towns, cities and metropolises... and public health factors interact in a huge network, accelerated by technological transport systems. This is the closed bubble of the biosphere, a thin skin of interdependence on the surface of the Earth, which universal communication is beginning to make transparent to us. It is a fragile envelope surrounded on all sides by a turbulent physical cosmos: the universe of quarks and atoms at the infinitely small end, and the universe of stars, galaxies and superclusters at the infinitely large end of the spectrum; between the icy cold of intergalactic space and the burning heat of nuclear fusion at the heart of the stars. The laws of physics that make this observable cosmos intelligible to us converge toward the south in a system of relativistic quantum transformations. The unity of this system of transformations is more a goal to be reached than an accomplished fact, but the goal is clearly established. At the south pole of information nature, our collective intelligence tries to grasp space, time, matter and energy – even the biosphere from which humanity emerges – in a single functional net.

Now we need to explore the northern hemisphere, the symbolic universe. Like the southern hemisphere, it is divided into two zones. In the temperate region, the one closest to consciousness at the present time, extends the mediasphere, where signifiers are stored, transformed and exchanged. This is no longer the sphere of material work and energy transformation, which we left in the southern hemisphere, but that of symbolic communication and manipulation. While there is no work on the sign, no calculation, no transmission of signals that does not expend physical energy (from sweat to electricity) and does not require some material medium (ink, paper, optical fiber, screen, hard disk, satellites, antennas and microwave towers on high elevations, etc.), I ascribe this material aspect of the symbolic universe to the biosphere, i.e. to the south. In the northerly mediasphere, on the other hand, the relevant forms are those of meaningful messages. Accumulated by memories, propelled through transmission networks, processed by computation centers, emerging in the sensory-motor interfaces of our moments of thought, myriads of symbols are transmitted and received every instant, dust of consciousness breathed in and dispersed on the winds of the mind.

Cultural evolution is moving toward the gathering of the mediasphere into a single digital infrastructure for recording, communication and calculation. In a future so close we can already touch it, the mediasphere is weaving a single social medium of human collective intelligence. Human intelligence organizes itself in this medium to accumulate the data it produces and use the data it accumulates. The Web of people, Web of data, Web of things, local and ubiquitous Web, Web of knowledge and cultural treasures, the great network is forming a single digital medium.

However, the messages that are accumulated and conveyed in the mediasphere come from different symbolic systems. Its signifiers are interconnected, but not its signifieds. The layers of complexity of the messages and discursive formations[2], the semantic resonances among the dialogic multiplicities, the long interwoven lines of hermeneutic transformations – everything that makes the subtlety, richness and very essence of culture – remain practically opaque to calculation. That is why, today, the fragmented collective intelligence still cannot represent its own cognitive processes to itself in the new digital medium. At the north pole of information nature, we will therefore have to illuminate the opaque, fragmented complexity of the mediasphere starting with a single thread of calculable transformations between concepts.

The North and South Pole of information nature are symmetrical. The exact sciences of matter have made organized life and sensory phenomena understandable to us: they have made a cosmos of them. As intelligence is never separate from action, these sciences have expanded our practical horizons. They have increased the material power of our species. A new task now awaits the scientists, intellectuals and scholars of the human sciences: to tame the chaos of the digital medium by discovering under its apparent disorder a cosmos of ideas. Our species would thus cross a threshold of reflexive capacity. This cosmos of ideas, marked out by the semantic sphere[3], would function as a mirror of human collective intelligence, capable of reflecting it from an infinity of distinct, equal and symmetrical perspectives. This assumes that the semantic sphere, at the North Pole, would be organized in a system of transformation as rigorously defined and computable (a semantic transformation group) as that of the South Pole. This power of symmetrical reflection – both unifying and infinitely differentiating – will make the digital medium the distributed reciprocal social observatory of the human sciences of the future. On the hypercomplex – but calculable – grid of the meridians and parallels of the semantic sphere, we will be able to read and write the fractal cycles of our cognitive ecologies.

The mind grows its binding energy between the network of bodies and the graph of concepts from the middle. Along the meridians and parallels of its omnidirectional tree, the sap of creation circulates between the Southern Cross and the semantic star.

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2 This term is from Michel Foucault in *The Archaeology of Knowledge* [FOU 1969], which made a lasting impression on me.

3 The semantic sphere is a scientific system of coordinates of the noosphere anticipated by Teilhard de Chardin [TEI 1955].

2.2. The information paradigm

In Europe of the 17th and 18th Centuries, the most complex machines were clocks, mills and mechanical automata. In keeping with the technology surrounding them, Descartes, Newton and most authors of the revolution in experimental science thought in terms of a "mechanical nature" of figures, movements and forces[4]. In the 19th Century, there were improvements in the mechanisms for transmitting movement, but the greatest innovations occurred in engines and energy sources. While steam and electric machines were powering the Industrial Revolution, experimental science was starting to think in terms of the thermodynamic nature of heat and energy transformations[5]. The 20th Century continued to refine vehicles and engines, but its most radical technical innovations were in the area of communication and control[6]: recording of sound and images, telephone, radio, television, computers, servo-mechanisms, robots and the omnipresence of networks. At the same time, the communication of information became an essential part of physics (speed of light, principle of quantum indeterminacy), biology (genetic encoding) and the social sciences (networked society, the rise of the communication sciences). We now live in an "information nature".

2.2.1. *Information and symbolic systems*

The main way of modeling information formally or scientifically – i.e. in a way that is calculable – is to represent it using patterns of symbols or relationships among patterns of symbols. I will discuss the concept of symbol in more detail below, but first I want to clarify the fundamental concept of symbolic system, since it is a prerequisite for understanding the information paradigm. The basic idea is relatively simple: there are no isolated symbols or symbols "in themselves", and no object of experience can function as a symbol unless it is interpreted within the framework or "grammar" of a given symbolic system[7]. A symbol is thus always a specific element, or a specific configuration, of a system of symbols. Symbolic systems comprise many symbols – which may together form a certain structure – as

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4 See Michel Serres, *La Traduction* [SER 1974].

5 See Michel Serres, *La Distribution* [SER 1977], and the book on thermodynamics in *Cosmopolitics I,* by Isabelle Stengers [STE 2003], as well as the now classic *Order Out of Chaos*, by Prigogine and Stengers [PRI 1978].

6 The word *cybernetics* comes from the Greek *kubernetes*, which means "steersman". The words *government* and *governor* are also related to it. Norbert Wiener (its inventor) defined cybernetics as the science of control and communication in the animal and the machine. See his *The Human Use of Human Beings: Cybernetics and Society* [WIE 1950].

7 See, for example, the concept, which I will use often in this book, of "language game" in Wittgenstein, which is developed mainly in his *Philosophical Investigations* [WIT 1958].

well as rules of manipulation that specify how the symbols can be validly used, how they are associated with each other and how they interact. In the game of chess, for example, the identity of each piece forms a system with the identities of the other pieces (each of them belonging to one of two enemy “armies”). These identities are defined by means of their initial positions and the rules of movement on the chessboard, rules of capture, rules of check and checkmate, etc. Symbols are abstract objects – and not concrete things – precisely because they belong to symbolic systems rather than to the material world. This does not mean that symbols do not have to be part of the material world, if only to be perceived. It is the game of chess as a symbolic system that determines what, for a piece in the game, belongs to its symbolic nature and what belongs to its physical existence. The identity of a piece (rook, knight, pawn, etc.), its color (black or white) and its position (A5, B6, etc.) are part of its symbolic essence. On the other hand, its weight, size, visual appearance, the material from which it is carved or molded, price, etc. – the characteristics that result from its necessary inscription in the material world – are not part of the symbolic system. They are therefore not included in the information that is relevant to the game. Of course, in another game (another symbolic system), for example the economy, the price and material (gold or wood) of a rook or a knight are relevant, and will therefore be counted as information. In short, what matters as relevant information in a chess match (the arrangement of the pieces on the chessboard, a particular move, etc.) depends solely on what is defined by the specific symbolic system of the game of chess. The rest is not taken into consideration at all, or only as the medium. Once again, a symbol is never a raw thing or a sensory object; it is an abstraction defined by a symbolic system.

In general, the contemporary scientific method considers as information only what is defined as such for a given symbolic system *taken as a model* of a situation or an environment. Consequently, only certain features of phenomena are considered relevant – and are therefore counted as information – and only insofar as these features constitute specific configurations of the symbolic system taken as a model. At the dawn of the scientific revolution, and as a challenge to the logicist, Latinist scholasticism of the late Middle Ages, Galileo made his famous declaration: “The great book of nature is written in the language of mathematics”[8]. Geometric (or

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8 “Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the characters in which it is written. It is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures without which it is humanly impossible to understand a single word of it; without these, one is wandering in a dark labyrinth”, Galileo Galilei, *Il Saggiatore* [*The Assayer*], [GAL 1623]. In his article “La Nature prise à la lettre,” in *Alliage* journal, no. 37-38 (1998), the physicist Jean-Marc Lévy-Leblond, after commenting on this quotation from Galileo, updates it as follows for contemporary physics: “The new way of writing physics has [...] the consequence

mathematical) language is a particularly convenient tool for the description or translation of symbolic systems. Indeed, since it is free of the ambiguities and polysemy of expressions in natural languages, it is a tool for the univocal (unambiguous) encoding of systems of symbols and their rules. It may also be used – most of the time, at least – to calculate the possible configurations of symbolic systems and the different types of possible transitions between these configurations. Since the scientific process is characterized by maximum explication and the operative nature of its models, it only considers information through the abstraction of formalized symbolic systems written in mathematical language.

2.2.2. *The sources of the information paradigm*

From the 1930s to the 1950s, authors such as Alan Turing, Warren McCulloch, John von Neumann, Norbert Wiener and Claude Shannon laid the foundations of what may be called the information paradigm of contemporary science. They brought information and its processing into the domain of scientific knowledge. At the same time, they set in motion a reinterpretation (which is still under way) of science as the formalization of information processes and pointed the way to the (re)discovery[9] of nature as information: information nature[10].

In 1936, Alan Turing (1912-54) published[11] a description of an abstract machine[12] consisting of a theoretically infinite recording medium, a tape, with a

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that its combinations of signs do not just present an encoded recording, a kind of passive stenography of the laws of the world, but constitute a true symbolic machine putting those laws into action. Thus the sign used for integrals (which we owe to Leibniz) and the sign used for derivatives do not only designate specific mathematical entities, but actually refer to the operations of integration and derivation used to produce these entities. We could no doubt speak of technograms. There is in every formula a virtual algorithmic mechanism ready to be activated at any moment by a physicist who will apply it to some concrete situation. An equation is not a static statement, a mere observation; it contains a mechanism of computation (of solution) that is always ready to produce new numerical or conceptual results". [Translation] On the often-discussed relationship between physical reality and its mathematical models, see the *Penser les Mathématiques* collection [DIE 1982].

9 I speak of a (re)discovery because in many respects Aristotelian philosophy (with its central concept of form, itself inherited from the Platonic idea) anticipated the concept of information.

10 I am speaking of information nature in a general, inclusive sense, without going to the extremes of researchers such as Stephen Wolfram, for whom space and time are discontinuous rather than continuous (because computers calculate in a discontinuous way) and cellular automata are the royal road to all scientific modeling. See [WOL 2002].

11 "On computable numbers, with an application to the Entscheidungs problem", *Proc.*

read/write head that could read, write and erase symbols in squares on the tape. Turing described this machine as universal because it could not only record input and output data of arithmetical and logical calculations, but could also contain all possible programs with deterministic mechanical rules defining the processes for going from input data to output data. These programs, or algorithms, govern the operations of the read/write head through finite sequences of instructions. The Turing machine is described as universal because, instead of being specialized in a certain type of data processing, it is programmable, i.e. it is theoretically capable of executing all calculable functions. In other words, the only calculable functions are those that can be executed in a finite time by the universal machine, on condition that it is properly programmed. Turing used his theoretical universal machine to demonstrate that there is no program (no calculable function) that allows us to decide in every case whether a given function is calculable or not. Even before the creation of the first computers, which only occurred about a decade later[13], Turing had thus described the abstract model of a computer, or a non-specialized automaton for manipulating symbols. As early as the 1930s, the mechanisms for information processing were "dematerialized" – at least theoretically – in the form of programs or software, and the concept of an automaton that manipulated symbols was defined in the broadest sense.

In an article published in 1943 – anticipating later research in the cognitive sciences, neuroscience and artificial intelligence – the psychiatrist Warren McCulloch (1899-1969)[14] described the brain as a network of automatic information processors. The "formal neurons" of McCulloch's model are simple logic and arithmetical machines receiving input signals (through their dendrites) and emitting output signals (through their axons). Despite the structural simplicity of the formal

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London Math. Soc, Vol. 42, no. 2, pp. 230 – 265, 1936–7. The best source on the life and work of Turing is Andrew Hodges, *Alan Turing: The Enigma* [HOD 1992].

12 The concept of an abstract machine (independent of its material implementation in the form of technical hardware or natural physicochemical networks) is one of the great scientific themes of the 20th Century. Scientists such as Turing, Von Neumann, von Foerster, Herbert Simon and Marvin Minsky (in *Finite and Infinite Machines* [MIN 1967]) worked on this, and after them, important schools in the cognitive sciences and artificial intelligence applied it to the human sciences. Gilles Deleuze and Félix Guattari used it in an unorthodox way in philosophy in *Anti-Oedipus* [DEL 1977] and *A Thousand Plateaus* [DEL 1987b].

13 See my chapter on the invention of the computer in *Eléments d'Histoire des Sciences* [SER 1989].

14 Warren McCulloch and Walter Pitts, "A logical calculus of ideas immanent in nervous activity", *Bulletin of Mathematical Biophysics*, Vol. 5, pp. 115-133, 1943. McCulloch's main articles are collected in: *Embodiments of Mind* [MCC 1965]. See also my articles "Brève notice sur les vies de Warren McCulloch et Walter Pitts," in *Cahiers du CREA*, Vol. 7, pp. 203-210, 1986, and "L'oeuvre de Warren McCulloch," in *Cahiers du CREA*, Vol. 7, pp. 211-255, 1986.

neurons described by McCulloch, their interconnection in networks and their combination with a memory gives them the power of Turing's universal machine. The theoretical model of the brain proposed by McCulloch, although obviously simplified in comparison to a real brain, still described for the first time the capacity of organic brains to calculate and reason, i.e. to manipulate symbols in an organized way.

In the 1940s, mathematician John von Neumann (1903-57), who was familiar with the work of Turing and McCulloch, drew up plans for one of the first programmable electronic computers (the EDVAC) – plans that computer scientists would draw on for decades to come[15]. He also worked in the 1950s on developing the theory of symbol-manipulating automata, exploring their self-referential and self-reproductive capacities[16]. Von Neumann applied his theories to biology and the neurosciences and cognitive sciences, which were developing rapidly at the time, as well as to economics, using game theory, which he helped found[17].

The engineer and mathematician Norbert Wiener (1894-1964) contributed to opening up an interdisciplinary field (baptized "cybernetics") to study information processing[18]. The originality of his work lies in the fact that teleological (goal-oriented) behaviors were for the first time being studied independently of their biological, social, psychological or artificial nature. Following in Wiener's footsteps, the cyberneticists of the 1950s, 1960s and 1970s showed that the capacity to pursue goals in changing environments – which is observed in living organisms, cognitive systems, human societies or industrial servo-mechanisms – was based on the circular causality of their feedback circuits. It was therefore ultimately based on the complex structure of their information communication and processing systems.

Working at the same time with slightly different formalisms, Claude Shannon (1916-2001) and Norbert Wiener devoted themselves to quantifying information, using probability theory and reusing classical mathematical models from

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15 John von Neumann, First Draft of a Report on the EDVAC, Contract No. W-670-ORD-492, Moore School of Electrical Engineering, Univ. of Penn., Philadelphia, 30 June 1945. Reproduced (in part) in Brian Randell, *Origins of Digital Computers: Selected Papers* [RAN 1982], pp. 383-392. See also [VON 1946].

16 See John von Neumann, *The Computer and the Brain* [NEU 1958], and John von Neumann and Arthur Burks, *Theory of Self-Reproducing Automata* [NEU 1966].

17 See John von Neumann and Oskar Morgenstern, *Theory of Games and Economic Behavior* [NEU 1944].

18 The founding article is Arturo Rosenblueth, Norbert Wiener and Julian Bigelow, "Behavior, purpose and teleology" [WIE 1943]. Wiener's two main books are *Cybernetics, Control and Communication in the Animal and the Machine* [WIE 1948] and *The Human Use of Human Beings: Cybernetics and Society* [WIE 1950].

thermodynamics[19]. According to the second law of thermodynamics, a closed physical system spontaneously evolves toward a state of "disorder" or homogeneous balance. Classical thermodynamics therefore posits that statistical disorder or homogeneous balance is *the most probable state* of a closed physical system. On the basis of this theoretical given of thermodynamics, Shannon and Wiener associated information with an *improbable* order or structure as opposed to the probability of entropic disorder. Information is a "negentropy".

Shannon proposed to quantify the information carried by a message by measuring how much it reduced uncertainty for the receiver. If a message tells me that the sun will come up tomorrow morning, the information (the difference produced in my knowledge of my environment) generated by my reading will be nil. But if a message tells me that I have won the big prize in a lottery, the amount of information it contains will be very high, especially since the odds of winning the jackpot in a lottery are extremely low. The information carried by a message is therefore very much a function of its improbability. It should be noted that the improbability itself is not in the message, but in the relationship between the message and the receiver's memory or knowledge. Thus, according to Shannon's approach, a second reading of the message about my winning the lottery obviously provides no additional information. The unit of measurement of the quantity of information, the "bit", is perfectly consistent with this probability approach to information. It is assumed that information is transmitted through a message encoded in binary, the basic symbols of which are 0 or 1. Before we read a symbol, there is one chance in two that it will be 0 and one chance in two that it will be 1. Reading a basic symbol reduces the probability of the presence of the symbol read from *one half* (50%) – before reading – to *one* (100%) – after reading. Each binary symbol contains one *bit* of information.

2.2.3. *Information between form and difference*

The concept of information is particularly difficult to grasp, and no simple definition completely does justice to its polysemy and its transversality. Rather than a definition, I would like to present below the beginning of a meditation on its complexity.

Two transdisciplinary concepts essential to the information paradigm emerge from the work of its founders: form and difference. Information as form is inseparable from a constellation in which it is associated with concepts of code, transmission, translation, noise and redundancy. For information as difference, it is

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19 Claude Shannon and Warren Weaver, *Mathematical Theory of Communication* [SHA 1949].

meaningful in a semantic network in which the concepts of operation, operators and transformation play major roles.

As form, information can be seen as an abstract structure, or a specific position in an abstract structure. I have already mentioned the close relationship between the idea of information and that of the configuration of a symbolic system. Form is abstract, as we have seen, insofar as it is – in principle – independent of its material medium. But form has yet another degree of abstraction. It is not enough to say that a code (a symbolic configuration) must be distinguished from its material inscription. We have to add that at the higher level of abstraction, a given symbolic configuration represents only one among several possible encodings of a form. Indeed, the same form can be expressed in many different encoding systems. Just as a symbolic configuration must necessarily be inscribed in the phenomenal world, a form must be encoded in a symbolic system in order to be defined.

A form cannot be manifested without encoding. For example, the number 12 can be encoded in the phonetic alphabet (*twelve*), in the Roman numeral system (XII), in the base two number system (1100), in the base 10 number system (12), etc. As you might guess, these different encoding systems are not at all neutral or insignificant. Suffice it to note here that there are always many possible systems of encoding of a form, and that – to come back to the example just given – the concepts of numbers (numbers as abstract forms) exist independently of their encodings in specific symbolic systems. We can define forms as *what remains invariant from one system of encoding to another*. Whatever the encoding that allows it to be manipulated physically and cognitively, the number 12 remains the number 12, and it is always divisible by two, three, four and six. Similarly, an image or a sound can be encoded in analog format (in a traditional radio or television station) or digital format, and the digital encoding itself can be done in a large number of different formats. Concepts can also be considered as abstract forms that are encoded in natural-language expressions or codes belonging to systems of scientific notation (both natural languages and systems of scientific notation are obviously symbolic systems). For example: the concept of tree can be encoded in French as the word *arbre*, in English as the word *tree* and in Latin (in Linnaeus's classification) as the word *arbor*; the concept of water is encoded in French as *eau*, in English as *water* and in chemical notation as H_2O, etc. In all these examples, something (the form) is preserved in the series of translations. But it is impossible to apprehend the invariable form *independently* of the specific variants presented in its translations[20].

Forms cannot only go from one encoding system to another through translation, but they are also capable of crossing time and physical space through transmission.

20 Ludwig Wittgenstein has some profound thoughts on this subject in *Tractatus* [WIT 1921]; see propositions 4.0.1 and 4.0.2 with their subpropositions.

We can define transmission as the combination of transportation through space and conservation in time. For example, in telephone networks a certain abstract form can be preserved in the translation between a variation in atmospheric pressure (a sound) and a variation in the electrical current (and vice versa), but the form is also preserved in the transportation from one place to another and in the relative permanence from one point in time to another.

In addition to the concepts of encoding, translation and transmission, information as form is closely associated with the concepts of noise and redundancy. Noise, like a parasite[21], degrades information circulating through transmission channels. Conversely, redundancy – or repetition of form – preserves information from the noise that threatens it. But the relationship of noise and redundancy to information is complex and almost paradoxical. Since the effects of noise are unpredictable, it adds improbability – and thus information – to the message it degrades. However, the more redundant a message is – the better it preserves its form – the less information it contains. These strange relationships between information, noise and redundancy have led to the definition of the creation of information in terms of the destruction of redundancy (for example, in learning theory and the neurosciences)[22] and an understanding of how what appears to be noise or interference in messages at a certain level of complexity can be interpreted as the emergence of information at another level[23]. To appreciate the profundity of this idea, it is sufficient to recall that all of biological evolution – one of the most impressive natural processes for creating complexity – is fuelled by mutations in the genetic memory of organisms, i.e. by "errors" of reproduction – noise – in the transmission of genetic messages between generations.

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21 In *The Parasite* [SER 1982], Michel Serres presents a transdisciplinary meditation (between biology and anthropology) on the concept of the parasite (which also means "static" in French), in which communication theory plays a pivotal role.

22 Jean-Pierre Changeux and Antoine Danchin, "Selective stabilization of developing synapses as a mechanism for the specification of neuronal networks" [CHA 1976].

23 The pioneering work in this field was done by Heinz von Foerster. His main articles are collected in *Observing Systems*: *Selected Papers of Heinz von Foerster* [FOE 1981]. Von Foerster (1911-2002) was secretary of the Macy Conferences, where cybernetics was developed in the late 1940s, and he directed the Biological Computer Laboratory at the University of Illinois from 1958 to 1975. He can be considered one of the founders of "artificial life", he is recognized as a leading figure in constructivist epistemology and he was one of the leaders of "second cybernetics", which focused on problems of self-organization and self-reference. See my article "Analyse de contenu des travaux du Biological Computer laboratory (BCL)" [LÉV 1986a]. The most subtle of the theories on the creation of complexity from noise was developed by the biologist and philosopher Henri Atlan (1931-) in his first two books: *L'Organisation Biologique et la Théorie de l'Information* [ATL 1972] and *Entre le Cristal et la Fumée* [ATL 1979].

Anthropologist Gregory Bateson (1904-80) developed a holistic epistemology of communication based on the main ideas of cybernetics[24]. His definition of information is often quoted: "a difference which makes a difference". Information *is* a difference, first of all, because a form is completely determined only by the place it occupies in a world of forms. The number 12, for example, is only what it is in relation to its factors (two, three, four and six), and in relation to 11, which it follows (12 equals 11 plus one) and with which it contrasts (11 is a prime number), etc. Ultimately, 12 is a particular numerical form only against the complex background of the entire system of numbers, i.e. as a result of all the differences between it and the other numbers. A form (here, a number) can be represented as a node of differences in the network of differences that is the world of forms. To return to the example of chess, a certain configuration on a chessboard has meaning only in relation to the configurations that preceded it and those it gives rise to, and ultimately, only in relation to the differences between it and all the configurations the rules of the game allow for. A musical note is distinguished by a position on a scale, and thus by its difference from the other notes, but also by differences of pitch or length from the notes that precede it and follow it in a melody, etc.

In short, the possible configurations of symbols, or the possible transitions between configurations in a symbolic system, constitute the ground against which a particular combination or a particular transition stands out as a figure, i.e. as a node of differences in the differential network of the system. And these differences "make differences", according to Bateson's definition, when the flows of messages result in differences of probability – or decreases in uncertainty – in the representation of the world or the cognitive functioning of their receivers. Indeed, what makes any particular difference *information* is that it carries *knowledge*: it "makes a difference" for a cognitive system.

For Aristotle (384 BCE-322 BCE), form is one of three possible definitions of substance, the other two being: (i) matter and (ii) the compound of matter and form[25]. While form presents the static or substantial aspect of information, difference presents its dynamic aspect, its aspect as event or process. Difference lies *between* forms. In other words, if a form can be compared to a position in an abstract universe of interdependent structures (the universe of numbers, figures, sounds, etc.), a difference can be compared to a virtual movement in that universe: the path from one position to another. I am speaking of a universe that is abstract in that it is not contained in ordinary three-dimensional space, but in what is called in physics a

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24 Gregory Bateson's key ideas are condensed in two collections of articles: *Steps to an Ecology of Mind*, 2 vol. [BAT 1972], and *Mind and Nature: A Necessary Unity (Advances in Systems Theory, Complexity, and the Human Sciences)* [BAT 1979]. The titles of these books give an excellent idea of Bateson's work.

25 See *On the Soul*, II, 1 [ARI 2009b].

phase space (the coordinates of which are the variables of a system) or in philosophy and literary theory, a "space of possibles"[26]. For example, a particular arrangement of pieces on a chessboard would represent a "point", and match a "succession of points" in the ultra-complex space of possible chess configurations. In the case of chess, this space can be seen as a decision tree that is much larger and more complicated than the 64 squares of the two-dimensional chessboard.

The passage from one form to another is a "trans-formation". In other words, the difference between two forms (between two points in a space of possibles) implies – at least virtually – an operation of transformation between the forms being compared. Difference only becomes completely defined when the operator that allows it to go from one form to another can be identified. Information then moves toward the operation or the act: it produces knowledge, it informs, it makes a difference. Information becomes transformation. Hence the affinity of the concept of information with that of function: an input form is "trans-formed" into an output form by a difference operator. It follows from the preceding discussion that information, which can take a multitude of forms, exists in both the variable forms and the difference operator: calculable functions are at the very heart of the concept of information. Information is *functional*. Given the affinity between the concepts of function and information, and since part of scientific activity involves formulating theories functionally, it is not surprising that the contemporary scientific process was led to discover an information nature.

2.2.4. *Information and time*

It is a commonplace in contemporary epistemology that phenomena become scientifically intelligible only if a theory filters them, homogenizes them and encodes their relationships[27]. What does this mean? The information process is organized and flows in complex circuits. The Romance languages can use the word *information* in the plural ("an information" or "informations"), whilst in English, in which the word is invariable, considers information as fluctuating energy or matter taken as a mass, like electricity or water. We can thus think of information in terms of waves in a continuous field of transformations (as in English) or in terms of particles of transformation in interaction in the same space of mutations (as in the Romance languages). The fact remains that information nature as explored by contemporary science reveals dynamics of transformations, fluctuations of forms in universes of calculable differences. These transformations are computable, explicable, interpretable, transparent to reason only because they are defined by

26 See Pierre Bourdieu, *Rules of Art: Genesis and Structure of the Literary Field* [BOU 1996].
27 See Karl Popper, *Objective Knowledge* [POP 1972].

appropriate symbolic systems or "theories" that are duly mathematized. In English as in the Romance languages, nature as modeled by contemporary scientific activity consists of information *events*[28]. In this framework, an event is a particular transformation within a coherent, calculable system of transformations of symbols. The modelable event can be thought of as a disruption of symmetry: from among all the available moves that respect the rules of the game, the chess player advances *this* pawn, and thus disrupts the symmetry of possibles.

In this meditation on time and information, the metaphor of the game takes us back to the thought of one of the founding thinkers of Western philosophy. The *aion*, said Heraclitus, is a boy-king throwing dice[29]. The dice represent a calculable system of symmetric transformations. The boy-king breaks the balance outside time, the balance among all the possibles. In the instant of his throw, Heraclitus' dice player establishes a dissymmetry between before and after. The event shatters the symmetry – and flows of information spring into the fluvial network of its fault lines. On one side is a group of symbolic transformations outside the space–time continuum – something like eternity, let us say. On the other side, a whirlwind of changes caught in cyclical processes of birth, metamorphosis and death: fleeting time, fragmented moments of generation and corruption. Heraclitus' *aion* points toward the flashes of information that crackle between the moments and eternity. Established in the middle of time like a playing child who is neither wholly in the structural eternity of the game nor wholly in the present of the throw nor in its irreversible and sequential consequences, this cosmic egg[30] binds the relationships between temporalities. Heraclitus is one of the first great thinkers of the *logos* and one of the best known of those who affirmed becoming, universal flux, impermanence: "You cannot step into the same river twice"[31]. Heraclitus' *logos* is both unique and common to all human beings. It expresses the cosmic order, yet it is separate, transcendent. While *becoming* characterizes the data of the senses, it is nonetheless essential to a profound understanding of the *whole* in its aspects of conflict, war, multiplicity, fragmentation and transformation.

The *aion* of information connects the *logos* (at the north of the cosmic egg) to *becoming* (at the south). It actualizes the irreversible succession of throws and virtualizes the reversible eternity of symbolic systems[32].

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28 See, for example, the first propositions of Wittgenstein's *Tractatus* [WIT 1921]: "The world is everything that is the case", and what follows.

29 Fragment 52.

30 See Pierre Boyancé, "Une allusion à l'oeuf orphique" [BOY 1935].

31 Fragment 49a.

32 On Heraclitus, in addition to the fragments themselves, see Kostas Axelos, *Héraclite et la Philosophie* [AXE 1962], and Clémence Ramnoux, *Héraclite, l'Homme Entre les Choses et les Mots* [RAM 1968].

2.3. Layers of encoding

2.3.1. *A layered structure*

Contemporary science "reads" or interprets nature according to an explicit hierarchy of types of forms (quantum, molecular, organic, etc.), and levels of encoding and information processing corresponding to these types. Each layer of information nature is studied by a discipline or a group of disciplines. In this section, I will describe how the forms of one layer are translated into forms of another layer through interfaces of transcoding, thus permitting the information processes to cut across the multiple layers of complexity. I will show, for example, that there is a neural transcoding of information between the organic forms observed in biology and the phenomenal forms studied in cognitive psychology.

Since the universes of heterogeneous forms are modeled – or encoded – by researchers using different symbolic systems, the unity of nature depends on the transcoding interfaces between these symbolic systems. This perspective is clearly very different from reductionism, in which there is only one relevant (or "central") universe of forms such as that of physics, biochemistry or the neurosciences. In contrast, in the approach I am proposing here, all universes of forms (all symbolic systems) are equally legitimate, and they are both the source and the destination of the information flows that "ascend" and "descend" the "ladder" of nature's complexity.

It is very possible that the hierarchy of layers I am now going to present will be overturned by new discoveries or reorganizations in the sciences, like those that have already occurred in the past. All I am doing here is proposing a general overview of the structure of information nature as it is understood relatively consensually in the scientific community in the early 21st Century. I have no desire to carve anything in stone or invalidate other possible synthetic approaches.

2.3.2. *The physicochemical and organic layers*

At the first level of the hierarchy, physics studies the mass/energy and wave/particle forms of information processes according to quantum and relativity frameworks of analysis. Chemistry or, as it is increasingly called, the molecular sciences, deals with the forms and transformations of molecules. Between molecular forms and quantum forms there is an atomic interface or level of encoding. There are only a little more than a hundred elements (or categories of atoms), and all molecules can be described, or "written", using three-dimensional diagrams of atoms. The periodic table of atomic elements (called Mendeleev's Periodic Table after the Russian chemist who invented it) shows the "alphabet" with which molecular "texts" are written[33]. From the perspective of the hierarchy of information levels I have adopted here, we can say that atoms encode, or inscribe, the molecular forms in the quantum layer.

At the next level higher, the organic or biological layer, the main forms are organisms, i.e. self-organizing and autopoietic (or self-constructing) cycles[34] of molecular dynamics. Organisms reproduce through the transmission of genetic memory encoded in molecules of DNA. The genetic "texts" are made up of sequences of four nucleobases: adenine, thymine, cytosine and guanine (the four "letters", A, T, C and G, of the genetic "alphabet")[35]. The intertwining lineages of organisms or populations that coordinate to transmit a collective genetic memory are called species. Relatively stable cycles of exchange and communication among different species are interlinked at a higher level of complexity to form ecosystems. We say that species are "adapted" to the ecosystems in which they take part and reproduce. The recombinations and mutations of the genetic texts transmitted by organisms−whatever the origins of those transformations − contribute to the emergence, differentiation and disappearance of species and ecosystems.

In short, biology studies the organic forms of information processes at different levels of composition (cells, tissues, organisms, species and ecosystems). Among biological processes, important mechanisms for reading/writing the genetic text carry out transcoding between molecular memory and organic forms and transmit genetic memory between organisms of the same lineage[36]. The genetic texts encode, or inscribe, the organic forms in the molecular layer.

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33 See Gaston Bachelard, *Le Pluralisme Cohérent de la Chimie Moderne* [BAC 1932] and Isabelle Stengers and Bernadette Bensaude-Vincent, *Histoire de la Chimie* [STE 1993].

34 The concept of autopoiesis in biology was developed by Humberto Maturana (1928-) and Francisco Varela (1946-2001), biologists and philosophers born in Chile, who worked with Heinz von Foerster. On the concept of autopoiesis, their main works are *Principles of Biological Autonomy* [VAR 1979], *Autopoiesis and Cognition* [MAT 1980] and *The Tree of Knowledge: The Biological Roots of Human Understanding* [MAT 1988]. It should be noted that Maturana and Varela's concept of autopoiesis plays a key role in the sociology of Niklas Luhman (1927-98); see his *Social Systems* [LUH 1995].

35 See the following works by two of the main actors of the information revolution in molecular biology: Jacques Monod, *Le Hasard et la Nécessité: Essai sur la Philosophie Naturelle de la Biologie Moderne* [MON 1970], and James D. Watson, *The Double Helix: A Personal Account of the Discovery of the Structure of DNA* [WAT 1968].

36 We know that in the case of microorganisms, the exchanges of genetic texts can be more transversal and that viruses *inject* fragments of text into other organisms in order to reproduce.

2.3.3. *The phenomenal layer*

Above organic forms, and directly dependent on them, are phenomenal forms. The word *phenomenon* comes from the Greek verb *phainein*, meaning "to appear" (appear to the senses in perception, or to experience in general). These perceptible appearances correspond to the products of sensory-motor[37] and affective cognition in animals with nervous systems. Animals – and only animals – can see, hear, touch, feel, imagine, dream or play actively with the images – the perceptible forms – that are phenomena.

Phenomena are far from being objective representations of "physical reality", since they present forms that do not exist at lower levels of the layers of information. To take only two familiar examples, colors and sounds do not come directly from the physical information layer (where we would search for them in vain), but are computed through complex neural processes from the way certain periodic variation in the electromagnetic field or atmospheric pressure affect the sense receptors. Bees see colors we do not see and bats hear sounds we cannot hear because they perceive different parts of the spectrum of electromagnetic or acoustic frequencies and make different calculations using these "measurements". Animals do not have representations of phenomena that exist before they are computed, but rather they actively produce them through neural calculations in the course of their interactions with their environment. Moreover, the phenomenal images produced in this way are not perceived "remotely" in a neutral way, but fully translate the organic reactions of the animals. They are thus usually colored by pleasure or pain, influenced by affects, desires and intentions, marked by goals, or imbued with more or less complex qualities of attraction or repulsion. Emotions play a significant role in cognition[38], since they result in behavior and contribute to the interpretation and shaping of phenomenal images. The complexity of the affects that color and reorganize data from the senses is especially highly developed among social mammals, including, of course, humans. This socio-affective processing of information is studied in ethology[39].

As in the lower levels, the layer of phenomenal forms is connected to the previous layer (the organic layer) through a system of encoding. The interface between organic forms and phenomenal forms is provided by the neural transcoding of information, which includes not only the dynamics of the oscillation of electrical

37 The psychologist and epistemologist Jean Piaget (1896-1980) was one of the first researchers to point out that cognition results from a sensory-motor loop. See *The Origins of Intelligence in Children* [PIA 1952].

38 See, for example, Antonio R. Damasio, *Descartes' Error: Emotion, Reason and the Human Brain* [DAM 1994].

39 See, for example, Boris Cyrulnik, *The Dawn of Meaning* [CYR 1993].

impulses in the neural networks, but also the delicate chemistry of the hormones and neurotransmitters that affect nerve reactions. Organisms without nervous systems cannot perceive phenomenal forms or visual, acoustic, olfactory, tactile, gustatory, synesthetic or kinesthetic images accompanied by emotions.

In the phenomenal world, forms follow one another rhythmically according to cycles of recurrence and complex patterns of differences and repetition. The "objects" of actions and perceptions emerge as invariant structures from waves of transformation in sensory-motor cycles[40]. The figures and textures of phenomenal experience follow one another sequentially – one by one – but this succession is invariably accompanied by operations of distinction and comparison among forms, which thus always stand out against a background of duration or memory[41]. Memory can be considered the characteristic context of the phenomenal world, the abstract (non-physical) space where phenomenal forms interact. But this abstract space is based on physical space, and it is obviously the nervous system that provides the main organic substrate where memory and learning are encoded. For short-term memory, this inscription takes the form of a recursion of streams of impulses in the neural circuits. For long-term memory, learning and operational habitus are inscribed instead in the transformations of neural connections[42].

In short, the nervous system forms a computational bridge between organic information and phenomenal information. At one end of the bridge, the nervous system is rooted in the world of organic forms, since it is composed of a network of closely interconnected cells in which the dynamics of electrical impulses and chemical exchanges take place. The nervous system is in constant interaction with the rest of the organism and its immediate physical environment. At the other end of the bridge, the nervous system computes the dynamics of phenomenal forms that develop in the sensory-motor and emotional experience of animals. The nervous system translates between organic processes and phenomenal experience along a self-organizing cognitive loop. It encodes the phenomenal forms in the world of organic forms.

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40 Again, the fact that permanent "objects" are *constructed* through cognitive activity – at least in humans – based on invariants in sensory-motor loops was pointed out by Jean Piaget. See his *Genetic Epistemology* [PIA 1970a].

41 The role of memory in cognition is studied by the contemporary cognitive sciences, but it had already been very closely analyzed by philosopher Henri Bergson (1859-1941) in *Time and Free Will: An Essay on the Immediate Data of Consciousness* [BER 2001] and *Matter and Memory* [BER 2004].

42 See John R. Anderson, *Cognitive Psychology and Its Implications* [AND 2005] for a general summary. For a specialized book on memory, see Eric R. Kandel, *In Search of Memory: The Emergence of a New Science of Mind* [KAN 2006].

2.3.4. *The symbolic layer*

At the highest level of the information hierarchy, the human sciences study the encoding and symbolic processing of information. I have already mentioned the systemic, regular nature of symbolism. I will now discuss its semantic, or signifying, aspect. The word *symbol* comes from the Greek *symbolon*, which means “to put together”. (Similarly, the word *algebra* comes from an Arabic word meaning “linking”, “joining” or “assembling”.) In addition, it refers to the custom (also Greek) of breaking a fragment of pottery into two pieces and giving one piece to each of two people so that they will be able to recognize each other in the future by joining the two pieces of pottery along the line of fracture. A symbol is precisely the fragment that is broken and joined; already in its etymology, as in the Greek method of recognition, symbolism is linked to a dialectic of duality in unity: the symbol conjoins or rejoins two distinct pieces of a continuum. The continuum can be interpreted as that of information nature. As for the two pieces, they could designate the layer of phenomenal forms (and all those below it), on one hand, and the layer of ideal forms, on the other hand. The symbol provides the interface between these two layers.

But what are the ideal forms, those abstract categories that the symbols connect to the phenomenal forms? At first glance, the symbolic connection between these two distinct types of forms, ideas and phenomena, corresponds to the well-known duality between signified and signifier – the two parts of a symbol – identified by linguist Ferdinand de Saussure in the early 20th Century[43]. For example, the signifier *tree*, whether the sound image of the spoken word or the visual image of the written word, belongs to the phenomenal world. As for the meaning, or the signified, of the word, it is a certain class of plant. The signified thus belongs – as a class or category – to the universe of abstract forms. On one side, there is a sound; on the other, a category. Signifieds, the kind of forms to which symbols give us access, would therefore be classes, types, general ideas, abstract essences, universals and other properties common to many individuals. By *categories*, I am referring not only to classes of phenomena, but also to the classes of symbols, classes of classes,

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43 Ferdinand de Saussure (1857-1913) was a Swiss linguist whose work is known through course notes published by some of his students [SAU 1916]. He is considered one of the founders of structuralism in linguistics, and his influence has extended to many fields of human sciences. For example, he influenced Claude Lévi-Strauss and Jacques Lacan. I would point out, however, that even though the words (the signifiers) used have varied widely, the conceptual distinction between signifier and signified is very old. We already find it in Plato, in the dialog *Cratylus* [PLA 1963], and in the first chapter of Aristotle’s *On Interpretation* [ARI 2009 a]. Whatever it is called, the signified/signifier distinction has been discussed by most philosophers, grammarians, linguists and semioticians in the Western tradition and it is also found in almost all non-Western scholarly traditions.

relationships between classes, and classes of relationships that proliferate on the signified side of symbolic life. These abstract forms are impossible to apprehend directly through the senses: no one has ever touched or seen a type or a category. Only a phenomenal representation (an image) of a category can be perceived by the senses. Thus, systems of symbols encode abstract categories using sensory images, permitting indirect perceptual apprehension, manipulation, sharing and transmission of abstract ideas within human communities.

This description is simplistic, however. In fact, it is a particular visual or sound *occurrence* of the signifier that belongs to the phenomenal world, not the signifier itself. We hear pronunciations of the signifier *tree* and not the signifier itself, which, strictly speaking, is identified with a *class* of sounds, occupying a particular place in the system of phonological differences and combinations of the language. In strictly acoustic terms, every pronunciation of the same word is different, so that recognizing or hearing a word means classifying it (usually automatically) in a class of sounds. Any signifier is therefore already itself a class of occurrences, a type, not only in the case of language, but in any symbolic system.

We have not yet distinguished the specific nature of the signified by defining it as belonging to the universe of classes or categories – because signifiers are also categories. We should not be surprised to find categories everywhere, because perception, in particular, and cognition, in general, necessarily involve categorization. It is clear, in fact, that animals, though they do not have access to symbolic life[44], are capable of classifying phenomena. What is more, the very nature of phenomena implies that they are structured through the activity of categorization. I have already mentioned the obvious capacity of animals to identify "objects" despite variations in sensory data; for example, they distinguish, between prey and predators, therefore they categorize. Not only can an ape recognize the same banana in different lighting, but it also clearly recognizes that this thing is a banana (a specimen of the category *banana*), of which it possesses the shape, color, smell and taste. Categorization is an essential dimension of animal cognition. It thus occurs at the presymbolic level. When we think about it, it is clear that perception without categorization would be nothing but a chaos of raw sensations that would be useless for action, and memory without categorization would not permit comparison, recognition, etc. The sensory-motor cognitive loop changes sensory data (coming through the retina, skin, eardrums, olfactory and synesthetic receptors, etc.) into motor data (control of muscle movements, hormone secretions, etc.), and motor data in turn feed (via the internal and external physicochemical environment of the

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44 I acknowledge this exclusion, which some view as reprehensible. Indeed, if we were to say that animals have access to symbolic manipulation and to the type of reflexive cognition and cultural evolution it makes possible, what would distinguish animal cognition from human cognition? And how would we explain the unique *fact* of human culture and its evolution?

organism) sensory data. The part of the information circuit – the neural calculation – that goes from the receptors to the effectors "controls" the data provided by the sensory receptors as much as is possible: avoid pain, catch a prey, etc. This control of perceptual data operates through the production of animal experience, i.e. through the emergence of distinct and comparable phenomenal forms within a memory. However, phenomenal forms are distinct and comparable precisely because they are produced or modeled by operations of categorization.

Now that it is clear, first, that categorization occurs in presymbolic cognitive processes, and second that even at the symbolic level, signifiers are already categories. The question of the specificity of the signifieds of symbolism can be formulated as follows: what is the unique identity of these abstract categories (signifieds) that symbolic cognition connects to categories of phenomena (signifiers)? Before offering my answer to this question, I would like recall that, in general, a class of operations can be represented by an operator. It can be logically deduced from the preceding proposition that a class of operations of categorization can be represented by a categorization operator. In causal terms, a category of phenomenal forms assumes a mechanism of categorization that actively imposes belonging on members of the category. This mechanism shapes phenomena on the basis of sensory-motor data and attributes to them the properties that make them members of a category[45]. From the point of view of the functioning of cognition, the actualization of any category in specific phenomenal forms necessarily assumes the existence of a categorization operator.

This being said, my answer to the problem of the identity of symbolism is as follows: the signifieds referred to by signifiers structured by symbolic systems are categorization operators. In contrast to presymbolic cognition, symbolic cognition categorizes (through signifiers) not only sensory-motor data but categorization operators. The nature of symbolic cognition is that it weaves a phenomenal world where signifiers polish the reflections of its operations. Human intelligence is reflexive – or self-referential – because its cognitive operators are projected in the phenomenal world in order to categorize themselves. I will analyze reflexivity in

45 This idea is as old as philosophy. See, for example, near the beginning of Plato's *Parmenides* (132d) [PLA 1963a]: "The best I can make of the matter is this – that these forms are as it were patterns fixed in the nature of things. The other things are made in their image and are likenesses, and this participation they come to have in the forms is nothing but their being made in their image". Neither set theory or the concept of function were available in Plato's time, but he conceived ideas as original, abstract (non-sensory) molds of phenomenal forms. When I claim that the ideas signified by the signifiers of symbolic systems are categorization operators that actively inform both the phenomena and the cognitive operations reflected in by symbolic cognition, I am not saying the same thing as Plato, but I am still relating to a tradition that attributes a formative role to ideas.

greater depth later, but I want to point out here the uniqueness of symbolic cognition in nature[46].

It is sometimes said that what distinguishes symbolism is its ability to represent or evoke a thing *in its absence*. This confuses index and symbol, since it seems that, beginning in presymbolic cognition, representations of absent objects can emerge from indexical signs and associations in memory. For animals, visual cues, smells and sounds evoke prey, predators or sexual partners. Pavlov's dog salivated when it heard a bell, even without food in front of it, because the bell had been associated with food during prior conditioning. More generally, the animal world, that of presymbolic cognition, already experiences signs and communication, since animals transmit, receive and understand many indices and signals. Like other signs, the symbol can thus communicate, evoke or re-present an absent phenomenal object, but its specificity lies elsewhere: it presents in phenomenal mode (its signifier) a cognitive operator (its signified), or even classes of operations on operators. When we recognize a tree, we carry out a cognitive operation of categorization through which we identify or categorize the phenomenon: "It is a tree". The signified of the signifier *tree* is precisely this *categorization operator* that we activate when we recognize a tree. This signified is not designated in isolation, but is addressed or situated in a complex network of cognitive operators that are encoded (often in a very flexible, even vague way) by a symbolic system – a language, in this example. Indeed, it is only because they play the complex roles specified by the semantic structures and syntactic rules of symbolic systems that signifying images can evoke categorization operators.

In the realm of virtuality, symbolism opens up to the self-creating loop of reflexive intelligence a semantic universe whose forms (signifieds) and transformations (cognitive operations on the signifieds) are of potentially infinite variety. As a result of the syntactic mechanisms provided by symbolic systems, cognitive operators represented by signifiers can themselves be part of complex operations such as composition, decomposition, arrangement, rearrangement, sorting, substitution, connection, disconnection, etc. Symbolism thus opens to cognition a practically unlimited dimension of recursively constructive complexity.

In the realm of actuality, cultural symbols encode cognitive operators in the world of phenomenal forms informed by these operators. Symbolic cognition can refer to things other than perceptual phenomena: beliefs, ideas, complex significations, stories, problems, etc. In order to be part of human experience, these things require the mediation of signifying images that function as phenomenal clothing – or masks – of the cognitive operators. Symbolism does give access to the workings of the cognitive machinery, but only on the stage of the phenomenal

46 See section 3.2.

world, i.e. under the revealing veil of the signifier. The phenomenal refers back to the neural, the neural to the organic, the organic to the molecular, and the molecular to the particulate. By transcoding the objects of the semantic universe in the phenomenal world and vice versa, human symbolic cognition connects the infinite openness of operations of categorization to all the previous layers of information nature.

The semantic universe comprises all the concepts – or abstract categories – that human cognition can deal with explicitly using symbolic systems. This semantic stratum occupies a very specific position in information nature. It is situated in the symbolic layer that emerges – with the human species – from the phenomenal, neural, organic and physicochemical layers. In the symbolic layer, the semantic universe is linked to the systems of signifiers that project its abstract objects into phenomena and thus enable it to be explored and transformed by the collective intelligence of talking primates.

2.3.5. *A synthetic view of the layers of information*

It may be useful to organize the layers of information nature around the north/south axis of the cosmic sphere. This axis is like a string of beads along which explosions of singularities (the beads) and encoding interfaces (the string between the beads) alternate, enabling two universes of complexity to communicate, as shown in Figure 2.1.

Beyond the South Pole, there is nothing, or rather an unfathomable, indeterminate, unobservable, unknowable chaos. At the South Pole, the layer of quantum-relativity encoding – ideally a unified system of symmetric transformations between space, time, mass, energy and velocity – connects all the complexity of the quantum universe to the dark background. This layer of encoding, like the others, is obviously a projection of human scientific activity. Quarks, hundreds of elementary particles, electromagnetic and gravitational waves and other manifestations of energy of all kinds make up the first bead. The teeming diversity of the quantum universe narrows with the atomic encoding that provides a kind of stable organization of material memory. There are 118 atomic elements, only 94 of which are observable in nature. After the bottleneck of atomic encoding, the second bead of complexity on our axial string is that of the molecular universe. Especially if we take macromolecules into account, the variety and complexity of the molecular universe, its cycles of transformation and exchange of energy are in principle unlimited. One more step to the north and there is another explosion of singularities, that of the organic world: from cells to organs, from organisms to the dynamics of populations and ecosystems. Between the molecular world and the organic world lies genetic encoding, based on the four nucleobases A, T, C and G organized in the double-helix structure of DNA. All living cells and all organisms use the same system of encoding – the same mechanism of transgenerational memory – of their internal structure and molecular composition. After the organic world, the next universe of complexity is that of the phenomenal world of animals: the sensory images, perceptions and emotions that are indissociable from interaction with the environment. Common to all animals is the neural interface – with its streams of impulses, the periodic excitation of its assemblies of neural circuits and its waves of chemical messages – that translates between the teeming world of perceptual phenomena and that of organisms. Finally, intersecting the plane of immanence at the cosmic equator, symbolic encoding connects and translates between: (i) the world of phenomenal complexity that ascends from organisms; and (ii) the expanding universe of semantic singularities, the ecosystem of concepts, the virtual time of songs and stories that occupies the northern hemisphere. This semantic universe, which is specific to human culture, is the last bead where information complexity broadens out… until the transformation group of the semantic sphere at the North Pole, the last net of calculable receptors projected by scientific thought, establishes an interface with the unthinkable, the irrational, the unknowable, the unsayable, the possible source – and inevitable end – of all cognition.

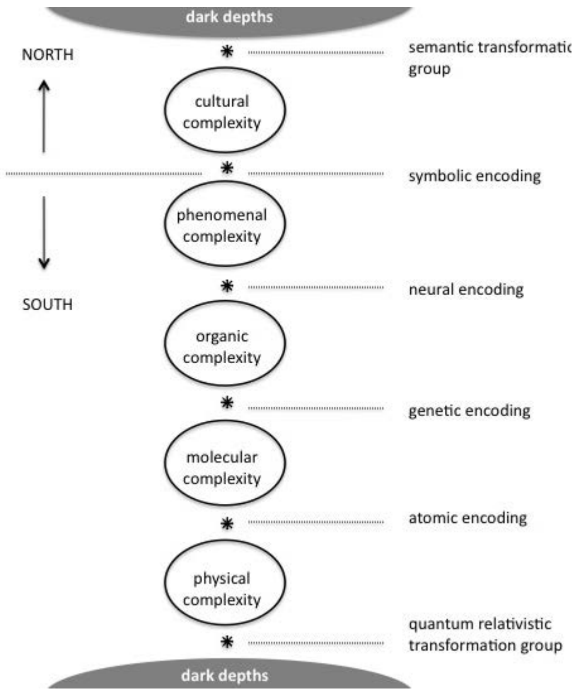

Figure 2.1. *The axial string of information nature*

2.4. Evolution in information nature

The hierarchy of levels described above recalls many traditional hierarchies. For example, in his treatise *On the Soul*, Aristotle distinguished three types of souls, i.e. three main kinds of biological functions, all present in human beings[47]. The vegetative soul corresponds to the functions of nourishment, reproduction, growth and decline that are found in both plants and animals (this is the organic layer). The sensitive soul corresponds to the activities of sensation and movement that are found in animals. Since sensation includes pleasure and pain, and movement is (generally speaking) attracted to pleasure and repelled by pain, desire is obviously part of the sensitive soul. Imagination, the capacity to produce images from sensations and memories of sensations, is also a function of the sensitive soul (the neural layer, in contemporary terms). The rational soul, finally, corresponds to the functions involved in processing symbols, which are specific to the human species as distinct from other animals. The intellectual soul (symbolic cognition, in contemporary terms) can explicitly involve an unlimited number of abstract ideas that animals are incapable of representing as objects of explicit thought, such as justice, universal gravitation, the end of time.

We find the same type of hierarchy in another culture. Xunzi, an important Confucian thinker of the Second Century BCE wrote in his major work: “Water and fire have energy (*qi*), but are without life. Grass and trees have life but are without consciousness. Birds and beasts have consciousness but are without a sense of duty. Humans have energy, life, consciousness, and in addition, a sense of duty. Therefore they are the noblest beings on earth”[48]. A sense of duty or moral sense obviously implies the reflexivity that is characteristic of symbolic cognition, and in particular *the capacity to represent to ourselves the reflexivity of others*.

As we have seen, each new information layer re-encodes the previous layer. Information nature is evolutionary, which means that the different levels of encoding appear successively or that the hierarchy of layers is laid down in a temporal sequence. Research in astrophysics and cosmology in the second half of the 20th Century showed that wave and particle forms of information pre-existed the formation of the atoms in the stars[49]. The construction of complex molecules in environments colder than that of the stars was in turn more recent than the construction of atoms. In conjunction with the earth sciences and paleontology, the theory of biological evolution has clearly shown that the organic molecules

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47 See [ARI 2009b].

48 *Xunzi: A Translation and Study of the Complete Works,* John Knoblock (Stanford, Stanford University Press, c1988-c1994).

49 This “cosmic evolution” was extensively studied beginning in the 1950s, see Fred Hoyle *et al.*, “Synthesis of the elements in Stars” [HOY 1957].

produced by single-celled organisms and plants appeared later than mineral molecules. Animals and their nervous systems emerged only after several hundreds of millions of years of development from bacteria and algae. The affects only began to become complex with the social mammals. We know, finally, that the layer of symbolic encoding was the last to come, since it is linked to the human species, which is only a few hundred thousand years old.

This evolutionary process (the successive building of types of forms and the layers of encoding that connect them) was first conceived by paleontologists and biologists in the 19th Century with regard to the relationship between biology and culture. Darwin, in particular – backed up by scientific data – was one of the first to maintain that, from a biological point of view, humanity is a particular species of social great ape that came into being in the same way as any other animal species. All biological species result from genetic mutations that are reproduced in given ecosystems, and the human species is no exception to this rule[50].

It is only at the level of information nature as a whole – which encompasses all the types of forms and all the levels of encoding – that humanity can be thought of as a "special" species. As we saw above, it is distinguished from other animal species not only by the symbolic encoding of the phenomenal and affective forms produced by its cognitive activity, but also by the encoding of cognitive mechanisms themselves: categorization operators. A clear distinction needs to be made between language and the ability to recognize signs or communicate[51]. I emphasize this point because there is very often confusion about it. Communication is universal in the living world. However, language is unique to the human species: it manifests in its signifying mirror a universe of meaning made up of intellectual operations.

The world of thought – or the cultural universe – is the specific expression of the human species. It encompasses all operations of symbol manipulation, i.e. cognitive operations on images representing concepts. This layer, the most recent one of information nature, may be designated by many names. Pierre Teilhard de Chardin[52] used the term *noosphere* in the spirit of an evolutionist spirituality that builds on Bergson[53] and recalls Sri Aurobindo[54] in Indian culture. *Noo* comes from the Greek *nous* and refers to the mind, thought or intellect as discussed by Anaxagoras and

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50 See Darwin's two major works on this point: *The Origin of Species* [DAR 1859] and *The Descent of Man, and Selection in Relation to Sex* [DAR 1871].

51 See Terrence Deacon, *The Symbolic Species* [DEA 1997].

52 Teilhard was not only a Jesuit whose evolutionary theology was condemned by the Vatican, but also a professional geologist and paleontologist. See *The Human Phenomenon* [TEI 1999].

53 In particular, *Creative Evolution* [BER 2007].

54 See his major work, *The Life Divine* [AUR 1990].

Aristotle. Etymology therefore gives "sphere of the intellect", "sphere of the *nous*". The semantic universe – Teilhard's noosphere – is the place of symbolic interdependence of the activities characteristic of the human species, activities that include the interdependent proliferation of the technical, institutional, aesthetic and other forms that characterize culture[55]. But then, why does Teilhard speak of the *noosphere* and not simply of culture? The word is constructed on the model of *biosphere*, which, as we know, means the interconnected set of all terrestrial ecosystems. The biosphere contains and nurtures a unitary layer of evolving biological complexity around the mineral sphere of the planet Earth. There is only one biosphere: all species share the same genetic code and the same terrestrial environment. Following the same pattern, the noosphere nurtures around the biosphere – and in interdependence with it – a layer of evolving complexity that is even faster developing and more creative than that of organic life. Like the biosphere, this layer is unitary – since it is based on the capacity for encoding and symbolic manipulation of a single species – and interdependent, which economic globalization and the growth of transportation and telecommunication networks is making increasingly evident. The term *noosphere* draws attention to the radical discontinuity – temporal and ontological – of the emergence of the human species, but also to the analogy between the layer of organic forms and that of symbolic forms. The word is intended to evoke the powerful impact of the advent of language on the destiny of life and the planet that sustains it[56]. The noosphere is actually nothing other than the invisible, shifting architecture of culture, the most recent of the layers of forms. The term *noosphere* enables us to envisage culture from the evolutionary perspective of a succession of layers of encoding, to think in terms of its interdependent unity – and to bear in mind the still-open event of its emergence. It is still open, because it is the nature of human culture and symbolic cognition that engenders it to creatively explore the *a priori* unlimited universe of possible cognitive operations. To do this, cultural evolution borrows the varied vehicles of sign systems, techniques and institutions, the forms and combinations of which are still far from exhausted. The process is ongoing, and the evolution of the noosphere is far from finished.

The essence of my proposition is to consider the noosphere against the background of a *system of coordinates* that would make its transformations *describable using calculable functions*. The semantic sphere – the system of

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55 Edgar Morin, in *La Méthode* [MOR 1977-2004], designates the study of ideas by the term *noology*.

56 "The change of biological state ending up in the awakening of thought does not correspond to a critical point passed through by the individual, or even by the species. Vaster than that, it affects life itself in its organic totality, and consequently it marks a transformation that affects the state of the whole planet", Pierre Teilhard de Chardin, *The Human Phenomenon*, pp. 122-123 [TEI 1999].

coordinates that would enable us to reflect and contemplate the cultural universe scientifically – is obviously a cultural construct and not an actual raw fact independent of our way of thinking. However, by increasing the global reflexivity of the noosphere, it could accelerate the process of its evolution.

2.5. The unity of nature

2.5.1. *Natural information and cultural information*

The symbolic dynamics re-encode in cascade – and are thus dependent upon – the information dynamics of the lower levels. Information processes of a symbolic nature can be conceptually or logically distinguished from presymbolic processes, but they cannot *really* be separated. This is to say that the layer of cultural complexity is always and everywhere based on physical/biological complexity: it is coextensive with it and supportive of it. Humanity carries semantic complexity only by going through all the types of forms this complexity actually depends upon: physical, molecular, genetic, cellular, organic, nervous-phenomenal and hormonal-affective[57].

The dependence also works in the opposite direction. It must be recognized that the knowledge that involves studying, analyzing, distinguishing and linking the different levels of encoding of natural complexity is itself produced and encompassed by cultural complexity. We describe nature using natural languages and cultural mechanisms for notation, representation and measurement. A culture coordinates its bodily and intellectual actions by establishing a symbolic order, a *cosmos* through which its various aesthetic, technical and socio-institutional systems are linked. For speaking human beings, a nature is never apprehended except in the envelope of a cosmos. Although not all the objects or all the data of human knowledge are symbolic, they are all symbolically re-encoded, integrated and translated through systems of measurement, images and narratives, and through a great many cultural institutions in general.

We sometimes use the term *nature* to designate only the presymbolic levels of encoding and processing. In particular, the study of the presymbolic layers of information is commonly designated by the term *natural sciences*, which may suggest that the human sciences are not "natural sciences". Since we now conceive of nature in terms of information, however, there is no reason to think that in studying culture the human sciences are not studying nature. Culture also consists of

57 See Boris Cyrulnik, *The Dawn of Meaning* [CYR 1993].

complex processes of production and differentiation of forms (in this case, symbolic forms)[58].

In summary: (i) all (human) knowledge about nature belongs to the symbolic layer, including presymbolic nature; and (ii) the information processes of the symbolic layer belong to nature, since our nature is now *a nature of information*. A general economy of information must therefore include the layers of symbolic and presymbolic encoding *in the same nature*, with the symbolic layer constituting until further notice (for us, human beings), the environment that reflects this unique, interdependent nature. The presymbolic layers are encoded symbolically, whether in systems of traditional knowledge or modern or postmodern scientific knowledge. However, traditional knowledge is diverse, given the multiplicity of cultures, and scientific knowledge is provisional, since there is no indication that the history of the sciences is finished now, or that it ever will be. The presymbolic layers of nature therefore cannot provide an immutable base or fixed foundation for the symbolic layer into which they are always already translated, even when we try to grasp them in a more objective way. As for the symbolic layer, including its last, semantic, level, we have seen that it is itself highly dependent on the presymbolic layers, at least in the understanding of the contemporary scientific community. Every culture depends on its ecosystemic environment, and human collective intelligence is unthinkable without bodily and technical means. Information nature thus manifests a kind of reciprocal implication of the symbolic and presymbolic layers along an autopoietic loop where empirical phenomena and the reflexive intelligence of human communities emerge in co-dependence.

2.5.2. *Nature as a "great symbol"*

It has long been recognized that the only reality we have direct knowledge of is that of our subjective experience as lived in the present, second by second. This flow of phenomenal experience occurs in a unified sensorium that weaves together the five traditional senses and the internal cenesthetic sense. Starting from this original environment of experience, and through the social coordination of its activities, enhanced by the manipulation and exchange of symbols, human cognition actively produces an Earth – the practical objectivity of a material world – and a Heaven – the existential necessity of a world of meanings and values[59].

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58 On all these points, see Chapter 5 on the human sciences. I should mention here Ernst Cassirer's monumental three-volume work *The Philosophy of Symbolic Forms* [CAS 1996].

59 The metaphorical heaven and Earth resonate with the equally metaphorical south and north of section 2.1.

I wish to point out that the great diversity of cosmologies and conceptions of the world throughout the human adventure shows that it is not only the symbolic universes (culture) that are conventional and dependent on place and period: *all* worlds, including the material and non-human worlds, are socially and culturally constructed or created. For example, in the Western scientific tradition and the "natural sciences" that continue this tradition in the 17th Century, there have been various competing theories on material nature. Once again, since scientific paradigms succeed one another[60] in time, it is clear that none of them represents any stable exteriority of material nature that would contrast with the arbitrariness and variability of cultural conventions. In other words, there is no objective material world that is independent of the social, cultural and technical context that enables us to construct it and think about it collectively. A few generations ago, the Earth was still flat and was located at the center of the universe. As they affect the *sensorium* and the cognitive processes, new systems of coordinates, new instruments of measurement and observation, new communication media, new symbolic tools for description and calculation create the conditions for new scientific and practical "objectivities".

Starting from its environment or its source, which is the flow of experience in the present, the unity of nature is divided into a virtual world (toward the north) and an actual world (toward the south). To simplify, let us say that the actual world consists of processes or entities *with space–time addresses*. Contemporary physics coordinates these addresses in four-dimensional Einsteinian relativistic space-time– until, perhaps, string theory models the fundamental unified field in 11- or 13-dimensional space[61]. In the depths of the cosmos lies an ultra-complex quantum relativistic transformation group where masses, energies and space–time addresses are exchanged dynamically.

The virtual world contains the symbolically encoded data of personal and social memory, as well as all the games of interpretation and evaluation of these data. Although data and their interpretations are necessarily supported by material entities and processes, their meanings and values (and this is what is important to us here) belong to the virtual world. From the perspective of the heaven of ideas, data are seen as vectors of meaning: they give rise to an inexhaustible multitude of concepts conceived by the discursive intellect and its hermeneutic activity. However, the signifieds, the classes or general categories, like their symbolic values[62], *do not have*

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60 On the concept of successive paradigms in the history of science, see the classic book by Thomas Kuhn [KUH 1962].

61 See Brian Greene, *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory* [GRE 1999].

62 Values: good, evil, important, unimportant, etc.

space–time addresses. It is this virtual world of symbolic abstractions that I am proposing to address in the formal model of the semantic sphere.

Let me make myself clear. Once again, I am not claiming that the virtual and actual worlds are separate. They are constantly being transformed and translated into each other and are basically *interdependent*, since they are none other than projections or useful creations of the contexts of personal experience of the humans who have to coordinate their practical activities and their semantic processing. The virtual and the actual are not two separate substances, but two opposite categories, two poles of the same reality of nature that can be only distinguished conceptually. Body and mind are only categories we use to organize our experience, not solid realities that exist independently of our cognitive activities. The space–time world of material bodies can only be perceived by us because it is always already organized in categories (distinctions of poles, qualities, objects, etc.), and the intellectual world that contains these categories has meaning and consistency only through reference to some sensory experience of a corporeal, or inter-corporeal, reality. The world of material bodies and the world of immaterial meanings should therefore be grasped within the unity of the information nature that connects them through the medium of human experience.

At the more subtle pole of nature, at the top of the heaven of virtuality, is the inexhaustible space of intellectual essences. At the more heavily material pole of nature, at the bottom of the earth of actuality, is the immense vibrating complex of mass/energy, the "unified field" of physics from which the objects and interactions of our phenomenal experience are derived. All the complexity of natural processes extends between these two poles, these two extremes, the relativistic space–time of "matter–energy" and the huge fractaloid network of the semantic sphere explored by the human discursive capacity. These two spaces – which can be modeled in calculable transformation groups – are not themselves objects of sensory experience but, I repeat, conventional abstractions that allow the coordination of the multitude of experiences, the seconds of human existence. According to this cosmology, the unity of nature therefore has a *symbolic structure*, since it connects a perceptual half made up of material configurations and an intelligible half made up of structures of semantic relationships.

Through multilayered translation processes of fractal complexity, this symbolic view of nature organizes the correspondence between a signifying phenomenal mechanism and a signified conceptual mechanism. Human collective intelligence (the dialog of environments of experience) generates and connects the two halves of the natural symbol: it goes "down" toward the pole of material interaction through its sensory experience, which is rooted in the body and in biospherical interdependence; it reaches "up" toward the intelligible pole of the semantic sphere through its collective capacity of manipulation of signs. It is between these two poles that we have to think of the unity of nature, including the infinitely branching networks of information circulation among dimensions, layers and levels of complexity.

Furthered by the cosmologies of Newton and Einstein, the Copernican revolution drove our tiny wandering planet from the center of the universe. The Earth that supports us is not the absolute center of three-dimensional space. The Darwinian revolution dated and situated our species on the great tree of biological evolution. Humanity did not appear in the universe at the beginning of time and was not the goal of the evolutionary mechanism of the biosphere: it is the random growth of a late-developing little branch on the genealogical bush of life. All to the good! By broadening our horizons, the science "of nature" has driven us out of the central place where traditional cultures had established us. The broadening of horizons and the decentering should, however, be carefully distinguished. The first scientific revolution liberated our perspectives because it was logically rigorous, because it practiced mathematical modeling, because it was based on public, shareable data from observation, and above all because it used instruments of observation, recording and communication that were more powerful than those of pre-print societies. I would like to argue that it drove us from the center only because it remained unfinished, limited to the material half of the world. If the scientific revolution were to be finished through the inclusion of the rich complexity of traditions and games of the human psyche, our species – through its avatar of interdependent creative conversations reflected in the semantic sphere – would perhaps return to the center of a complete cosmos. But it would no longer be the immobile, closed cosmos of traditional societies, which has vanished forever. A science reconciled with the unity of nature, a second scientific revolution, would give us the gift of an open, dynamic, creative, evolutionary cosmos in which human cognition – always an imperfect master, but nevertheless responsible for the great symbolic game – would explore the active interface between the unlimited Earth of phenomenal configurations and the unbounded Heaven of conceptual constellations.

Chapter 3

Symbolic Cognition

Having discussed the general nature and structure of information, I would now like to return to the processes of symbolic encoding that provide the interface between the phenomenal world and the semantic world of human beings. I will therefore expand on and provide more detail and context for certain concepts discussed in the preceding chapter. The purpose of this chapter is to establish as clearly as possible the specificity of human cognition in relation to animal cognition, with respect to both the processes of individual cognition and the emergent processes of collective cognition. Rather than a systematic presentation, this chapter provides a spiraling series of meditations in which the same themes are re-examined in increasing detail from different perspectives.

Section 3.1 delimits the field of symbolic cognition. Section 3.2 defines the type of reflexivity specific to human cognition. Section 3.3 discusses the power of human symbolic cognition, in particular its capacity to generate cultural phenomena. Section 3.4 focuses on the impossibility of separating the phenomenal and conceptual dimensions of symbolic cognition. Then section 3.5 discusses the openness of symbolic cognition, its creativity and the unlimited diversity of its manifestations. Section 3.6 completes the chapter with an inventory of the differences between human and animal collective intelligence. This final section provides a transition to the next chapter ("Creative conversation"), which deals with contemporary human collective intelligence as enhanced by the digital medium.

3.1. Delimitation of the field of symbolic cognition

3.1.1. *Singularity*

We know that biological evolution invented the eye (and the visual faculty) several times in the line of vertebrates and invertebrates: the eyes of octopuses, bees and apes are not all derived from the same initial eye. In contrast, symbolic cognition is a hapax of evolution: it emerged one time only, in the lineage of the primates who mastered fire. Unique in the history of evolution, symbolic cognition is indissociable from a reflexive, or self-referential, capacity of creation, exchange and transformation of the cognitive operators we call concepts. All cognition implies categorization. Only humans represent their categorization operators using symbolic systems and explicitly use symbols as objects of manipulation and contemplation.

3.1.2. *Social and technical dimensions*

As a general rule, symbolic systems are collective mechanisms produced and transformed at the level of cultures. Their holistic functioning and their coherence become apparent only when our intellectual lens is focused on a society or institution as a whole. The canonical example is always languages, but it is clear that musical, religious, political, legal, economic, technical, ludic and other symbolic systems belong to the same conventional, collective dimension of cognition. Just as human memory is embodied in a great many environmental, technical and institutional mechanisms[1], symbolic systems can obviously incorporate technical and social elements that go beyond strictly personal cognition. For example, in the 21st Century, networked computers externalize many functions of syntactic manipulation and interconnection of units of meaning. These functions may be carried out by hardware and software modules shared by millions of people: tools for processing numbers, texts, images, sounds; search engines; online dictionaries and encyclopedias, etc. With respect to the social extension of cognitive processes, an example of a symbolic system that is not a language and that functions on a cultural scale is a country's legal categories, rules and judicial procedures. The legal categories are the "dictionary", while the rules and procedures provide the "grammar" of the legal symbolic system. Historical experience shows that this type of symbolic system is capable of organizing a very effective process of collective cognition. The conceptual thought of human beings is thus almost always structured by symbolic systems that pre-exist and transcend them. We can see individual cognitive systems as processors associated in a distributed calculation using shared symbolic systems and operating on the sociocultural scale of a mixed techno-biological collectivity.

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1 See Geoffrey Bowker, *Memory Practices in the Sciences* [BOW 2005].

3.1.3. *Symbolic manipulation goes far beyond linguistic competence and "reason"*

The distinguishing feature of human beings is traditionally said to be that they are the animals endowed with language, reason or logos. But I want to stress here the fact that the faculty of explicit conceptualization that distinguishes us from other species cannot be reduced to the mere *linguistic* encoding of information. What medieval philosophers called the "intellective faculty" can manipulate all the forms of symbolic encoding characteristic of the human species, not only language. The symbols that are used in intellectual operations can be iconic, musical, choreographic, mathematical, technical, religious, political, economic[2], legal, culinary[3], vestimentary[4], sexual[5], erotic[6], parental[7], medical[8], etc. This means that our capacity to explicitly manipulate categories is not only the condition that makes speech possible, but it also underlies all cultural institutions. These institutions presuppose: (i) systems for symbolic encoding of the objects of human experience; and (ii) the use of this symbolic encoding for the distributed techno-social processing of those objects. It is therefore clear that symbolism goes far beyond languages. Moreover, within linguistic encoding, symbolic cognition is not limited to the purely logical function – deductive, inductive, abductive – or the reasoning function in general. It includes all actual or possible uses of linguistic symbols, all kinds of "language games"[9], whether they are practical[10], poetic, rhetorical, ludic, affective or other.

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2 For example: writing and accounting systems, currencies, prices, deeds, banknotes, financial operations.

3 Culinary symbolic systems may combine or alternate: raw and cooked; hot and cold; crisp and soft; bitter, sour, sweet and salty; etc. The Chinese, Korean and Japanese cuisines are particularly subtle in this regard.

4 See Roland Barthes, *The Fashion System* [BAR 1990].

5 In the sense of sexual acts that are permitted, recommended or prohibited according to the parental, social, legal and sexual status of the partners, as well as their state of ritual purity, the calendar, etc.

6 The classic example of a traditional codification of erotic symbols is the *Kama Sutra*.

7 See, for example, Claude Lévi-Strauss, *The Elementary Structures of Kinship* [LÉV 1969].

8 The World's medicines are based on very different symbolic systems, which can lead to surprising differences even with regard to anatomy, as shown by Shigehisa Kuriyama in *The Expressiveness of the Body and the Divergence of Greek and Chinese Medicine* [KUR 1999].

9 The concept of language game is one of Ludwig Wittgenstein's great discoveries. After having developed a philosophy aimed at standardizing the logical and descriptive uses of language at the beginning of his career (in the *Tractatus Logico-Philosophicus* [WIT 1921]), Wittgenstein arrived at an open exploration of the grammars of actual language games at the end of his life. The practical uses of language games and the relationships between heterogeneous language games are at the forefront of his *Philosophical Investigations* [WIT 1958]. From the early to the late Wittgenstein, one theme nevertheless remains

3.2. The secondary reflexivity of symbolic cognition

3.2.1. *The primary reflexivity of phenomenal consciousness*

Some researchers[11] see the beginning of cognitive processes in the biological functioning of the cell or of plant organisms because of the autopoietic and self-referential nature of living things in general. It is generally agreed, however, that "sentient" or "conscious" cognition begins only with animals that have nervous systems. Nervous systems interpose complex computational circuits between the sensory reception of information (excitation of the sensory nerves of touch, receptors of the retina, taste buds, etc.) and the control of muscular movement. Heinz von Foerster noted that the nervous system works on its own results much more than on raw sensory data received by the sensory receptors[12]. Indeed, in the most advanced animal organisms there are many more neurons that receive their inputs from intermediate neurons than neurons that are fed directly by sensory receptors. Sensory qualities such as colors, shapes and odors are not received directly from the external world, but are actually *calculated* from the patterns of excitation of the sensory receptors. There would be no colors in a world without eyes, optic nerves or the complex biological computation machine of the brain, just as there would be no pleasure or pain without nerve impulses and the transmission and reception of various chemical messages in the interdependent ecosystemic networks in which animal organisms participate.

The main effect of neural calculations is the categorization of sensory data, first at the most basic level (pleasure or pain, salty or sweet, round or angular, blue or yellow) and then at the level of the construction of objects such as prey, predators, partners or indicators of them. And perception is always colored by an affect

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constant: that of the limitations of the intellectual faculty associated with language, and particularly the limitations of its capacity for self-description. See, for example, the final aphorisms of the *Tractatus* and many aphorisms in the *Investigations*.

10 Similarly to Wittgenstein, Austin, in *How to do Things with Words* [AUS 1962], and after him, Searle, in *Speech Acts* [SEA 1969] and *Intentionality* [SEA 1983], clearly showed that factual description and logical reasoning were only one aspect of language use. The "pragmatic" dimension discussed by these authors is less concerned with truth than with the more or less constraining practical force that conventional rules give to acts of enunciation such as promises, commitments, judgments, etc. As François Rastier suggests (in "La triade sémiotique, le trivium et la sémantique linguistique" [RAS 1990]), reflection on the pragmatic uses of language, at least in the Western tradition, probably dates back to the rhetoric of antiquity.

11 In particular, the Chilean school of biological philosophy represented by Humberto Maturana and Francisco Varela; see *Autopoiesis and Cognition* [MAT 1980].

12 See *Observing Systems* [FOE 1981].

(starting with attraction and repulsion), whether this affect is conscious or not. Based on the reception and calculated production of chemical messages, emotions such as fear, aggression and sexual attraction come to infuse a range of subjective energies into the sensory world constructed by the apparatus of perception.

There are no raw phenomena, on one hand, and no categories that exist independently of phenomena, on the other hand. Rather, phenomenal experience and perceptual-affective categorization are two aspects of a single cognitive process. The phenomenal experience of animals is the subjective counterpart of the work of categorization and affective coloring carried out by their nervous systems. A flow of phenomenal experience emerging from the sensory-motor loop brings with it the perception of objects, qualities and poles of attraction and repulsion, which necessarily correspond to categories. There is no visual image, for example, without colors, light contrast or contours of some kind. In short, to perceive is to categorize. The process of categorization that occurs in the sensory-motor loop – and particularly in the neural computation that takes up most of that loop – in my view shows the reflexivity of animal cognition. The animal is "conscious": that is, its phenomenal experience shines from within, lighted by the primordial glow of the perceptual: the (non-visual) light of categorizing experience with its affective tonality. This *primary reflexivity* of animal cognition is constitutive of the phenomenal world in general.

3.2.2. *The secondary reflexivity of discursive consciousness*

We come now to symbolic cognition and its secondary reflexivity[13]. The characteristic feature of symbolic cognition is its capacity to represent – and therefore to conceive – the organizing categories of experience, *using classes of phenomena*. The classes of phenomena (auditory, visual, etc.) representing the categories are signifiers and the categories themselves are signifieds. In the primary reflexivity of the animal sensorium, the categories are implicit: they are incorporated into the *modus operandi* of the neural circuits. In the secondary reflexivity of the human intellect, the world of categories becomes explicit; it goes from the wings of the neural circuits to the stage of phenomena. The activities of certain assemblies of neurons[14], those that distinguish color and stabilize the visual category *red*, for example, are reflected, oddly, in a class of sounds (or in a series of visual characters): "red" in English. This class of phenomena is itself recognized by means of other dynamics of neural excitation, so that the brain becomes capable of designating its own activities using phenomenal images chosen (by the culture) as

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13 In *Language and Human Behavior* [BIC 1995], linguist Derek Bickerton provides an excellent analysis of reflexive human consciousness based on linguistic capacity.

14 See Jean-Pierre Changeux, *Neuronal Man* [CHA 1983].

means of self-reference. The symbol is therefore based on an encoding of categories in two degrees, which involves not only the nervous system *at the level of categorization of phenomena*, but also a conventional correspondence – established by the collective intelligence of the culture – between signifiers and signifieds *at the level of the projection of categories onto phenomena*. This representation of the process of categorization in the phenomenal world is the essence of language. Through human language, the world of categories becomes an object of cognition and the activity of knowing can therefore reflect itself. It is this circular process that I call the secondary reflexivity of symbolic cognition. In short, given that at the most abstract level "the observer" is a system of categorization of a flow of data, symbolic cognition is intrinsically reflexive *because it permits self-observation by the observer,* i.e. the cognition of a categorization system by itself. This is only possible because the categorization system is projected onto the data flow that feeds it.

3.3. Symbolic power and its manifestations

At the origin of human cognitive reflexivity is a capacity for symbolic manipulation that is more general than language, and more basic than music, myths, rituals and techniques. Jacques Derrida[15] speaks of a writing originating in thought that is in no way a transcription of speech, and whose marks are not the traces of any previous presence. This primordial writing can also be related to the basic intuitions at the origin of Chomsky's "universal grammar"[16]or to the "language of thought" of the philosophical tradition[17], but without limiting it to merely being the archetype of languages. As I conceive of it, this cognitive proto-writing is, rather, the abstract objective counterpart of our general capacity to arrange symbols on some kind of grid and to carry out symmetrical, reversible operations of reading and writing on those symbols. This universal abstract capacity for reading and writing is an innate *symbolic potential* that the hunter-gatherers of oral cultures realized long before the literate people of scribal civilizations. We find this same cognitive potential at the source of the three main types of games that characterize human beings: semiotic, social and technical.

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15 In particular in *Speech and Phenomena*, *Writing and Difference* and *Of Grammatology* [DER 1973, DER 1978, DER 1976].

16 See *Syntactic Structures* [CHO 1957], which outlines the formal core of this "universal grammar", and *New Horizons in the Study of Language and Mind* [CHO 2000], in which Chomsky summarizes his philosophical positions on this subject.

17 See *Le Discours Intérieur. De Platon à Guillaume d'Occam,* by Claude Panaccio [PAN 1999]. Particularly notable is the concept of the "inner word" developed by St. Augustine in *On the Trinity* [AUG 2002].

We are distinguished, first, by our linguistic, narrative, musical and artistic abilities in general. We enjoy producing, modifying and transmitting messages. No other species on the planet plays with signs as we do[18]. There is no need to insist on this obvious fact.

Second, the complexity of our institutions and our social relationships goes far beyond that of other primate societies. Without going into detail on the intricate, complicated legal and political structures of the great civilizations, it suffices to consider the importance of rituals in the vast majority of cultures and in every realm. In ritual, it is people, their costumes, their attitudes, their words or songs, their deeds carried out collectively, with each one playing a role, that act as signifiers. Confucian teachings consider excellence in the practice of ritual (which includes not only special ceremonies, but also everyday behavior) as one of the goals in the education of a cultured person. Filial piety, familiarity with classic texts, elegance in writing, precision in language and ease in performing rituals are part of the same human virtue[19].

Third, if humans are a species of technicians, it is precisely thanks to their capacity to process any material object as a meaningful occurrence of a system of categories in complex relationships. The complexity of a printed circuit or an aircraft engine is equivalent to that of a tragedy in verse, a classical symphony or the design of certain Persian carpets. The excellence of contemporary engineering equals that of the sacred architecture of ancient Egypt or India in producing intricate structures and systems of alternating symmetries. Was Dedalus, the Greek hero of technology, not also the architect of the labyrinth? Handling a bow requires as much manual dexterity as using a paintbrush, and the same direct Zen intuition of the target. *È cosa mentale*. In their apologias for painting, Leonardo da Vinci and Vasari were still struggling with the old hierarchy between the vulgar mechanical arts, concerned with things, and the noble liberal arts, concerned with signs[20].This inequality was more a matter of social convention in a particular time and place than of anthropological universality. The movements of the saw and the violin bow are similar: while one produces musical sounds, the other carves a three-dimensional shape. The actions of the musician or the carpenter have meaning within long traditions of practices, which in turn are part of larger cultural wholes. In all cases, signifiers are produced or manipulated: phenomena that are datable and addressable

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18 See what a certain school of “French thought” has produced as a variation on this theme. For example, Barthes in *The Fashion System* [BAR 1990], Baudrillard in *For a Critique of the Political Economy of the Sign* [BAU 1981] or Guattari in *Chaosmosis* [GUA 1995].

19 See Herbert Fingarette, *Confucius, The Secular as Sacred* [FIN 1972], and Anne Chang, *Histoire de la Pensée Chinoise* [CHA 1997].

20 They were trying to show that painting belonged to the liberal arts, to rhetoric, even though it did not use words.

in the space–time continuum, but extend from rhizomes deep in the virtual worlds generated by symbolic power, intangible worlds where meanings move.

3.4. The reciprocal enveloping of the phenomenal world and semantic world

A symbol consists of two parts: a signifier and a signified. We always encounter occurrences of the signifier part of a symbol in a phenomenal or sensory-motor mode. I am talking here of *occurrences of signifiers* and not just *signifiers* because signifiers are themselves classes of phenomena, and not phenomena that are dated and situated in the space–time continuum. Let us think, for example, of words (signifiers), which only have a place in the virtual system of language, as opposed to the pronunciations of these words (occurrences of signifiers), which are very much part of the space–time continuum. The processes of symbolic cognition always ultimately involve *classes* of interactions perceived, remembered, imagined or dreamed with phenomenal appearances, since concepts have to be represented by signifiers. Phonemes of language, notes of music, characters of writing, icons of ritual, religious or artistic expressions are such classes of phenomena. During actual cognitive processes, however, they are *occurrences* of signifiers, which are not only perceived but are also produced, transformed or displaced through actions, corporal movements, possibly by means of tools such as pens, brushes or musical instruments. Since categories or ideas (which are by nature abstract) cannot be perceived, imagined and manipulated independently of their perceptible signifiers, we can say that, for human cognition, the intellectual world of categories is necessarily enveloped – but also veiled – in the phenomenal world.

I would now like to show, still from the point of view of human cognition, that the phenomenal world is symmetrically enveloped by the world of the intellect, where relationships exist among categories. Let us begin by noting that the phenomena we perceive, produce and act on are generally named or labeled by us in one or more symbolic systems, in particular languages. We categorize not only the beings and objects we are in contact with, but also their relationships, the dynamics of their relationships and the rules of the games these dynamics obey.

Once a phenomenon is named or categorized in some way, it can be processed as the occurrence of a signifier, i.e. manipulated according to the *conventional* syntactic, semantic and pragmatic rules that characterize human communities. Thus, a dynamic configuration of phenomena only becomes meaningful on a playing field and according to invisible rules, which belong to the symbolic order. This order is symbolic because it goes beyond the perceptible appearances of the phenomenal world. It involves, in addition, networks of categories invested with all manner of affective energies according to widely varied yardsticks of measurement and evaluation[21]. This is how our musical intelligence processes sounds. We combine and decode the phonemes of language in this spirit, based on meanings and relationships among meanings in practical situations. Our politeness refines the choreography of social relationships according to complex meaningful patterns rather than mechanical relationships among material bodies. Practically all our interactions with perceptual phenomena can be thought of in terms of the recognition and transformation of meaningful configurations.

I began by saying that symbolic cognition always has a physical, phenomenal, sensory-motor counterpart; we write with our eyes and hands, we speak with our whole bodies. At the same time it should be recognized that all human works, all activities that are part of a cultural framework, including those that seem purely physical or material, *also* manipulate symbols. We interact symbolically with the phenomenal world and we manipulate images to have access to the world of concepts.

That is why, for example, the secret dance performed by hunters in the forest, involving times and winds, weapons and movements, animals and their tracks, is also symbolic in nature, as projected on the wall of the caves of Lascaux or Altamira at the dawn of prehistory. The same is true of the complicated procedures followed by car mechanics to disassemble and assemble engines, or seamstresses to stitch, mend and embroider garments. In all cases, including what seems at first glance to be a series of utilitarian actions involving only the material world, humans are interacting with occurrences of signifiers, images or bodies that refer to complex arrangements of categories, ideal models, evaluation criteria, scales of emotional intensity, game rules – a whole symbolic universe. We almost always, I repeat, treat actual bodies – including our own bodies – *as meaningful images*. We do so independently of the senses (hearing, sight, touch, smell, etc.) to which these bodies present themselves or the sensory-motor dynamics from which our cognitive calculation of the bodies emerges. Human beings cannot have any (phenomenal) experience without giving it meaning. What happens is real or fictitious, true or false, insignificant or important, good or bad, safe or dangerous, sad or happy – and to what degree, against the backdrop of what horizon of meaning, practical expectations or desires? Interaction with and between phenomenal bodies is therefore inevitably projected into a world of variables, operations and possible relationships that is *not* the world of material things in three-dimensional space, but that of conventional symbolic systems. Human symbolic cognition is a strange operator that connects and reciprocally envelops ideas and phenomena. This loop also goes between individuals, since symbolic systems are organized by culture and the phenomena we experience daily are socially co-produced.

21 In his *Philosophical Investigations* [WIT 1953], Wittgenstein observes that "language games" are not only linguistic phenomena, but *forms of life*.

3.5. The open intelligence of culture

Animals' system of categorization is hard-wired in the dynamics of neural circuits and programmed in metastable balances of hormone concentrations. This does not exclude a certain plasticity, as shown by their capacity to learn. The fact remains, however, that the categorizations carried out by the nervous systems of non-human organisms are first encoded genetically at the level of the species. Despite this, the *symbolic* encoding of categories is not decided at the level of the human species, but in the context of cultural communities that establish and share symbolic systems. It is the *capacity* of encoding and symbolic manipulation that has been decided once and for all at the level of the species: linguistic capacity is innate or natural in humans. The codes themselves are adopted by cultures: languages, for example, are conventional and variable.

To grasp the nature of symbolic cognition, two points should always be kept in mind. First, symbols (signifier–signified relationships) never exist in isolation: they belong to sets of symbols that form systems: languages, writing, religions, political constitutions, economic rules, etc. Second, the users of these systems of symbols never exist in isolation either: to be effective as symbolic systems, languages, writing, religions, political constitutions and economic rules must function at the level of communities or societies.

As animal organisms, we participate in the collective intelligence of primate societies, the human communities we belong to. As carriers of the logos, we participate in cultural cognitive systems that are much more complex than those of societies of bonobos or gorillas. With respect to symbolic cognition, talking bipeds do not represent autarkic cognitive systems, but rather interconnected processors that carry out – with a margin of real but limited autonomy – the cultural computations of emergent collective cognitive systems. These emergent collective intelligences produce the cultural fabric, first because they interface with and in some way connect many symbolic languages and rules, and second because in doing so they coordinate individuals' symbolic processing activities. This is how human institutions, in the broadest sense of the term, can function.

Even though the higher animals are capable of learning, the presymbolic cognition of the members of any animal species is usually confined to the closed circle of the categories hard-wired in its nervous system. Symbolic cognition, on the other hand, opens up a general capacity to use almost any durable assemblage of systems of categorization. With its capacity to process symbols, the human brain operates a little like a "universal machine" that can interpret and carry out instructions from a great many systems of categorization, as shown by the huge diversity of languages, music systems, literary genres, religious rituals and technologies created in the history of our species. In addition, at the level of human societies, processing of data is carried out by collective intelligences equipped with recording, communication and calculation devices that enhance our strictly biological capacity to classify experience and manipulate symbols. This means that human cognition is not in principle limited either in the variety of categorization systems and rules for manipulating symbols it can use or in the power of memory and processing of its reflexive intelligence.

3.6. Differences between animal and human collective intelligence

The first scientists to study collective intelligence were ethologists, who observed and modeled the behavior of animals. They showed that although the cognitive capacities of individual ants or bees are quite limited, anthills and beehives, when considered as "wholes" or "superorganisms", are capable of solving complex problems in a coordinated way[22]. The combination of many simple individual behaviors results in complex, refined social behavior that exceeds the understanding of the individuals. Collective intelligence exists not only in insect societies but also in schools of fish, flocks of birds, herds of herbivores, packs of wolves and troops of apes. In general, living in societies in which individuals communicate and cooperate is a competitive advantage for many animal species.

Humanity is a highly social species and, as such, it manifests properties of collective intelligence just as other species of social primates do. To end this chapter on symbolic cognition, I would like to sum up the main differences between human and animal collective intelligence[23]. The scientific question is as follows: is the use of models of animal collective intelligence sufficient to describe symbolic cognition in cultural contexts? I think not.

The root of the difference between the two forms of emergent cognition is the innate biological capacity of humans to manipulate symbols, whether these symbols are linguistic, iconic, musical or other. Once again: we need to distinguish clearly between communication and symbolic potential. For example, many mammals and birds of the same species are capable of communicating among themselves to draw each other's attention to food sources or the arrival of predators. It is clear, too, that mammals in particular are skillful at communicating emotions such as aggression, fear, joy and desire to mate. Communication can even be elaborate enough to

22 See the classic works by Edward Wilson, *The Insect Societies* [WIL 1971] and *Sociobiology: The New Synthesis* [WIL 1975]. See also more recent works by Bonabeau and Théraulaz, such as *Intelligence Collective* [BON 1994] and *Swarm Intelligence* [BON 1999].

23 By *animal*, I mean here *non-human animal*, although, strictly speaking, humans are obviously also animals.

encompass metacommunication, for example, in play activities[24]. But this does not make animals manipulators of symbols or masters of language. As they do not possess the symbolic potential that distinguishes humans, animals cannot ask questions, tell stories or conduct dialogs. Although a few ethologists consider certain animal societies to have a "culture", i.e. a certain capacity to transmit invented or learned behaviors, it is clear that nothing equivalent to the history of technology, music or political forms (for example) exists in the animal kingdom or in any particular species. In contrast with the cultural (therefore human) history of architecture, beavers have built their lodges in the same way for as long as there have been beavers.

From the perspective that concerns us here, there are thus two essential differences that distinguish animal and human collective intelligence.

The first difference is that humans not only have remarkable capacities for problem solving; above all, as we have seen, they have reflexive consciousness, which is imparted by discursive thought, whether the speech underlying their thought is internal or part of a dialog[25]. Animals are also "conscious", in the sense that their organisms support subjective experience such as perceptions, sensations of pleasure and pain, emotions, etc., but they have no autonomous reflection on their own behaviors. They do not think discursively about their actions before, during or after them, for the simple reason that, lacking language[26], they have no means of maintaining any kind of rational thought. They do not represent themselves to themselves in the mirror of their own discourse. We must not, therefore, view human collective intelligence as emerging from the interaction of unreflexive behaviors that lack the autonomy provided by discursive thought – as is the case for collective animal intelligence. In human beings, a threshold has been crossed, because human collective intelligence brings together, connects and organizes individual cognitive processes that are radically more complex and exceptional than those of collective animal intelligence, cognitive processes that are in a sense illuminated from within by discursive reason[27].

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24 This point was made by Gregory Bateson in *Steps to an Ecology of Mind* [BAT 1972].

25 For the great Russian psychologist Lev Vygotsky, the development of internal discourse (and therefore thought) is the result of an internalization of dialog. See *Thought and Language* [VYG 1986].

26 This lack is obviously not a "flaw". Animals, including their various cognitive styles, are perfect as they are.

27 This reason may be sick, perverse, saturated with unconscious impulses, conditioned by somatic or cultural structures that are beyond it, but none of this prevents reason from existing and remaining, in spite of everything, unique to humanity.

The second difference is that human collective intelligence is applied from one generation to the next over the course of history or cultural evolution. For example, the history of the processes of material production and transformation over the long term shows an increase in the power of the human species over its environment. Once pottery and metallurgy were invented, these processes were transmitted and perfected, and were added to what had previously been acquired in the history of technology. The same is true for communication media and systems of signs, such as writing or currency. In general, inventions that increase the power of the societies that use them are preserved, whether they involve material processes or symbolic institutions. Unlike animal collective intelligence, human collective intelligence learns not only on the scale of the time of a generation or the space of a society, but also on the much broader scale of the space–time of the human species as a whole.

Chapter 4

Creative Conversation

This chapter explores the creative conversation from which human collective intelligence is emerging in the new digital communication environment and looks at how it functions and possible improvements. Creative conversation is the fundamental engine of knowledge communities, that is, communities seen from the perspective of their cognitive functioning. The first main idea put forward in this chapter is the inseparability of collective intelligence and personal intelligence. This idea is expressed in practical terms in the dialectical interdependence of social and personal knowledge management. Second, I stress the growing role of creative conversation in explicating, accumulating and organizing knowledge in the shared memories of knowledge communities. The chapter concludes with a third key idea: that the technical and social conditions for the collaborative construction of memory on the Web force us to radically rethink our traditional ways of organizing archives. Memory beyond the Web calls for a new symbolic medium for creative conversation, an open, universal, democratic and computable semantic sphere.

4.1. Beyond "collective stupidity"

Since the publication of my book *Collective Intelligence* in 1997[1], I have continually met with the classic (and, in my opinion, weak) objection that it is individual humans who are intelligent, while groups, more or less organized communities and, even more so, crowds are for the most part stupid. What are we talking about here? The term *collective intelligence* can have many different meanings, but all these meanings involve the combination of two concepts:

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1 See [LÉV 1997].

cognition ("intelligence") and society or community ("collective"). Cognition here is, very classically, the activity of perceiving, remembering, problem solving, learning, etc. *Collective intelligence* therefore refers to the cognitive capacities of a society, community or collection of individuals. This collective cognition can be seen from the perspective of the two complementary aspects of the dialectic between individual and society. On the one hand, the individual inherits and benefits from the knowledge, institutions and tools accumulated by the society he or she belongs to. On the other hand, distributed processes of problem solving, decision-making and knowledge accumulation emerge from conversations and, more generally, symbolic interactions among individuals.

With regard to inherited intelligence, it should be noted that individual cognitive capacities are almost all based on the use of tools − symbolic (languages, writing systems, various social institutions) or material (instruments of measurement, observation and calculation; vehicles and transportation networks; etc.) − that individuals have not invented themselves but that have been transmitted or taught to them by the surrounding culture. I have emphasized this enough in the previous chapter. Most of the knowledge used by those who claim that intelligence is purely individual comes to them from others, through social institutions such as the family, school or media, and this knowledge could not have been accumulated and developed without long intergenerational chains of transmission.

With regard to emergent cognition, it should be noted that the most advanced contemporary societies are based on institutions whose main engine is precisely collective intelligence in the form of well-ordered conversation: these include democracy, the market and science.

The principles of democracy do not guarantee that inept or corrupt leaders will never be elected or that extremist or violent policies will never be adopted by the majority of a population. Universal suffrage, political pluralism, the balance of powers, freedom of expression for all and respect for human rights in general (and those of minorities in particular) are, however, more conducive to civil peace and human development than dictatorships or regimes dominated by a single party or a closed group of the privileged few. In democracy, collaborative intelligence comes about, not as a result of the majority imposing its will, but rather, out of the decisions of voters or the members of various parliaments after open deliberation during which different views can be expressed and responded to[2].

2 For how the new digital mediasphere can enrich the democratic process, particularly public deliberation, see my two books *Collective Intelligence* [LÉV 1997] and *Cyberdémocratie* [LÉV 2002]. See also Manuel Castells', *Communication Power*, Oxford University Press, 2009 [CAS 2009]

The existence of a free market regulated by law will not prevent economic crises or income inequalities. Historical experience, however, shows that planned economies in which a small number of bureaucrats decide the orientations of production and set prices are much less efficient than market economies, in which producers and consumers as a whole contribute − imperfectly and with all the attendant distortions − to deciding prices and levels of production and consumption[3]. Here, creative conversation is ideally an economic negotiation informed by realities and respectful of laws. I note, in order to avoid any misunderstanding, that this perspective is open to government interventions aimed at making markets more dynamic and more conducive to human development, such as through the construction of infrastructure, the creation of circumstances favorable to education and research, or the implementation of social assistance programs.

Finally, the scientific community is governed by principles of collective intelligence such as peer evaluation, reading and citing of colleagues, reproducibility of observations and sharing of data. None of these principles prevent repetitive mediocrity, errors or "false" theories. Conversation by the scientific community, conversation that is both collaborative and competitive, is obviously preferable, for the advancement of knowledge, to arguments from authority or hierarchical, dogmatic, opaque institutions with inquisitorial powers.

More recently, the success of the open software movement, which is based on the free collaboration of programmers worldwide, and the multilingual online encyclopedia *Wikipedia*, in which authors, readers and editors exchange roles to further the dissemination of knowledge, are striking examples of the power of collective intelligence emerging from a civilized creative conversation.

Thus the facile irony about collective stupidity (which is obviously always the stupidity of "others") fails to recognize all that our individual wisdom owes to tradition and that our most powerful and useful institutions owe to our ability to think and decide together. Need I add that my emphasis on the collective aspect of human intelligence in no way implies the abdication of critical thought or individual originality? The concept of collective intelligence for which I am arguing here is the

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3 See *The Wisdom of Crowds*, by James Surowiecki [SUR 2004] for a recent discussion of this subject. See also "Economics and knowledge" [HAY 1937] and *Law, Legislation and Liberty* [HAY 1979] by Friedrich Hayek. Hayek was one of the first to provide an explicit theory of the emergence of a *spontaneous order* based on interaction among responsible individual intelligences. This spontaneous order is obviously not perfect for any one person, but it is generally better than an order planned by a small group of leaders, because it incorporates distributed knowledge of the complexity of real situations, knowledge that is more accurate, rich and varied. I have dealt with the subject of competitive cooperation in the economy and elsewhere in my book *World Philosophie* [LÉV 2000].

opposite of conformism or sterile standardization. The full recognition of what we owe to the traditions or communities we are part of implies precisely the moral obligation to enrich the common good through original, relevant creative effort. Collective intelligence can only be productive by combining or coordinating unique elements and facilitating dialog, and not by leveling differences or silencing dissenters. Finally − need it be repeated? − no common knowledge can be created, accumulated or transmitted without an individual effort to learn.

4.2. Reflexive explication and sharing of knowledge

4.2.1. *Personal and social knowledge management*

4.2.1.1. *Introduction to knowledge management*

Most of us no longer live, as our ancestors did, in a single tribe. Contemporary social life generally has us participate in many communities, each with a different cultural tradition or knowledge ecosystem. Members of a family, speakers of a language, citizens of a city or nation, followers of a religion, practitioners of a discipline, learners of a technique, amateurs or masters in an art, collaborators in a business or organization, fans of a TV show or video game[4], members of a thousand networks, associations or working groups, we participate in more than one cultural community. If we look at these communities from a cognitive perspective, they are constituted through an autopoietic process of construction, reproduction and transformation of knowledge ecosystems. These are "working" communities in the information economy or, if you will, social learning enterprises. Their creative conversations accumulate, manage and filter memories in which collective identities and personal identities define each other, and the capacity for thoughtful interpretation and the capacity for informed action answer each other. For each of these communities, the maintenance and use of its knowledge capital, or the management of its knowledge, is thus a major concern.

Since I am going to use the now classic term *knowledge management* (KM), I would like to prevent any misunderstandings at the outset[5]. It is generally agreed that the only things that can be "managed" objectively and rationally are data, in particular digital data. On the other hand, it is still possible − but rather more difficult − to manage the conditions (financial, technical, social, emotional, etc.) of a creative conversation in which the participants will produce, discuss, explicate, filter

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4 See, for example, *Convergence Culture*, by Henri Jenkins [JEN 2006], which clearly demonstrates the collective intelligence of communities of fans, displayed in online creative conversations.

5 For a general overview of the field, see Kimiz Dalkir, *Knowledge Management in Theory and Practice* [DAL 2005].

and internalize in their practice an evolving collective memory. This second type of management is obviously much more subtle than the first, since it involves the sensitive concepts of shared views, relational familiarity, trust and incentives to creativity. Finally, actual knowledge cannot be separated from the consciousnesses in which it is reflected in the present, or from the individual learning processes it starts from and returns to. This subjective dimension of knowledge obviously cannot be "managed" by some outside authority like a thing or an objective situation. It belongs to the inner world, that is, to the desire to learn and share, to individuals' work on themselves or their autonomous discipline. Having clarified these points, I will speak in familiar terms about "KM"; just as in general usage, people say the sun rises even though they know very well that it is the Earth that revolves.

The question of KM becomes more complicated when we consider the contemporary fashion of personal knowledge management (PKM)[6].

4.2.1.2. *The cycle of personal knowledge management*

In the new ubiquitous digital environment − especially in social media − people are confronted with information flows so varied and abundant that they must learn to process them systematically. The complete cycle of PKM can be broken down into several distinct steps.

4.2.1.2.1. Attention management

People must first learn to control their attention: they therefore have to define their interests, order their priorities, identify their areas of effective competency and determine the knowledge and know-how they wish to acquire. Once all this has been properly clarified, PKM practitioners must strive to concentrate on their objectives without letting themselves be distracted by the multitude of information flows that cross the field of their consciousness. This should not prevent them from remaining open or from usefully placing their preferred objects of attention in the overall context that gives them meaning. They also have to be able to relate to people who have priorities different from theirs. The balance between openness and selectivity is a tricky exercise that must constantly be refined.

4.2.1.2.2. Choice of sources

Once we have set our priorities, we have to choose our sources of information. In contemporary social media, these sources are mainly other people. We thus need to spend time examining the information flows produced by others in order to choose

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6 See, for example, "Personal knowledge management: putting the 'person' back into the knowledge equation", by David Pauleen [PAU 2009]. It is clear that PKM is not a contemporary invention: only the conditions and tools are new.

those that best correspond to our objectives. We must also identify the institutions, businesses, research centers, networks and organizations of every kind that offer the information that is most relevant to us. It goes without saying that we can follow the choices made by people we trust and who share our interests, either automatically (collaborative recommendation systems are proliferating) or manually.

4.2.1.2.3. Collection, filtering, categorization and recording of information flows

The information flows from all sources identified must be aggregated or assembled in a single place so that they can be filtered in the most practical way. The collection tools can be RSS feeds from selected sites or blogs, colleagues, experts or institutions followed on Twitter or other social media, participation in online forums or various automatic alert systems. The choice of sources is the first form of filtering. But even feeds from our favorite sources have to be roughly evaluated and categorized in order to eliminate redundant information as quickly as possible. The information that is not eliminated must then be explicitly categorized (tag, comment, source name, etc.). Tags permit flexible, emergent categorization by means of freely chosen labels (social tagging) and the formation of networks for sharing references (for example, among researchers). Generally, only categorized information will be able to be used by others sharing the short-term collective memory (e.g. Twitter or Facebook) or long-term collective memory (e.g. YouTube, Flickr, Delicious or CiteUlike) where it is accumulated. It is impossible to classify without having a classification system, whether this system is implicit and unconscious or explicit and deliberately constructed. It is in our interest to make our own classification system explicit, if only to be able to perfect it and construct a more refined and effective memory.

4.2.1.2.4. Synthesis, sharing and conversation

Once information has been filtered, categorized and recorded, we need to be able to make a critical, creative synthesis. Only by so doing can we assimilate the information and transform it into personal knowledge. This synthesis, which as a rule is periodic, can be carried out in a blog, in an article, by editing a wiki entry, in a video, through incorporation into a computer program or in any other way. The essential point is to make the synthesis public, i.e. to introduce it into the open process of creative conversation of a community or network of people. The creative synthesis will be indicated in social media or disseminated through an RSS feed, or will feed an open source collaboration process or be made accessible through search engines and reported by automatic alert or recommendation systems or through the online social activity it generates. The synthesis will thus inevitably be exposed to criticism and comment from a community of people interested in the same subjects.

4.2.1.2.5. The feedback loop of personal knowledge management

In short, we pick up information, assemble it, categorize it, filter it, synthesize it, share the synthesis with others and then repeat this cycle creatively, always keeping a critical eye on our methods and tools. In this way, we prevent fossilization of our reflexes or blind attachment to our tools. After receiving feedback from creative conversation, we must periodically question our priorities, redefine the context, connect to new sources and eliminate old ones, perfect our filtering and classification tools, explore new methods of synthesis, get involved in other conversations, and so on. In doing this, PKM practitioners help not only themselves but also others to whom they are connected and who are doing the same thing.

4.2.1.2.6. Techniques pass but cognitive function remains

We must avoid unduly reifying the tools I have mentioned, which are only those used in the most advanced practices of 2011. In fact, in a few years, they will undoubtedly be replaced by new tools, or all aspects of PKM will be brought together in technical environments yet unknown as I write these lines, e.g. new types of browsers. In any case, the need for a personal discipline for collection, filtering and creative connection (among data, among people, and between people and data flows) will remain for a long time. Techniques pass but cognitive function remains. Without denying the importance of collective strategies and the shared visions that support them, I believe that social KM should be thought of as an emergent level based on the creative conversation of many individuals' PKM. One of the most important functions of teaching, from elementary school to the different levels of university, will therefore be to encourage the sustainable growth of autonomous PKM capacities in students. This personal management should be conceived from the outset as the elementary process that makes the emergence of the distributed processes of collective intelligence possible and which in turn feed it.

4.2.2. *The role of explication in social knowledge management*

Let us make an inventory of the content of the memory of a knowledge community.

It is, first, all the signifiers recorded and manipulated by the community: these are documents in general, texts, images, sounds, multimodal signs, software, etc.

Second, we need to consider the languages or symbolic structures that organize signifieds and make it possible to read documents: jargon, classifications, thesauruses, codes, correspondences among various systems, etc.

Third, we need to add "abstract machines"[7], ways of doing things, pragmatic rules by which documents are activated or processed, symbolic structures and relationships among people: methods, customs, know-how, and criteria and conventions of all kinds, which are often implicit. These rules include the methods of measurement, evaluation and judgment that produce the formally quantified or qualified data that are stored in the organization's memory. Only mastery of these methods makes it possible to connect the documents to their referents.

Finally, we must consider a fourth aspect of the symbolic organization of a knowledge community that is not located at the same logical level as the others and ensures its self-referential looping. I am thinking here of reflexive reification, the work of self-modeling that allows the community to synthetically represent its own emergent cognitive processes to itself. We can say that one of the goals of KM is to support this self-referential modeling in such a way as to encourage the improvement of the processes of collective intelligence and facilitate individuals' identification of their own roles (and those of others) in creating and maintaining the knowledge of the group they belong to.

Whether we are producing useful documents, clarifying or improving shared symbolic structures, spreading the most effective methods and practices or raising individual and collective awareness of the emergent cognition of the community, we will almost always find ourselves confronted with the problem of explicating implicit knowledge and processes.

The distinction between explicit knowledge and implicit knowledge echoes other dialectical pairs of opposites of the same type, such as objective knowledge and subjective familiarity or formal knowledge and practical competency. I suspect that the opposition between implicit knowledge and explicit knowledge in a new context reactivates the very ancient philosophical distinction between theoretical knowledge and empirical knowledge.

The explication of knowledge was studied and developed by the father of contemporary KM, Ikujiro Nonaka[8]. Nonaka proposed a cyclical model of the cognitive life of organizations. According to this model, called SECI (Socialization, Externalization, Combination, Internalization), knowledge exists first of all in an implicit form in individual practices. These practices are then socialized (S) and shared informally to become incorporated into organizational cultures. The critical

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7 I borrow the term from Deleuze and Guattari in *A Thousand Plateaus* [DEL 1987b].

8 The pioneering work, already quoted in the introduction of this book, is *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation* [NON 1995]. See also *Enabling Knowledge Creation: How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation* [NON 2000].

phase of KM in organizations, according to Nonaka, is the transition from implicit knowledge to explicit knowledge (E). This externalization begins with a practice of questioning and dialog, which can only develop in an atmosphere of trust. It essentially consists of representing the largest possible part of the informal practices and the surrounding culture in the form of written documents, software or databases. The explication of knowledge has many advantages: it makes it possible to decontextualize and thus distribute and share information on a large scale, to critically examine the state of knowledge and possibly even to automate its application. The externalization of knowledge takes the form of explicit concepts, classifications or (computer) ontologies, methodological documents, rules, algorithms or programs. Once knowledge has been formalized in concepts and rules, it can be distributed in the information system of the organization, combined (C) and applied − possibly automatically − to the data flows that indicate the internal state or environment of the organization. The personal learning effort is not forgotten, since in the end the results of the explication and combination phases have to be integrated or internalized (I) by collaborators in order to be implemented, tested and perhaps transformed in practice. This will lead to a new cycle of socialization, questioning, dialog, formalization, recombination, and so forth. The organization's knowledge is the life cycle I have broadly outlined, and not any one of its phases, artificially isolated. This model provides a general conceptual framework in which the organization can represent its own cognitive functioning to itself.

The SECI model was developed at a time when the Internet already existed but the Web was very new and social media were still unknown, except for a few pioneers of virtual communities. As I suggested above, our view of KM today draws much more on collaborative learning networks using social media than on the administration of central information systems controlled by experts. We need to promote organizational cultures and technical environments conducive to transparency, flexible reorganization of skill networks and continuous collaborative creation of immediately usable knowledge. Despite this, this dialectic of socialization, explication, combination and practical integration is still relevant for understanding the sustainable functioning of a creative conversation that produces knowledge.

The emergent discipline of KM has taught us that there can be no systematic exploitation of the knowledge capital of a community without the explicit modeling of the intellectual and social functioning of that knowledge capital. The following three points clarify the main relationship that in my view connects knowledge communities assembled around a common memory, on the one hand, and the models that explicate the functioning of their knowledge capital, on the other hand.

The first point I would like to make here is that we must not confuse knowledge capital with its explicit modeling. The map is not the territory[9]. A code of law does not encompass the living system of a nation's mores. An English dictionary and grammar book provide only a "snapshot", a partial image of a language spoken by a population dispersed over five continents and evolving in multiple forms. An explicit model is less than the living knowledge capital it reflects and disseminates. It is only an abstraction − and I would add, only one possible abstraction − of that reality.

My second point is in a way complementary to the first: there is no model that does not coproduce the reality it models. A map brings into being a territory where there are only experiences of movement and memories of travels[10]. Through its perlocutory force[11], a code of laws transforms the mores of a nation. Dictionaries and grammar books influence learning in school and the literary practices of languages[12]. The model is a factor in the reality it explicates.

Third, the types of technical media used for the reflexive modeling of knowledge profoundly determine the identities of its referents. The old handwritten portolanos of medieval sailors, printed maps using the Mercator projection, dynamic online maps that combine GPS, satellite images, quick zoom-ins and zoom-outs on the screen of a laptop or an electronic tablet all structure our relationship to space and travel. Knowledge that is reflected in and transmitted through sung narratives does not have the same flavor as knowledge that is formalized logically in writing. And if this knowledge is represented in an online database and computer programs that automate reasoning, we are dealing with a third scenario that is different yet again. The medium of the model articulates not only the model itself, but also the distributed cognitive process that is modeled[13].

To reproduce, improve and expand its shared memory, any social learning organization must have an explicit modeling method for the cycles of cognitive

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9 See Alfred Korzybski, *Science and Sanity, An Introduction to Non-Aristotelian Systems and General Semantics* [KOR 1933].

10 On this point, see Bruno Latour, "Les vues de l'esprit, une introduction à l'anthropologie des sciences et des techniques" [LAT 1985].

11 On the concept of the perlocutory force of performative statements, see John L. Austin, *How to do Things with Words* [AUS 1962].

12 This point was emphasized by Sylvain Auroux in *La Révolution Technologique de la Grammatisation* [AUR 1994].

13 The role of the communications media in symbolic organization will not be discussed in detail in this chapter. Among the huge mass of scholarly work on this subject, I will mention only works by McLuhan [MAC 1962, MAC 1964] and myself [LÉV 1990, LÉV 1994b, LÉV 1997].

operations it carries out on data flows. It must create a (multimedia) image of the signifiers, systems of concepts and pragmatic rules that are part of its operations. Each of its participants must be able to filter, find, synthesize, analyze and comment on the data accumulated in its technical memory. One of the main effects of the explication of knowledge is that it makes its "distribution" beyond the geographic and social contexts in which it emerged possible. In short, knowledge must be reified and mediated so that it can be better shared. It can then benefit a broader community than the one (perhaps local or limited) where it emerged. Rather than knowledge being shut up in silos and Balkanized within small closed communities, one of the ideals of social KM is clearly its decompartmentalization, exchangeability and commensurability. An intelligent collectivity or a collaborative learning network has a truly shared memory only insofar as that memory is constructed and modeled by the creative conversation of its members in a unifying medium.

4.2.3. *Dialectic of memory and creative conversation*

Before going further into the question of the unifying symbolic medium of the memory, in order to make the reader realize its importance I would like to help elucidate the complex relationship between shared memory and creative conversation. To start with, where does the word *conversation* come from? Etymological dictionaries tell us that the verb *to converse* originally meant "to live with or among, to keep company with". It was only in the 17th Century that it acquired the meaning of talking together or exchanging ideas. However, *versare* in Latin means "to turn or return", and the prefix *con-* comes from the Latin *cum*, which means "with". I am therefore proposing a hypothetical first etymology according to which, in *con-versation*, people *turn* to each other and *exchange the direction* of streams of discourse addressed to each other. According to my second hypothetical etymology, conversation is a process of *con-version* of knowledge from an implicit mode to an explicit mode and vice versa, and this reciprocal conversion is done "together" (*cum*).

Returning to the cosmic compass I have been using as an orientation instrument since the beginning of the chapter on the nature of information[14], I would say that its intertropical zone is made up of processes of creative conversation. Its southern hemisphere consists of actual (implicit) processes of perception and action and its northern hemisphere is a virtual (explicit) memory shared online, removed from the flux of the immediate present. Creative conversation is thus the active interface, the original environment or source of the process of individuation of the knowledge community[15]. In the south–north direction, it transforms knowledge that is implicit,

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14 See section 2.1.

15 On the concept of individuation, see Gilbert Simondon, *L'Individuation à la Lumière des*

opaque, immersed in action, into shared virtual memory. In the north−south direction, it transforms the accumulated shared memory into actual effective sensory-motor activity.

Although physical meetings remain essential for establishing trust, increasingly conversational interactions oriented toward collaborative learning are taking place online, e.g. through social media. Judging by my personal experience on Twitter, the most constructive exchanges consist of short messages pointing to URLs containing multimedia data. The messages categorize these data with a brief comment and/or a hashtag[16], a metadata label. Hashtags are used to bring together and find URLs, discussion threads or comments on a subject on specialized search engines[17]. The now increasingly widespread experience of watches or collaborative learning using social media makes it possible to observe in action how a creative conversation constructs a shared memory and is in turn constructed through the relationship to that memory. The immense flow of raw data is filtered and categorized by certain participants. Other participants confirm[18] or dispute these categorizations, which may lead to discussion. The members evaluate the relevance and validity of the filtered data, reading recommendations and categorizations on the basis of their experience and knowledge of a field of practice[19]. If they are engaged in an active learning process, they will integrate the information received into their PKM systems, which in the end will transform their practice, and will also disseminate the information in other circles of conversation. The data are thus filtered, categorized and recategorized by a community, then found (by means of metadata) and used in practice by individuals, which changes the personal capacities of these individuals to filter and categorize, and the cycle begins again. This is how a conversation engine accumulates (data) and organizes (metadata) its shared memory. Through the integration of memory into practice and personal experience, creative conversation transforms data into knowledge. Symmetrically, implicit knowledge is transformed into data through blog entries, wikis and articles, and into metadata through an activity of participatory categorization.

Notions de Forme et d'Information [SIM 1958a].

16 A hashtag is a keyword preceded by a hash symbol (#), e.g. "#PKM" to indicate that the "tweet" (the message and the URL it points to) concerns PKM.

17 For example, Twitter search, Twazzup or Topsy (in 2010).

18 A mark of confirmation on Twitter is *re-twitting* messages considered most relevant, that is, *forwarding* them to your own subscribers.

19 In emphasizing the importance of a *shared practice* (at various levels of expertise), which needs to be combined with a *community of people* and a *common subject* to obtain a creative conversation, I am in agreement with Etienne Wenger's studies of communities of practice. See his *Communities of Practice: Learning, Meaning, and Identity* [WEN 1998].

The process of collaborative production of shared memory favors individual learning insofar as the individuals involve their personal experience in the conversations (the process of explication is always instructive) and involve the results of the conversations in the reorganization of their personal experiences. Here there is no purely individual learning, since data are exchanged and pooled. The imposition of metadata in a shared memory assumes a system of metadata common to a community. An open conversation validates the relevance of these metadata or diversifies the categorization of the data[20]. There is no purely collective or only emergent learning, because the relevant filtering of data and the validity of metadata are ultimately based on experience and personal judgment.

We have seen that creative conversation organizes the dialectic of the relations between data and metadata. At a first degree of elaboration, the data − since they are externalized and shareable − belong to explicit knowledge. If we focus only on an analysis of digital memory, however, disregarding the living know-how, then the data belong to the implicit, opaque pole, while the metadata occupy the explicit pole that generates transparency and exchange. The explicit/implicit or virtual/actual polarity is thus more a matter of a pattern fractally repeated at various levels of analysis than of a clear and distinct separation between fields of being or knowledge. Thus, from the perspective of the constitution of shared online memory, creative conversations carry out an activity of “stitching” or interfacing between the opaque actuality of data flows (digitized phenomena, including texts) and the transparent virtuality of metadata (which make it possible to organize and search for information).

What do we call the characteristic site of this creative conversation that reciprocally converts virtual and actual modes of knowledge? Nonaka[21] proposes that it be called *ba*, following recent developments in philosophy in Japan[22]. *Ba* is a place in the broadest sense of the word, that is, it can be material or institutional or based on a digital social medium. Its main characteristic is to enable the actual world

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20 Contrary to what happens, for example, in traditional libraries, it is always possible to categorize the same document in many ways, according to the various points of view of the users. For more information on the freedom of open categorization through collaborative online memories, see David Weinberger, *Everything is Miscellaneous: The Power of the New Digital Disorder* [WEI 2007] and the online article by Clay Shirky “Ontology is overrated” [SHI 2005].

21 For example, in his article “The concept of Ba: Building a foundation for knowledge creation” [NON 1998] and his book *Enabling Knowledge Creation* [NON 2000].

22 See K. Nishida, *Fundamental Problems of Philosophy: The World of Action and the Dialectical World* [NIS 1970] and *An Inquiry into the Good* [NIS 1990]; specifically on the question of the creation of information, see H. Shimizu, “Ba-Principle: New logic for the real-time emergence of information” [SHI 1995].

of pragmatic action and the virtual world of discursivity to communicate within the same encompassing unit. From the point of view of social KM, *ba* is a condition of the creative conversation that feeds the life cycle of the knowledge of a collectivity. From the point of view of a more "emergentist" approach, we could say that *ba* springs from the creative conversation when a community succeeds in individuating (or in self-maintaining its process of individuation) around an activity of knowledge creation and sharing. In my view, in order to understand *ba*, it is best not to artificially separate the following three partial types of *ba*:

– the usual physical environments: offices, classrooms, meeting places;

– various digital environments: certain communities are organized using Facebook, LinkedIn or Ning groups *and* hashtags and subscription networks on Twitter, *and* networks on Delicious or Diigo;

– occasional encounters, such as conferences, symposia and seminars.

If all these times, places and social media are used by the same network of people, they become the components of a unique *ba* supporting the network's knowledge creation process. It is creative conversation and its emotional tone that will unify all the communication and meeting media in a welcoming *ba*, and not any specific medium or architectural element labeled *ba* that will magically create a satisfying and productive knowledge community. In short, *ba* is the *milieu associé*, the environment specific to creative conversation, and it is being built as the knowledge community is individuated and its collective memory grows and is organized[23].

I note in conclusion that the collective individuation of a knowledge community is accompanied by processes of personal cognitive individuation on the part of its members. This personal cognitive individuation takes place horizontally, in social relationships of mutual aid, interactions among peers or relationships of users with discussion leaders of the community. Specifically, the type of effective participation by individuals in a community (rather than their official status or place in an organizational chart) will shape their social roles as experts, discussion leaders, collaborating learners or more passive users. Personal cognitive identity is also formed vertically, insofar as in each community individuals occupy specific semantic places according to their areas of expertise and learning paths. These places are identified by the traces the individuals leave through their activities of construction and use of the shared memory. While each knowledge community constitutes a distinct cognitive microworld, it is clear that the same areas of personal

23 On the concept of the *milieu associé*, see Gilbert Simondon, *L'Individuation à la Lumière des Notions de Formes et d'Information* [SIM 1958a]. The processes of individuation obviously have a counterpart in processes of dissolution: communities are not eternal.

expertise will be projected differently in different communities. It should be noted in this regard that the names of users or persons often serve as markers of semantic zones. In many social media, in fact, subscription to a feed from a particular user may be interpreted as a statement of interest in the subject in which the user specializes[24].

In short, creative conversation transforms implicit personal and local know-how into explicit knowledge codified in a collective memory. This construction of a shared memory implies distributed work of production, filtering, categorization and evaluation of data. In its dimension of personal integration or learning, creative conversation in turn transforms explicit knowledge into know-how applied locally in the corresponding fields of practices. This alternating cyclical transformation is coordinated in a *milieu associé*, *ba*, which cuts across and unites the organizational mechanisms, physical places and digital environments that support the conversation. Finally, creative conversation is the source of personal and collective processes of cognitive individuation that determine its consistency and duration.

4.3. The symbolic medium of creative conversation

4.3.1. *The question of the symbolic medium*

The preceding descriptive analysis, which deals with the ideal creative conversation, could leave the impression that all is for the best in the best of all possible digitized worlds. But this is not the case. In fact, we are currently a long way from possessing the symbolic medium − or the intellectual technologies derived from that medium − that would allow us to obtain the greatest advantage from the distributed creative conversations whose memories are accumulated on the Web. The problem is threefold. It has to do with the transversality of individuals with respect to communities, the transversality of communities with respect to digital environments, and the transversality of knowledge with respect to the various memories accumulated by communities.

First, a single person usually participates in several social or occupational networks, or various knowledge communities. Individuals thus act as "cross-pollinators" among various cognitive ecosystems. Communities use different languages, modes of conceptualization and metadata systems. The problem arises

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24 Etienne Wenger stresses the importance of the construction of identities in communities of practice; see his book, cited above, on communities of practice [WEN 1998]. My work on *knowledge trees* [LÉV 1992a] also presents − and graphically models − this relationship of reciprocal construction of personal identities and collective identities in online knowledge communities.

because a personal knowledge management system should be able to automatically[25] be fed information and in turn feed the online memories of the knowledge communities the person takes part in. Today we are a very long way from that. The data formats of these memories are often incompatible[26], and their metadata systems (the conceptual organization or classification) even more so. In addition, the general view is that automatic language translation systems work well enough to provide a quick idea of the content of a text or the meaning of a word, but that they cannot be used to transfer information from one language to another reliably − and acceptably in terms of reading quality − without serious human revision. In fact, few French, American or Brazilian Internet users have any idea of the content of the Chinese blogosphere or the Japanese Twittosphere, and vice versa.

Second, a single knowledge community often uses many applications and digital environments, as I stated in my discussion of *ba* above. For example, a college or university class may use Delicious, as well as both Facebook and Twitter groups, while a community of professionals may use a LinkedIn forum, Diigo, a network of blogs, etc. We encounter the same problems as those mentioned above regarding people's participation in many different knowledge communities. It should be noted, however, that interoperability among various services supporting creative conversations is developing, thanks to the spread of open APIs[27] and third-party applications specializing in data transfer. To give two simple examples: when I post a message on Twitter, it is reproduced in my Facebook, Friendfeed, LinkedIn, etc., feeds, and when I bookmark a page on Delicious, the URL is indicated in my feeds on Friendfeed, Facebook, Plaxo, etc. We are still far from having transparent circulation among online knowledge management applications or eliminating barriers among competing social media, however, particularly in terms of the semantics of categorization processes.

Third, there are obviously many communities that should be able to connect their memories, especially when all or parts of these memories concern the same subjects. Despite this, once again the disparate nature of classifications and metadata systems,

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25 This automation *includes* filtering controlled by individuals as well as collaborative filtering that selects information according to its relevance for a group of people whose choices are similar.

26 The increasing adoption of the XML standard and, with more difficulty, the RDF standard (both proposed by the WWW consortium), as well as the use of other data exchange formats such as JSON should in principle make it possible − eventually − to overcome the obstacle of the incompatibility of data formats.

27 API stands for Application Programming Interface, an interface that can be used by a program external to a particular service. These interfaces facilitate data transfer and form the basis for interoperability between services.

not to mention the multiplicity of languages, makes such connections, or even the suggestion of them, difficult to automate.

Knowledge management on the Web is still too collectivized, in fact Balkanized among many competing services, languages and ontologies. The situation is often much worse in big companies and public administrations, whose databases are frequently unable to communicate with each other. With the possible exception of blogs, paradoxically, most PKM tools are centralized by big companies specializing in social media and search engines. Just as computer science underwent a revolution in the 1980s with the widespread use of personal computers, it is possible that KM in the 21st Century will experience a decentralizing revolution that gives more power and autonomy to individuals and self-organized groups. This can only take place through the adoption of a common protocol for the expression of semantic metadata, which would free creative conversation from the limits imposed by the major players of the Web[28]. Through such a semantic protocol, operating as a shared tool for explication and modeling, creative conversation could fully realize all its transversal potential: people participating easily in many communities, communities transparently using many applications, and information being exchanged and connected automatically among the memories of various communities. Above all, the adoption of a shared semantic metalanguage would make it possible to advance toward a social KM that would emerge without too much friction from autonomous practices in PKM, and that would ultimately serve these practices. We thus come back to the question of a unifying symbolic medium, with which I ended the section on the role of explication in KM[29].While the Internet is currently the unifying medium in terms of techniques for the material communication of messages, we still do not have a symbolic medium or common language that allows us to share knowledge in a computable and transparent way and thus to develop a creative conversation on a global scale, with all the resulting benefits we can expect in terms of human development. It is only on condition that such a symbolic medium exists that we will be able to properly speak of online explicit knowledge as a commons[30] that is actually usable by everyone according to the goals and viewpoints of all communities.

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28 I am not speaking here of a protocol on data or metadata formats − this work is being pursued today by the WWW consortium and other standardization organizations − but of a symbolic system, a *language* in the full sense of the word, such as IEML, which is especially designed for semantic calculations and interconnections.

29 See section 4.2.2.

30 I will discuss the subject of the commons below. See also section 6.1.2.

4.3.2. *The metalinguistic articulation of organized memory*

The question of how to organize recorded information in a coherent and useful memory is not new. In fact, it is as ancient as libraries. In the 17th Century, when the proliferation of print publications led to a huge increase in the number and size of libraries, the problem of how to classify publications became very urgent. Those responsible dealt with this problem of organization by proposing a metalinguistic articulation, just as I am doing today. Since it is not advisable to imagine the future without recognizing the heritage of the past, I would like to provide a broad outline of the main stages of thought on document metalanguage, associating each of them with a "big name". What follows is not an exhaustive history of the documentation sciences, but merely the identification of some of their main paradigms[31].

At the end of the 17th Century, the philosopher and mathematician Leibniz studied the writing of the 14th-Century Dominican kabbalist Ramon Llull on the art of mechanically producing true propositions[32]. He took an interest in the ideography and hexagrams of the *I Ching*[33], which the Jesuits had just brought back from China. He explored binary arithmetic and combinatorics. He built the first calculating machine capable of performing the four arithmetic operations. Bringing together all these areas of practice and thought, he imagined a writing system he called the *universal characteristic*, which would be able to express and combine all ideas mathematically. Leibniz's work had a strong influence on the founders of contemporary logic and computer science[34]. Leibniz was a librarian for 40 years, and thus had to deal with the concrete problems of managing the catalogs of many libraries. He is the first philosopher and scientist to think rigorously about the problem of classifying knowledge as it relates to the organization of libraries[35]. He theorized on the need for a metalinguistic layer that would be distinct from the documents and would help users find their way around the library: abstracts and

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31 For an overview of the intellectual principles of the documentation sciences, see Elaine Svenonius, *The Intellectual Foundation of Information Organization* [SVE 2000].

32 The main reference on Llull's work on logico-linguistic combinatorics is the *Ars Magna* [LLU 1990].

33 *I Ching: The Book of Changes* [YIJ 2002].

34 On Leibniz's thought, see Gilles Deleuze, *Fold: Leibniz and the Baroque* [DEL 1993]; Michel Serres, *The System of Leibniz* [SER 2003]; Yvon Belaval, *Leibniz Critique de Descartes* [BEL 1960]. In the introduction to his first book on cybernetics, Norbert Wiener outlines what the new science of computers owes to Leibniz's thought: to explain a fact, it starts with a matrix of possibilities and then tries to understand why one particular possibility was realized rather than another, whereas Cartesian thought looks for real sequences of causality leading to the fact that is being explained. See *Cybernetics* [WIE 1948].

35 See Jacques Messier, "Un bibliothécaire parmi les humanistes: Gottfried Wilhelm Leibniz (1646–1716)" [MES 2007].

indexing. He also imagined the ideal physical architecture for a library, reflecting the organization of knowledge: a kind of panopticon of knowledge. In one of his works, he even tried to calculate the maximum size of a future universal library of humanity[36].

In the 19th Century, the American Melvil Dewey created the decimal classification system that bears his name[37]. The decimal classification is rational and universal, and independent of institutions, languages and physical establishments. An advance compared to the systems then in use − which assigned books to certain shelves − Dewey's system provides a hierarchical (nested categories and subcategories), exclusive (a document cannot belong to two separate categories) classification of knowledge. Most classification and indexing systems in use today − including the American Library of Congress system and the French RAMEAU system[38] (itself based on the Library of Congress system) − are derived from the hierarchical classification created by Dewey, although they are both more flexible and more complex.

In the 20th Century, the Indian mathematician Ranganathan, one of the founders of modern documentation sciences, restructured the profession of librarian around users[39], called for a universal semantics and invented a faceted classification system[40]. The system was based on the principle of intersecting categories − or the composition of "semantic primitives" and allowed a document to be found from several perspectives. The metalanguage created by Ranganathan (Colon Classification) has been used very little outside India, but the principle of faceted classification was accepted and frequently applied in other forms.

Even before the Second World War, the Belgian Paul Otlet had considered the theoretical problems of a universal library and its indexing. Otlet popularized the microfiche − which was already in use in the USA − in Europe. He created the Universal Decimal Classification (UDC), an adaptation of the Dewey system that was more flexible[41] and used faceted language. He then undertook an unfinished

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36 Gottfried Wilhelm Leibniz, *De l'Horizon de la Doctrine Humaine*, 1693 [LEI 1693].

37 *A Classification and Subject Index for Cataloguing and Arranging the Books and Pamphlets of a Library*, 1876 [DEW 1876].

38 RAMEAU (*Répertoire d'Autorité Matière Encyclopédique et Alphabétique Unifié*) is a language used to index the collections of public libraries.

39 See his *Five Laws of Library Science* [RAN 1931]. The five laws are: "(1) Books are for use. (2) Every reader his [or her] book. (3) Every book its reader. (4) Save the time of the reader. (5) The library is a growing organism".

40 See his book presenting the principle of faceted classification: *Colon Classification* [RAN 1933].

41 The UDC is still in use, with nearly 65,000 subdivisions. See http://www.udcc.org/.

project of building a collective memory of humanity for the League of Nations. In his books *Traité de Documentation* (1934)[42] and *Monde* (1936)[43], Otlet conceived of a networked intellectual world coordinated by means of a classification system that was universal but would constantly be reconfigured according to links created among documents by users. This was the first detailed formulation of the principle of hypertext interconnection, before those of Vannevar Bush, Douglas Engelbart and Ted Nelson[44]. Paul Otlet had a coherent vision of the world of documents as a growing ecosystem and he foresaw that electronic technologies would soon make information ubiquitous (he was writing in the 1930s!).

4.3.3. *How can creative conversation organize digital memory?*

The classification and indexing systems that allow library users to find the documents they are looking for work well. Why not use them on the Web? Why invent a new metalanguage when so many already exist and have proven their worth?

Software forms of memory are very dependent on their material and technical media. The indexing methods and document metalanguages developed and perfected in the 19th and 20th Centuries were designed to manage searches for print documents or material media in physical institutions or, at most, national networks of institutions. The existence of a large number of different classification and indexing systems in the world did not create too many problems as long as each library or documentation center was organized using a single system. However, since the beginning of the 21st Century, practically all libraries, museums and archives have been digitizing and offering not only their catalogs but their collections online. As a result, human memory tends to be collected in a single technical medium. Consequently, national and institutional disparities in indexing and classification methods or document metalanguages are no longer acceptable in the long term.

This is one of the reasons library and documentation sciences have been undergoing a major reexamination since the public appearance of the World Wide

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42 Nearly unobtainable until recently republished by the Centre de Lecture Publique de la Communauté Française de Belgique [OTL 1934].

43 See [OTL 1936].

44 See Vannevar Bush, "As we may think" [BUS 1945]. The work of Douglas Engelbart at the Stanford Research Institute in the 1960s has been documented by Thierry Bardini in *Bootstrapping, Coevolution, and the Origins of Personal Computing* [ENG 1962], [BAR 2000]. For Ted Nelson, see his *Literary Machines* [NEL 1980], several previous versions of which were published in the 1970s.

Web around the end of 1993[45]. The size of the memory has grown immeasurably: a universal multilingual multimedia library is on the horizon. The documents and the links among them are undergoing constant change, being almost fluid. The general interconnectedness and ubiquity are changing users' search methods and practices. If we analyze the current situation through the eyes of future generations, it is clear that the possibilities for automatic calculation and interactivity are still largely underused for lack of standards and metalanguages suited to the new conditions.

We need to develop new ways of thinking about archives and their organization in order to deal with the elimination of constraints involving the physical location of documents − constraints that have existed since the beginning of writing 5,000 years ago. In fact, all documentary systems and indexing metalanguages prior to the Web have had to deal with the eminently practical imperative of the material placement of documents. The need to store information media "somewhere" seemed so natural that it was hardly recognized as a real constraint. As David Weinberger points out[46], it was not only the library's books, disks and cassettes, but even the files and catalogs, that required three-dimensional spatial organization. Since the existence of the Web − a very recent phenomenon on the scale of cultural evolution − digitized information has proliferated and it can be distributed indefinitely to every node on the network at minimal cost. Archives can be multiplied at will or reached by pointing to hyperlinks in the ubiquitous (i.e. ever present) digital environment; they thus no longer first have an address in physical space[47], but in an intangible semantic sphere. It is their meaning or relevance to readers that now constitutes their main address. The basic addressing has gone from the physical order (the library call number) to the semantic. This change leads to a second one: the possibility of indefinitely varying the semantic addressing of a document according to points of view and uses. As I pointed out above, and as actors/users of the participatory Web know from experience, it is now possible to structure and index the same set of documents in a thousand different ways. It is no longer only experts in documentation and information sciences, using well-established methods, who classify documents, but billions of users, tagging them in their own ways[48]. Indexing, until recently reserved for experts, is now practiced on a large scale by

45 Although Tim Berners-Lee's initial idea was published in an internal memo at CERN in 1989, there were still only 50 Web servers in the world in 1991. It was only with the first version of Mosaic by Marc Andreessen in September 1993 (which became Netscape in 1994) that the Web began to experience world-wide success.

46 In *Everything Is Miscellaneous: The Power of the New Digital Disorder* [WEI 2007].

47 Obviously, digital files still have to be located someplace in the physical memory of one or more servers.

48 See Isabella Peters, *Folksonomies: Indexing and Retrieval in the Web 2.0* [PET 2009] and Gene Smith, *Tagging: People-powered Metadata for the Social Web* [SMI 2007].

anyone and everyone on Amazon, LibraryThing or YouTube[49], social bookmarking sites, blogs, Twitter and, thanks to Faviki, even *Wikipedia*. The result of this collective classification activity is called a *folksonomy* (the word is modeled on *taxonomy*). It is true that the tags of folksonomies are inconsistent because of synonymy (many key words are used to designate the same concept) and homonymy (some key words have many meanings), not to mention the noise introduced through spelling mistakes, plurals, abbreviations, etc. In addition, the tags correspond to very disparate levels of generality and cannot readily be organized in classes and subclasses. Finally, the multiplicity of natural languages (in which the tags are usually expressed) still seriously fragments the creative conversations that have been starting in the last few years to organize the global memory. As imperfect as the folksonomies of 2010 are, however, they prefigure the creative conversation of the future, which will be capable of providing as many points of view for the universal memory as there are human communities and interests.

This perspective allows us to glimpse an emerging new type of metalanguage, a kind of writing in the second degree. This "meta" writing no longer places − or no longer only places − signs on a page or even on a screen, but attaches them to flows of digital data. Of course, as we have just seen, the concept of a document metalanguage is very old, but I am speaking here of a new generation of metalanguage: universal, democratic and calculable. This new language will be *universal* because memory is now world-wide. Unlike previous metalanguages, which were all local and based on a single culture, the new metalanguage will have to be radically equanimous, capable of expressing the perspective of any culture or tradition[50]. It will be *democratic* because its manipulation will no longer be the

49 For further information on YouTube as a medium of participatory cultural practices, see [BUR 2009].

50 To illustrate the narrowly ethnocentric nature of traditional document metalanguages, the following are the 10 subdivisions of category 200 (religion) of the Dewey Decimal Classification, one of the most widely used in the world:

200 Religion / 210 Philosophy and theory of religion / 220 Bible / 230 Christianity, Christian theology / 240 Christian moral and devotional theology / 250 Christian orders and local church / 260 Social and ecclesiastical theology / 270 Christian Church history / 280 Christian denominations and sects / 290 Other and comparative religions. If we wanted further confirmation of the ethnocentrism and dated nature of the Dewey classification, the following are the subdivisions of category 290 (Other religions): 291 Comparative religion / 292 Classical (Greek and Roman) religion / 293 Germanic religion / 294 Religions of Indic origin / 295 Zoroastrianism (Mazdaism, Parseeism) / 296 Judaism / 297 Islam, Bábism and Baha'i Faith / 298 Mormonisn / 299 Other religions.

It should be noted, for example, that Buddhism is not even mentioned directly and that the Baha'i faith − for which I have the greatest respect, but which has seven million members and whose followers are persecuted in many Moslem countries because it is not one of the preserve of information experts, but open to all participants in creative conversation by means of sensory-motor interfaces and translation into natural languages. Finally, it will be *calculable*, because all previous metalanguages were designed before the digital medium and its almost unlimited calculating power. The new metalanguage will make it possible to categorize information, evaluate it according to different rules, and trace navigation routes through the ocean of data[51]. Semantic computation based on the new metalanguage will not be limited to automated reasoning that infers the properties of a class from its belonging to a super-class. It will be able to generate and regenerate at will the hypercomplex fractaloid graph of formal concepts that will encompass the huge mass of information in their regular net. Obedient to the billions of pairs of hands in the creative conversation, this new kind of computation will steer the trajectories of attention and value in the unlimited semantic sphere that coordinates the library of Babel[52]. To transform the deluge of information into useful, organized memory carrying knowledge across language barriers, moving with ease through the diversity of cultures, the creative conversation that arises from cyberspace needs a symbolic medium in keeping with its scope.

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religions of the book mentioned in the Koran − is put in the same category and on the same level as Islam, which has a billion and a half believers. We find the same absence of equanimity, the same ethnocentric myopia and the same dated quality of the classification in other areas of knowledge. Other classification systems (including the Library of Congress system, which is obviously dependent on the particular situation in the United States) are not much better in this regard. That is why, rather than a classification or super-ontology, I am proposing a *formal language of creative conversation* that will make it possible to express any concept and any classification.

51 Vannevar Bush spoke of creating lasting "trails" in the forest of the future computerized memory [BUS 1945].

52 See Borges's famous story entitled "The library of Babel" [BOR 1998c].

Chapter 5

Toward an Epistemological Transformation of the Human Sciences

This chapter presents the study of human development, in broad terms, as one of the main objects of the human sciences. If human development depends even partly on the advancement of the human sciences, then increasing the capacity of these fields to produce, disseminate and manage knowledge effectively is crucial. I therefore intend in the following pages to analyze the epistemological weaknesses of the contemporary social sciences and literary studies, in contrast with the maturity of the "natural" sciences. Far from limiting myself to this negative observation, I will show that full use of the data, calculating power and collaborative tools of the digital medium could lead to a veritable scientific revolution in the human sciences in the 21st Century. It will not, however, be possible to reach this goal unless we adopt a *common system of semantic coordinates* that leads to better knowledge management (KM) and to theories (and even works) that can be expressed in terms of calculable functions. The chapter ends with a cautionary note against a positivistic scientism that would overly objectify the results of the human sciences, even after such a scientific revolution, since what is known here is the expression of knowing subjects.

5.1. The stakes of human development

Many official reports from governments and international agencies have identified the digital revolution not only as a factor that is destabilizing societies and cultures, but also as an *opportunity for human development*. This approach is advocated by many citizens' groups, experts, institutions and governments. To further a trend that is already well established internationally, I am proposing that the new forms of knowledge and action made possible by the digital medium be systematically used to serve human development.

5.1.1. *The scope of human development*

What is human development? Today, we generally understand this expression to mean the balanced, sustainable improvement of the living conditions of a population. In my opinion, the main indicators are education, health, economic prosperity, human rights, good democratic governance, peace, security, transmission of cultural heritage, scientific research that serves society, technical and institutional innovation and environmental balance. The United Nations and international development agencies increasingly use the concept of *integral human development*, which goes beyond economic development alone. In his book *Development as Freedom*, the 1998 Nobel Prize Laureate in Economics Amartya Sen[1] explains that human development cannot be reduced to the growth of the gross national product and the opening of markets. It must also take into account all those "goods" that are not directly included in the monetary circuit, such as ethical, aesthetic and social values, personal and collective freedoms and the quality of the environment. Sen's approach emphasizes elements that, although qualitative and subjective, are essential to a decent human life. We can further extend our approach to human development along two major parallel paths: dialog among cultures and reflexive knowledge of collective cognition.

In the area of intercultural dialog, this means promoting curiosity, openness and mutual understanding in order to dissipate ignorance, fear, disrespect and aggression as much as possible. Everyday events show indisputably that there is still room for progress in civilized cross-cultural dialog. All the great wisdom traditions, whether religious or secular, share this call for polite, respectful dialog among languages, religions, national identities, philosophical points of view, disciplines, occupations and communities of all kinds.

The study of distributed symbolic cognition is a second path of exploration for human development. Indeed, we have mainly developed our science and technology to understand and control bodies and perceptible phenomena. Technoscience enhances our power and freedom in the external material world, which is obviously not insignificant. But according to Rabelais's famous saying, "science without conscience is the death of the soul"[2]. That is why we should be capable of balancing

1 The Nobel Prize in Economics is, in fact, the Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel. See *Development as Freedom* [SEN 1999].

2 "Sapience n'entre point en âme malivole, et science sans conscience n'est que ruine de

our knowledge of the universe of material phenomena with an equally diligent and systematic quest directed toward a different order of reality: that of the feelings, emotions, thoughts and ideas that are interwoven into our cognitive ecology. This more "internal" order of reality conditions our behavior and constructs the cultural world we live in. Symbolic cognition is obviously the object of the human sciences, understood in the broad sense as including arts and letters[3].

In short, the human development approach calls for a shared international effort to increase the material, social, cultural, intellectual and personal opportunities open to every human being, and to do so in a sustainable way. One of its goals is peaceful intercultural dialog. It also advocates the development of an emotional and cognitive climate favorable to the growth of intellectual, aesthetic and social creativity and the establishment of increasingly refined intellectual and moral standards.

5.1.2. *In search of models of human development*

One of the reasons why the human development approach is much easier to describe than to put into practice could very well be the existence of a cognitive deficit. Indeed, in a world that everyone agrees is complex and interdependent at every level, what does it mean "to make the right decisions" for the good of human development? Is our knowledge sufficient to provide the foundation for a coherent practice, a long-term cooperative learning process in the area of human development? Can we envision extending the zone of predictability of the collective consequences of our actions, in spite of the qualitative, subjective and contextual nature of their meaning?

I stated above some of the relevant indicators of human development: education, health, sustainable prosperity, human rights, transmission of cultural heritage, scientific research, environmental balance, etc. Even a quick glance at this list suggests that there are probably strong causal relationships among the phenomena measured by these indicators. However, economic indexes, epidemiological data, education statistics, reports on human rights, etc., are usually collected using different methods and theoretical approaches. Increasing the fragmentation, this information is managed and used by different ministries and agencies at many levels of government.

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l'âme". Rabelais, *Pantagruel*, chapter VIII (1532).

3 The French *sciences de l'homme* correspond to the English social sciences and humanities, the subjects taught in faculties of arts and social sciences, including communication, education, law, etc.

In all probability, the causal circuits do not end at the boundaries of our disciplines, our ministries or our professional or national cultures. However, we have no consistent, calculable models that would enable us to simulate and study the interdependent causal circuits that generate human development in their entirety. In contrast, there are standard economic indicators (gross national product, growth, employment rate, etc.) that are accepted internationally and that therefore permit comparisons. The human development index used today by the United Nations does not have the same authority[4]. It combines statistics on life expectancy at birth, literacy and education with the per capita gross national product. It should be noted that this index − as useful as it is − is rather crude, as even its authors acknowledge. It does not in any way constitute a causal model of human development: it is at best an approximation that is easily measurable with the means available today.

5.1.3. *Social capital and human development*

Some people might counter these pessimistic remarks by pointing to the many contemporary studies on social capital[5]. The concept of social capital, which has been developed mainly since the late 20th Century, seems at first glance to integrate or reflect many dimensions of human development. It can be approached from various perspectives. First, social capital may refer to the quality of the social bond, the essence of which is commonly called *trust*. Second, researchers who study social capital often do mapping of networks of relationships among individuals, which include affective relationships among family and friends (bonding) and inter-community relationships among members of different social categories (bridging). Third, the concept includes the vitality of the public space and of associative and community relationships. The concept of social capital is interesting because it cuts across many fields of integral human development (peace, economic prosperity, health, education, human rights). Many studies suggest, in fact, that public health, education levels and economic prosperity are strongly correlated with social capital[6].

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4 The reports on human development and the method of calculation of the United Nations index can be found at this address: http://hdr.undp.org/.

5 I am not using the concept of social capital in Bourdieu's sense (network of relationships showing a socially dominant position), but in Putnam's sense (quality of social links in a community). See:

- Alain Degenne and Michel Forsé, *Les Réseaux Sociaux* [DEG 1994].
- Francis Fukuyama, *Trust, the Social Virtues and the Creation of Prosperity* [FUK 1995].
- Robert David Putnam (probably one of the most influential thinkers in the area of social capital), *Bowling Alone: The Collapse and Revival of American Community* [PUT 2000].
- Lin Nan, *Social Capital: A Theory of Social Structure and Action* [LIN 2001].

6 It has been demonstrated that there is a strong correlation between the social capital of a community, its health and its level of education, for example; see the OECD report *The Well-*

Since the beginning of the 21st Century, the development theory of the World Bank (an international financial institution based in Washington) has officially been based on the general concept of social capital.

Nevertheless, as it is used today, the concept of social capital suffers from two handicaps: it is neither precise, nor complete. It is imprecise, first, because it lacks a clear, detailed operational definition that would make it measurable and shareable in different contexts. For this reason, it is difficult to find significant data that are really comparable in studies on social capital. More important, however, the concept is incomplete. Many significant factors in human development are absent from the model provided by the theory of social capital. Social relationships, precisely because they are human, follow the *technical* channel of relationships to the material world and the *semiotic* channel of languages and symbolic systems. Theories of social capital and social networks do not include the technical and symbolic dimensions of human relationships − or do so poorly. Nor do these theories describe in detail the *cognitive* functioning of social networks, which I have particularly emphasized in the preceding chapters. I should, however, point out that an increasing number of researchers are taking an interest in the role that *KM* which includes the dimension of social capital could play in strategies of integral development. This trend is still marginal, although it too is being officially encouraged by institutions such as the World Bank[7].

5.1.4. *The knowledge society and human development: a six-pole model*

The preceding remarks lead us to another major approach to human development: one focusing on the cognitive rather than the social dimension. Many international agencies responsible for stimulating development link it officially to a "knowledge society", an "information economy" or a "knowledge-based economy" that favors high levels of education and a capacity for innovation in all sectors of society[8]. While so many governments and transnational bodies are officially promoting it, there is no systematic collection of data that clearly shows the basic cycles of the information economy or the functional relationships among its various factors. Of course, we find statistics on the communications and high-tech industries, marketing data on the consumption of paid information or tables of figures showing the percentage of people who have elementary, secondary or post-

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being of Nations: The Role of Human and Social Capital [OEC 2001].

7 See, for example, Catherine Gwin, *Sharing Knowledge. Innovations and Remaining Challenges* [GWI 2004]. For a more philosophical approach, see Kathia Castro Laszlo and Alexander Laszlo, "Evolving knowledge for development: the role of knowledge management in a changing world" [LAS 2002].

8 I will go into more detail on all these concepts in Chapter 6, on the information economy.

secondary education. Various international organizations, such as the OECD, provide lists of countries classified by the number of patents filed or the amount of royalties collected. Despite this, as for human development, there is no coherent set of empirical data *organized on a causal model* for the knowledge society

In any case, it seems to me that social capital and trust, which are based on networks of affective and social relationships among individuals, or knowledge capital, which is based on education levels and life-long learning and correlates with capacities for innovation, each represent only one of the poles of a more general dynamic of human development. After thinking long and hard about this problem and combing through large quantities of statistics and reports, I feel that a balanced approach should include at least the following six poles:

– networks of explicit knowledge, the reservoir of ideas and symbolic forms available in minds (epistemic capital, or knowledge capital);

– networks of will, the mode of governance, the values and shared vision of communities (ethical capital);

– networks of powers, in particular the availability of occupational skills and financial liquidity (practical capital);

– body networks, in particular technical equipment, public health and the quality of the environment (biophysical capital);

– networks of people, individuals with various social roles and relationships of trust (social capital);

– document networks, the media, power of dissemination as access to cultural resources and accumulated memory (communication capital).

Figure 5.1 highlights the symmetry of the relationship between two dialectics. Vertically, a *bipolar* virtual/actual dialectic opposes and links two complementary triplets: document/people/body networks, in the *actual* area (south); and knowledge/will/power networks, in the *virtual* area (north)[9]. Horizontally, the *ternary dialectic* that structures the three columns reproduces the semiotic triangle. The column to the west corresponds to the sign or the signifier (in its ideal forms in the *virtual* area and in its documentary and media inscription in the *actual* area). The central column corresponds to the signified for an interpreter, i.e. to the human mind or to the *being* (in its abstract intentionality, in the *virtual* area, and in its personal and social incarnation, in the *actual* area). The column to the east, finally, corresponds to the referent or the *thing* (in its aspect of a dated and situated material body, in the *actual* area, and in its aspect of a reservoir of potential, in the *virtual*

9 For a philosophical explanation of the concepts of virtuality and actuality, see my book *Becoming Virtual: Reality in the Digital Age* [LÉV 1995].

area). The ternary dialectic sign/being/thing opposes and links three complementary pairs: 1) document networks/knowledge networks; 2) people networks/will networks; 3) body networks/power networks[10].

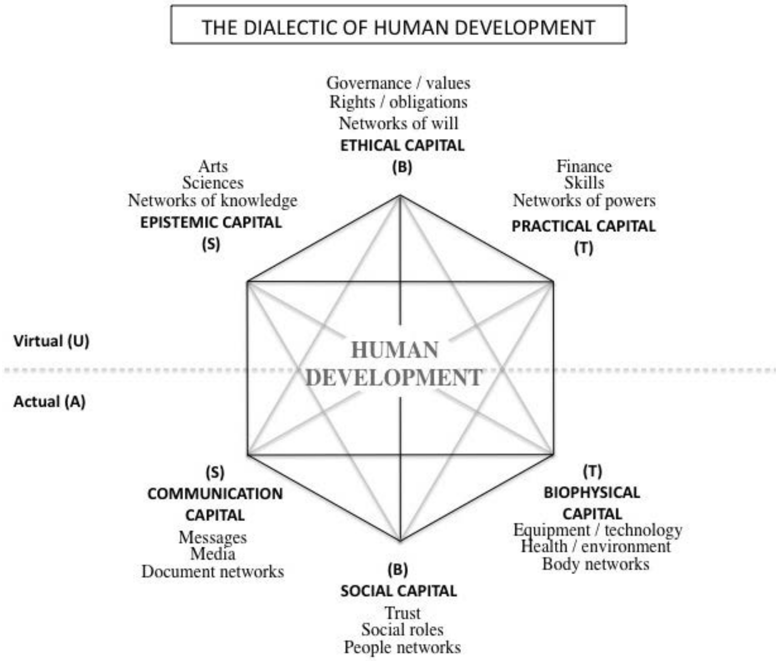

Figure 5.1. *A multipolar diagram of the human development process*

This representation of the basic dynamic of human development is compatible with actor-network theory[11] and more generally with the theory of the networked society that is widespread in the contemporary social sciences[12]. These approaches, like the one I am outlining here, call for the integration of the mathematical tools of graph theory into the human sciences[13]. The diagram in Figure 5.1 suggests that

10 Readers will undoubtedly recognize the general model shown in Figure 1.7 and others in Chapter 1.

11 For an introduction to this theory, see Michel Callon (ed.), *La Science et ses Réseaux: Genèse et Circulation des Faits Scientifiques* [CAL 1989], and Bruno Latour, *Science in Action* [LAT 1987].

12 See, for example, Mark Granovetter "The strength of weak ties" [GRA 1973], Manuel Castells, *The Information Age* [CAS 1996] and Barry Wellman, "Computer networks as social networks" [WEL 2001].

13 The idea of a new scientific paradigm organized around network modeling was put

distributed symbolic cognition, the engine of long-term human development, should be oriented toward a balanced interdependence and an ongoing exchange of resources among the six networks − or among the six "capitals" of a general information economy − with each one of them fueling the other five. I am not claiming that this diagram provides a fully constituted theory of human development. At best, it offers a conceptual map or semantic compass, a critical instrument that may enable us to avoid forgetting any important dimension of human development and situate competing theories. The fact remains that I have not found a *causal theory* of human development anywhere that satisfies the requirement of a uncentralized interdependence, as shown in my multipolar diagram. There is no common observation instrument, no tested intellectual technology today that allows us to study human societies as autopoietic cognitive machines in which informational energies circulate among signs, beings and things, or as self-referential systems in which creative conversation transfers the value of virtual networks toward actual networks and vice versa. The contemporary human sciences have not yet provided us with an integrated model of human development.

5.2. Critique of the human sciences

My diagnosis is that this failure of the human sciences to provide an integrated model of human development is due mainly to the fragmentation of their disciplines and paradigms, the non-calculable nature of most of their qualitative models and, more fundamentally, the absence of a system of coordinates to support the interoperability and calculability of their theories. I am not suggesting, however, that we imitate physics. It should be understood that I am not calling for qualitative models to be reduced to quantitative ones, but for a computable formalization of symbolic structures and relationships among semantic qualities. Before going into detail on my criticism of the contemporary state of the human sciences, I would like clarify the parallel I am drawing between the revolution in natural sciences that took place in the 17th Century and the one that is required in the human sciences in the 21st Century.

5.2.1. *Human sciences and natural sciences*

The work that led me to develop the IEML semantic sphere is situated at the convergence of many traditions seeking the unity of nature. These traditions are spiritual, philosophical and scientific, but I am focusing here on the scientific quest. "Matter" and "mind", the world of material bodies and the world of intelligible ideas, the objects of the exact sciences and those of the human sciences, interact in

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forward by Albert László Barabási; see his *Linked, the New Science of Networks* [BAR 2002].

obvious ways and are certainly part of the same reality. It is not hard to reach a consensus on the *fact* of the unity of nature. The real difficulty lies in the absence of an articulate *scientific model* of this unity. In Chapter 2 I outlined the unifying pattern of an organization in successive layers − quantum, molecular, organic, phenomenal and semantic forms − with the layers connected by transcoding interfaces: atoms between the quantum and molecular worlds; DNA between the molecular and organic worlds; neurons between the organic and phenomenal worlds; symbolic systems between the phenomenal and semantic worlds[14]. These layers of information extend between two basic transformation groups: the unified field of physics, in the south, and the semantic sphere, in the north. If the IEML semantic sphere − or some equivalent formalism − were adopted as the system of coordinates for addressing the symbolic processes of cognition, we would have taken a giant step toward the unification of nature. That would involve a true epistemological transformation of the human sciences, however, comparable to the one that took place in the natural sciences in the 17th Century.

Before Galileo and Newton, the celestial world and the terrestrial (or "sublunar") world were still considered to be subject to different systems of modeling. The heavens, with their hierarchies of angelic intelligences, were the place of perfect geometrical movements and theological speculation, while the crudely material sublunar world was subject to physical processes of generation and corruption, and without geometrical reason. Alchemy mixed practices for transforming materials with symbolic practices of spiritual transformation inherited from a distant pre-monotheistic past.

The modern revolution in the experimental sciences brought together all perceptual phenomena in the same universal, infinite three-dimensional space and reduced the essential core of scientific explanations to the mathematical formalization of causal mechanisms (however complex, indeterminate and irreversible those mechanisms might be)[15]. It should be understood here that the only thing required for us to be able to speak of a "mechanism" is its description in terms of calculable functions. Quarks, atoms, molecules, organisms, biosphere, planets, stars and galaxies are in principle part of the same material universe coordinated by a single space−time continuum, and the sciences that study these subjects can therefore talk to one another.

What about the objects of the human sciences, such as prices, governments, social movements, literary works and rituals? Let us begin with the most striking similarity: the objects of the human sciences circulate in an environment in which

14 See section 2.3.5

15 See Alexandre Koyré, *From the Closed World to the Infinite Universe* [KOY 1951] and Isabelle Stengers, *The Invention of Modern Science* [STE 1993].

quantities exist, exactly as in the material world, as evidenced by the extensive use of statistics in the social sciences. The symbolic universe where human symbolic cognition exists also has two dimensions that are absent from the material universe: value (as it results, for example, from moral judgment: good or bad) and meaning. Neither value nor meaning can be directly situated in three-dimensional space, although they can be indirectly connected to the material world through our cognitive processes. Even though great philosophers such as Spinoza and Leibniz thought rigorously about the unity of nature, the scientific revolution of the 17th Century remained unfinished: at the technical level of mathematical modeling, nature as conceived by science is incomplete and fragmented because it does not include culture, i.e. human collective intelligence structured by symbolic systems.

I am therefore proposing the adoption of a system of semantic coordinates. This system − the IEML semantic sphere − would make it possible, first, to address meanings and, second, to precisely represent the circulation of values − the general economy of information. It is based on a transformation groupoid, so the proposed system of coordinates would enable movements, metamorphoses and variations in meaning and value to be described using calculable functions. As it is structured by a hypercomplex fractaloid circuit, this system of coordinates could represent any model in the form of a graph, including networks of knowledge, will, powers, documents, people, material bodies, and all the mixed and hybrid networks anyone could want. The edges and vertices of these graphs could be addressed using not only space–time coordinates, but also conceptual coordinates in the semantic sphere. In short, today's fragmented world of culture would be unified through a single (practically infinite) system of semantic coordinates, and its dynamics of meaning and value could be described by calculable functions, using network-type modeling. Let us now examine the contemporary problems of the human sciences in greater detail.

5.2.2. *Internal fragmentation*

Today, each of the human sciences deals with only a limited portion of the complete circuit of meaningful information. Fields such as theology, philosophy, anthropology, sociology, economics, psychosociology, psychology, linguistics, literary studies, communication studies, history, geography and education sciences are based on different − and most often incompatible − principles and traditions. In addition, there are conflicts of paradigms and theories within individual disciplines. Each social science and each discipline of the humanities has its own universe of reference, which is not necessarily consistent with that of the others, even though we can sense that there are resonances and complementarities between economics, psychology, sociology, history, linguistics, literature, etc. Separation and absence of communication are not absolutely negative in themselves; they are only a problem because the goal of the sciences is to comprehend (in the etymological sense: "take together") phenomena. The divergent perspectives and principles in the human sciences do not make it possible to grasp the interdependent complexity of the causal circuits that lend coherence to the symbolic life of humanity.

Is this fragmentation normal, natural, insurmountable and desirable − as the majority of scientists today believe? Or is it, as I feel, a dated and situated state in cultural evolution and scientific history?

5.2.3. *Methodological weaknesses*

Some of the human sciences take intellectual formalisms seriously, in particular linguistics, economics, law and the cognitive sciences. There are generally different formalisms in each discipline, and even each subdiscipline. In other fields in the human sciences, statistical quantitativism[16], concepts that are vague (which is a source of pride for certain "postmodern" writers) or even political convictions sometimes take the place of scientific method. The means of analysis applied are generally weak in relation to the objects to be understood. What needs to be understood, in general, is the *meaning* of phenomena and their transformations. Yet I have not found a *formal*, *operational method* for representing the rhizomatic multiplicity of meanings of information in context, nor for representing the interdependence of the technical, economic, social, cultural and symbolic dimensions of distributed human cognition from which these meanings emerge. The complexity of social phenomena is already being represented using models in networks, but the nodes and links of these networks *are not* variables of calculable functions.

As convincing as current approaches in the human sciences are, they offer no calculable theory that would be capable of expressing the autopoietic, self-reproducing, self-referential nature of their objects[17]. For these objects − societies, communities, networks or individuals − *are also subjects* that are as capable of interpretation, or production of meaning, as the researchers themselves. Whether they are works of art or symbolic systems, their worth as objects of the humanities arises from the fact that they are *engines of interpretation* rather than passive objects.

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16 Which too often amounts to nothing more than counting answers to a questionnaire and calculating averages, standard deviations, etc.

17 Niklas Luhman (see his *Social Systems* [LUH 1995]) clearly identified the self-referential, autopoietic aspect of the objects of the social sciences, but he did not propose any operational or calculable formalization.

With respect to calculable theories − because there are some − they are most often limited to purely quantitative models (for example, in economics), or (as in the cognitive sciences in the broad sense) to oversimplified logical/arithmetic mechanisms (automatic reasoning), simulations of networks of logical automata or the *metaphorical* formalization of mechanisms borrowed from the physical or biological sciences. I am thinking, for example, of memetics, which borrows its model from the theory of biological evolution, or studies of emergent collective intelligence based on models borrowed from neurology or animal ethology. While all these models are indeed calculable, they are not good at capturing the complexity of human meaning.

5.2.4. *Lack of coordination*

In addition to their fragmentation and their methodological weaknesses, a third handicap prevents the human sciences from fulfilling the role they should play in promoting human development. Unlike knowledge in physics, chemistry or biology, knowledge in these areas is usually not explicit, formalized and coordinated enough to be combined and exported into a variety of different contexts. For most of them, narrative − theoretical or experimental − in natural language is still the main way of presenting their non-quantitative results. This is what makes it so difficult to make comparisons from one cultural context to another in the areas of the meaningful (semiotic and aesthetic symbolic manipulation), the valid (legal and ethical reasoning) and the possible (speculative, fictional and ludic expressions), although these areas are essential.

In the emerging discipline of KM, which was discussed in Chapter 4, this type of knowledge is known as *tacit knowledge*. It is a distinguishing characteristic of the contemporary human sciences: their requirement for "personal participation" to actualize meaning. We have seen that one of the main operations involved in KM is making the tacit knowledge of a community explicit so that it can easily be transferred from one context to another and combined in shared information systems. The tacit mode is not bad in itself. For KM, tacit does not mean of inferior quality. Tacit knowledge is perfectly valid and useful in its original context, but it is not possible to *accumulate it*, or *transfer it to other contexts*. In the best case, the process of explication concludes with a cultural change that is manifested in: (i) respect for common standards; (ii) the use of compatible observation and measurement instruments; and (iii) the use of symbolic systems that facilitate translation, coordinated representation and calculation. Through this cultural change, knowledge becomes shareable in a sustainable, potentially universal network of different communities.

By way of comparison, unlike researchers in the human sciences, all chemists work with the same elements. Chemistry is a science precisely because chemists share: (i) a language for describing their objects; (ii) a standard set of observation and measurement instruments; and (iii) reproducible methods. The language of chemistry makes it possible to explicate − as much as possible − the experimental knowledge of chemists. In the grammar of its system of signs, it reflects what is considered to be the structure of the chemical universe. However, we still do not have common elements, standard measurement instruments or a general method of observation for the non-quantifiable aspects − the most important ones − of the human phenomenon. We have no *metalanguage for the explication of knowledge* in the human sciences.

Is this the reason why we sometimes have the feeling that there is no progressive accumulation of knowledge in the human sciences as there is in the material natural sciences? If we compare a book on physics or biology from the end of the 19th Century with one from the beginning of the 21st Century, we will observe that there has been rapid change and remarkable advances in knowledge about life and matter. On the other hand, if we compare the books of some of the founders of sociology (e.g. Emile Durkheim, Marcel Mauss and Max Weber) with a sociology book published in 2011, would we observe the same progress in knowledge? Would we learn less about the essence of social life by reading the old texts? To ask the question is to answer it. Sociology certainly includes a large portion of philosophy. Although there is obviously an irreversible history of philosophy, we cannot really talk about "progress", since each great philosophy represents a unique thinker and none makes the preceding ones obsolete. Aristotle or Leibniz is always current.

In spite of the philosophical and critical nature of sociology, the discipline claims the status of a positive science. In this regard, it is rather shocking that no consensus has emerged in the community of sociologists (which includes Marxists as well as practitioners of social network analysis or ethnomethodology[18]) on the discoveries or major advances in the discipline.

5.3. The threefold renewal of the human sciences

To go beyond their fragmentation and work in a coordinated way to promote human development, the human sciences will have to seize the opportunities created by the digital medium and undertake a complete overhaul of the management of their knowledge. As I pointed out above, this agenda implies a major

18 According to ethnomethodology, the theoretical spontaneous creation of communities is a major element in the very construction of the social. See Harold Garfinkel, *Studies in Ethnomethodology* [GAR 1967].

epistemological and cultural change. This revolution has already begun in (1) methods of collaboration; it is beginning to appear in (2) instruments of observation and calculation; but (3) the prospect of a common metalanguage of modeling is still generally beyond the concerns of the community of researchers.

5.3.1. *New possibilities for collaboration*

Just as printing transformed the practices of scholars and scientists in the Renaissance and was one of the technical conditions for the revolution in modern science[19], the arrival of the Internet is transforming the way the scientific community functions. Since the 17th Century, its creative conversation mainly took place through handwritten correspondence or print publications. Today, this pattern is tending to be replaced by new communication mechanisms based on the digital medium. This new pattern of communication includes three interdependent practices: direct access to and collective use of data and tools; open publication; and the acceleration of informal exchanges of ideas.

5.3.1.1. *Direct access to and collective use of data and tools*

Among the changes taking place, one of the most important is without doubt the sharing of primary data in real time. Once digitized, collections of documents and primary information sources are immediately available to researchers anywhere there is a connection to the network. This new situation is transforming the work of historians and researchers in the human sciences whose work involves the use of archives. Since the considerable effort previously required to access primary sources is no longer necessary, the center of gravity of researchers' activity has shifted almost exclusively to the interpretation of data, which is increasingly automated, and to critical conversation with other researchers using the same corpus. Thus, close collaboration takes place in huge "virtual teams" that are widely dispersed geographically and institutionally, but are working on the same questions. Moreover, research communities join together systematically online in real time to share their models for analyzing and interpreting data, including software and simulation tools that operationalize these models.

5.3.1.2. *Open publication*

New mechanisms for personal and collective management of articles are being put in place, redefining the rules of publication. New observations and theories can be made public without going through the traditional scientific journals because they are published on specialized sites where researchers criticize each other's work (peer

19 As shown by Elisabeth Eisenstein in *The Printing Revolution in Early Modern Europe* [EIS 1983].

review) *after* publication. The site that initiated this revolution is http://arxiv.org/ at Cornell University. The movement started in the physical sciences and engineering in the late 20th Century, but it began to have an impact in the human sciences in the early 21st Century. Most public research institutes and big universities have encouraged this movement[20]. An increasing number of voices are criticizing the privileged position of scientific publishers and calling for free open access to the results of research subsidized by tax dollars. This change is linked to the use of distributed systems for collection and sharing of articles, such as (around 2011) CiteUlike and Mendeley.

The consequences of this change in publishing are twofold: the circulation of research results is much faster, and their subsequent evaluation through citation, comment and reference is also faster. I would like to point out in conclusion that the centuries-old traditions of the scientific community are not only being respected, but are enhanced: “open science” using the new digital mediasphere is more than ever based on the principle of critical conversation and inter-citation.

5.3.1.3. *A new type of informal creative conversation*

Without prejudging the tools researchers in the human sciences will use for informal conversation in the future, we can say that in 2011 this conversation takes place primarily in the hypertextual interweaving of research blogs and conversations in social media. The social media used may be general ones such as Ning, Facebook or Twitter, or specialized for research. This practice has given a growing number of researchers a foretaste of what could become an even more effective interconnection of their systems of personal KM in the future. It goes without saying that all these forms of online collaboration are usually accompanied by a good deal of travel and conferences, rather than the isolation and immobility predicted by prophets of doom such as Virilio.

5.3.2. *New possibilities for observation, memory and calculation*

5.3.2.1. *Availability of data and calculating power*

Perhaps we have no science of symbolic cognition that unifies culture (as modern experimental science unified nature) simply because its object − meaningful information circuits in their interdependent totality − has until now been unobservable and thus only an object of speculation. This situation is now changing.

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20 In this regard, *The Budapest Open Access Initiative* (2002) must be mentioned. See http://www.soros.org/openaccess. A great deal of historical documentation on the Open Science movement may be found on the French-language site of the Institut de l’information scientifique et technique (INIST): http://openaccess.inist.fr/.

In the era of cyberspace, all earlier media are converging. Almost all cultural signs are created, recorded and interconnected in an ever-expanding digital network that includes computers, smart phones and mobile electronic gadgets, as well as things and machines of all kinds with embedded radiofrequency identification chips. Digital data are both localized and delocalized. In terms of localization, the new augmented-reality systems provide real-time access to relevant information associated with places and situations. They make it easier than ever to find people and services we are looking for according to their geographic position. In terms of delocalization, the recording of data and applications in the "clouds" of the Internet permits their access from any point on the network[21]. More generally, we are slowly but surely progressing toward a situation of *ubiquitous computing*, in which capacities for memory, calculation and wireless communication are almost unlimited and are completely integrated into the environment.

All documents are virtually interconnected, in principle forming a single fluid hypertext, read and written by a huge number of readers and writers of various languages, cultures and ethnicities. In the digital era, language has moved beyond the autonomous memory provided by writing, the capacity for automatic reproduction provided by printing, and the near ubiquity provided by electricity. It now possesses a capacity for autonomous action and interaction. Indeed, what is software, if not a type of writing adapted to the world of networked computers and capable of acting on its own, interacting with other software, creating combinations of signs of all kinds, starting up a machine, activating a robot or reproducing itself even more automatically than the printed word? In this regard, computer viruses are simply a spectacular manifestation of this general characteristic of all software. Plastic and metal robots are activated from within by this writing that is capable of decoding and sending signals. In the new environment of ubiquitous computing, the universe of the *soft* is the logical liquid, the sea of living complexity, the culture medium from which images, music and words now spring. I maintain that this new techno-cultural situation has profound implications for the human sciences.

I said above that we do not yet have a commonly accepted method capable of providing a precise, objective and measurable account of the totality of the intertwined causal circuits that hold together a viable society. However, the intertwined unity of the circuits of the human symbolic ecology could, if we so desired, become apprehendable in the digital medium to which an increasing proportion of the content and transactions of human collective intelligence has begun to migrate. The ubiquity of data, the unity of their binary encoding, their hypertextual interweaving and the calculability and local traceability of information

21 I am referring, of course, to cloud computing: material resources, applications and data are provided to users on demand through the Internet.

circuits in the digital network have given rise to a new epistemological situation[22]. It is now socially and technically possible to establish a holistic, critical, reflexive scientific discipline of which the object − the observable object − is the general circulation and organized transformations of meaningful information within human communities.

5.3.2.2. *Absence of the tools for semantic synthesis needed to make full use of the new situation*

As we have seen, the data on symbolic cognition are increasingly being spontaneously produced and accumulated in the digital medium by human communities themselves. Yet, in the early 21st Century, we have no means of synthesizing − and observing − a dynamic image of the collective intelligence that is evolving in cyberspace.

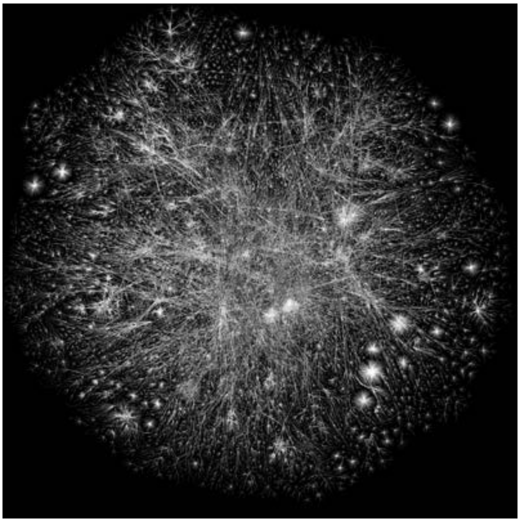

Figure 5.2. *Image of the Internet constructed by Barrett Lyon*

The famous image[23] in Figure 5.2 represents the decentralized structure of the Internet well, and if only we could identify the nodes, gives an idea of the source and quantity of the information flows exchanged in the network. But such an image

22 This new situation also creates problems with respect to ethics and the protection of privacy. As a provisional moral principle, I suggest that the human sciences not keep any personal data, processing only the semantic, axiological and quantitative dimensions of data flows.

23 This image is taken from http://www.opte.org/maps/.

really gives no idea of the *content* of the information exchanged, and even less of the *relationships among the meanings* of the information flows. Statistics from search engines can provide indicators of the popularity of certain words over time, but these are words in natural languages, not concepts independent of language. No search engine or social medium currently provides a dynamic, explorable representation of the relative distribution and interrelation of concepts found in searches, messages exchanged or documents posted on the network. However, the minimum we can ask of a useful scientific representation of the collective intelligence that is developing in the digital medium is that it maps the relationships between meanings.

To usefully query and interpret data produced by − and reflecting − human symbolic cognition, we need appropriate observation instruments and practical units of measurement. The *common nature* of these observation and measurement tools is a *sine qua non* condition for open scientific dialog. It is not possible to envisage the establishment of a science without sharing the interoperable open source observation tools, standard units of measurement and, finally, a common system of semantic coordinates to harmonize everything. This constraint is not trivial. Indeed, this is the first time we have found ourselves in the situation of having to coordinate the totality of symbolic activities.

5.3.3. *Toward a system of semantic coordinates*

5.3.3.1. *Historical context*

The following are some of the main conventional systems currently used for communication and distributed human cognition:

− calendars, time zones, systems of time measurement;

− systems of cartography and geographic location, meridians and parallels;

− scientific units of measurement (length, weight, heat, electric potentials, etc.);

− systems of numerical notation, mathematical notation;

− accounting systems of businesses and governments, standards governing public statistics.

All these systems of notation, accounting, measurement and coordinates are universal or tend toward universality. Yet they are conventional and perfectible. As its name indicates, the main function of a system of coordinates is to harmonize knowledge and human action in a specific field. There is thus no reason that new systems of coordinates should not be adopted when humanity opens up new spaces of knowledge and common action, as is the case today with the digital revolution.

By way of comparison, the invention of money has enabled us to mobilize, measure and calculate quantities of value. What we now need to mobilize, measure and transform automatically is meanings, and even circuits for processing meaning: symbolic configurations. Still with regard to mobilization, measurement and calculation, we could also draw a parallel between the unification of geographic space−time and the unification of semantic space. For a long time, every major culture had its own system of mapping and its own "center of the world" (for example, Mount Meru, Jerusalem). Furthermore, although the base map or geometric system of coordinates was conceived in antiquity, it only began to be used in the "Age of Discovery" at the turn of the 15th and 16th Centuries by Portuguese, Spanish, Italian, French, Dutch and English sailors navigating the Atlantic. Geometrization is very important, since it alone permits the calculation of angles, distances and positions. It should be remembered that the system of geographic coordinates − meridians and parallels − in use today only began to be effectively universal in the 18th and 19th centuries, spread by European printing and imperialism[24]. The measurement of time, with its circular representation and its division into minutes and seconds, was inherited from the number and measurement systems of ancient Mesopotamia. The system of time zones was adopted, after much discussion, only at the beginning of the 20th Century, when the globalization of land and sea transportation networks made a new type of time coordination essential[25]. It is this system that today enables us to coordinate the flights of the World's airplanes. Systems of space−time coordinates, which are both universal (hence their usefulness) and cultural (they are symbolic conventions, tools constructed for a purpose) have been a very concrete part of the journeys, exchanges and global unification of the past three or four centuries[26].

5.3.3.2. *A metalanguage that serves the human sciences*

The human sciences now have new methods of collaboration available that make it possible for vast international networks to co-construct and use huge databases whose contents are renewed in real time. For the first time, they also have an instrument for observing human symbolic life, insofar as this symbolic life directly uses the digital medium or is reflected in it[27]. The epistemological transformation of

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24 See the beautiful book *Cartes et Figures de la Terre*, published by the Centre Pompidou in Paris [COL 1980].

25 See Peter Gallison, *Einstein's Clocks, Poincaré's Maps* [GAL 2003].

26 This unification has often been accompanied by conflict, but there has been unification all the same.

27 It is clear that we will not go to the dentist, hairdresser or tattoo parlor on the Internet, at least not in the foreseeable future. On the other hand, all the data on dentists, hairdressers, tattoo parlors and the services they provide will soon be available online. We therefore need to make a distinction between cases in which symbolic life takes place *directly* through the

the human sciences will only be complete, however, when they have adopted a common metalanguage of description equivalent to elements in chemistry, or meridians and parallels in geography. In adopting such a metalanguage, the human sciences would go from an uncommunicative, fragmented state to one in which the explication and semantic interconnection of ideas and data would become the new common currency of scientific practice. It would then become possible to carry out strategies for human development based on coordinated observations and verifiable causal models. A creative loop could be initiated between: (i) more precise data; (ii) theoretical refinements; and (iii) practical wisdom to serve human development; all brought about by; (iv) creative conversation among researchers enhanced by their online KM tools.

Ordinary three-dimensional space and the system of geographic coordinates of the Earth's surface obviously do not provide adequate models for marking out the symbolic universe. A concept, an idea or a meaning cannot be precisely located using this type of system of coordinates: where would justice, the number 12 or the color red be? A concept has no space–time address. That, however, does not preclude there being clearly definable relationships and operations among concepts. In everyday life, we use natural languages to identify ideas and their relationships. Due to their multiplicity and their irregularity, however, natural languages do not lend themselves to calculability, "geometric" projection and interoperability, which are required here.

Like all scientific metalanguages, this system of coordinates will have to represent its object through its grammar, i.e. through its articulation or its formal structure, rather than through the names that are conventionally given to its elements. Only on this condition could such a language be operational and permit automatable simulations, and thus be useful. It is therefore inevitable that the metalanguage of explication of the human sciences will be based on a hypothesis (whatever it may be) regarding the type of structural articulation that would govern the symbolic universe. No scientific metalanguage functions differently.

In terms of KM, this metalanguage would have to possess two usually incompatible qualities: (i) computability and (ii) the potential to express the complex relationships of meaning of the objects of the human sciences in infinitely variable contexts. We need a system of coordinates that is universal (i.e. not just common but also sufficiently broad, deep and open to be all-inclusive), on which we could "project" the in principle unlimited capacity for semantic differentiation of the phenomena of symbolic cognition. Far from reducing or flattening the cultural creation of meaning, this metalanguage would have to make measurement and

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network (issuing and reading news, for example) and cases in which it is *reflected* there (dentist appointments, for example).

calculation possible in a virtually infinite space of semantic variation on the scale of the digital medium.

Once there was such a system of coordinates marking out creative conversations, the processes of collective intelligence, as transversal, heterogeneous and miscellaneous as they are, could begin to observe themselves − to reflect themselves − in the immanent mirror of the Hypercortex.

Once we had a common semantic medium, KM would have a new method of explication that would take it into a new phase of effectiveness and cross-cultural “geometric” transparency.

Once a protocol for modeling symbolic configurations has established standard exchanges of semantic metadata and made all possible games of indexing, classification, research and circulation of value measurable, then, far beyond mere access to documents, we would have something like the true *common good* of an information economy that serves human development.

5.4. The Ouroboros

As I noted above, from the 17th to the mid-20th Century, scientists only had the printed word as a means of recording and communication. To automate their calculations they only had mechanical machines, which were slow and unwieldy. Since the early 21st Century, thanks to the ubiquitous digital medium, memory capacity for data has become virtually limitless, and data communication on a global scale is instantaneous. As for automatic calculation, its speed, distributed power, flexible programming − not to mention its intuitive, interactive and multimedia control − have achieved heights far beyond anything imagined by previous generations. It therefore falls to our generation and those that follow to use this increase of our cognitive capacities to complete the construction of a unique, immense, inexhaustible, scientifically determinable nature that includes human symbolic cognition.

Although this meaningful information nature is an object of science, it should not be reified or overly objectified: it is also a nature in evolution that is emerging from a self-referential creative process. Indeed, everything we can perceive, imagine or know about the inexhaustible immensity of nature is a product of this cognitive system in open evolution: human collective intelligence.

Symbolic cognition is in a sense the active mirror of nature as we are able to know it. We have no access to nature that is not a reflection in this cosmic mirror. At the same time, it is impossible for us to observe this mirror independently of what it reflects. As I discussed at length above, the ideas or categories that organize our phenomenal experience always appear to us in the form of perceptible or imagined signifiers. These signifiers are recorded, communicated and processed by large numbers of very material devices and machines that clearly play an important role in the functioning of collective intelligence.

Our bodies and our artifacts are immersed in a biosphere on which they are dependent, and beyond that, in a dizzying ultra-complex universe of interacting masses and energies. The Ouroboros is eating its tail: the scientific or mythical/traditional representation of the cosmos from which human symbolic cognition emerges is itself a product of this symbolic cognition, and this representation is evolving in complexity as cognition grows in power. The empirical and the transcendent co-emerge and co-evolve[28]. The metaphor of the mirror is relevant insofar as it is impossible to observe the shiny face of a mirror reflecting nothing: human collective intelligence is inseparable from the nature it reflects and to which it belongs.

It is misleading to imagine a nature independent of the cognitive processes that reflect it: the phenomenal face of nature (i.e. the nature that appears to us), once again, is inseparable from the cognition that structures it, observes it, experiments with it and transforms it.

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28 On this co-emergence of the empirical and the transcendent, see my article in the journal *Chimères*: "Plissé fractal, ou comment les machines de Guattari peuvent nous aider à penser le transcendantal aujourd'hui" [LÉV 1994].

Chapter 6

The Information Economy

The information economy is generally understood to mean a particular moment in economic development (the knowledge society or the economy based on knowledge and innovation) or a particular sector of the economy (research and development, communication, education and training, cultural production, etc.). What I am calling the *information economy* here represents a much broader process. The *semantic* information economy indeed includes the traditional information economy, but it is not limited to one period or one sector, nor does it stop at the boundaries of the monetary economy. In fact, it encompasses the economy of meaning in its inexhaustible totality and the complexity of its circuits. When he describes the dynamics of exchange in certain primitive societies, Marcel Mauss, one of the fathers of anthropology, is actually speaking of this semantic economy: "Everything − food, women, children, property, talismans, land, labor, services, priestly functions, and ranks − is there for passing on, and for balancing accounts. Everything passes to and fro as if there were a constant exchange of a spiritual matter, including things and men, between clans and individuals, distributed between social ranks, the sexes and the generations"[1]. I propose to model this semantic information economy as a circulation of symbolic energy flows (Mauss's "spiritual matter") in the channels of the IEML semantic sphere. As we shall see, these flows are regulated by "collective interpretation games" that categorize, evaluate and put into context the digital data the creative conversations have to process.

The purpose of this chapter, which completes Part 1 of this book, is to present what could be the object of a renewed human science; that makes full use of the all-

1 *The Gift* [MAU 1990], p.18.

inclusive memory and calculating power of the digital medium through the adoption of a common system of semantic coordinates. This unique but open object of the human sciences is none other than the information nature discussed in Chapter 2. It is an information nature that is reflected simultaneously in large numbers of collective interpretation games, with these games, each in its own way, attributing a *value* to information. In other words, the information economy is an information nature that is not only addressed in the space−time continuum but is also categorized and assessed in the IEML semantic sphere. The semantic information economy must therefore be understood as a common framework for modeling ecosystems of ideas, a convention that would not only provide tools for use in creative conversations, but also make it possible to provide a scientific account of their diversity and interdependence. This project is not only contemplative. The capacity to effectively model the semantic information economy in the digital medium will transform the Internet into a Hypercortex that reflects collective intelligence. By making the semantic information economy visible, and thus increasing the cognitive potential and cooperative capacities of creative conversations, the Hypercortex will take us to a new level of civilization.

The general plan of the Hypercortex, including a formal model of the semantic information economy, will be presented in Part 2 of this book. In this chapter, I will outline the philosophical orientations on which this formal model is based. Section 6.1 offers a reflection on the cognitive labor and knowledge capital of the information economy from the perspective of the cooperative management of knowledge considered as a common good. Section 6.2 provides a survey of some of the pioneering work on the information economy, the knowledge society and collective intelligence in the field of economics. It also discusses the inadequacy of the tools now available for modeling the processes of collective intelligence in their semantic and self-organizing dimensions. Section 6.3 deals with the flows of symbolic energy among ideas, or the semantic current, considered as the general equivalent of the information economy. Then section 6.4 discusses the concept of the ecosystem of ideas. The chapter ends with a discussion of the "global brain" and the information economy in the digital medium.

6.1. The symbiosis of knowledge capital and cognitive labor

6.1.1. *The genealogy of capital*

I believe that, far from being a mystery, the capacity of capital to grow and reproduce is a property that defines the very concept of capital in a way that is quite natural. My understanding of the word *capital* is based on its etymological meaning of "cattle" (in Latin, *caput*, *capitis*): several head of cattle. Capital originally consisted of a living domestic population that was capable of reproduction and could be improved by artificial selection. If the archetype of capital is the herd, that of labor is the activity of shepherds, cowboys or gauchos. To the tribe of herders that leads it to the best pastures, influences its development through careful cross-breeding, protects it from non-human predators and tends to its newborns, the herd in return supplies its fat, meat, bones, hides, hair, milk, manure, warmth and animal strength to carry people and goods. Capital and labor are in a relationship of interdependence: the life of one depends directly on the life of the other. We could say that the herd of animals and the human tribe form a symbiotic unit. Thanks to their association, they are able to survive and reproduce better in their common ecological niche than they could have done separately. Domestication has been beneficial to both partners − as in any symbiosis − and not only to the humans: the huge populations of the plant and animal species domesticated by humans now represent a burden for the biosphere.

Let us now substitute a knowledge network (an ecosystem of ideas) for the animal herd, and a community of communicating thinkers (a creative conversation) in the knowledge society for the tribe of herders. Bear in mind that capital and labor have a symbiotic relationship. In other words, knowledge itself, on one hand, and the activities of symbolic cognition that the members of the community engage in and that "give life" to this knowledge, on the other hand, are complementary aspects of a single autopoietic, self-organizing, evolving and fragile process: that of the semantic information economy.

The interdependence of knowledge needs to be seen in terms of its temporal dynamics. Knowledge is received from a tradition and must be retransmitted. The primary goal of the labor of collective intelligence is thus to *reproduce* the ecosystems of ideas. Then these ecosystems must be *improved* through controlled change by means of selection and cross-breeding. The criteria for this additional value or power, which is the purpose of selection, obviously depend on a variety of contexts and changing conditions. Despite this, the guiding principle remains relatively simple: the living knowledge maintained, reproduced and improved by a community must return useful information[2]. This is the heart of the symbiotic process: a population of talking primates maintains and refines the reproduction of its cognitive capital in the semantic sphere only if the knowledge ecosystem in turn helps to reproduce and maintain the well-being of the actual human bodies living in the biosphere. Ecosystems of ideas must thus help maintain the biophysical ecosystems of the communities that support them (agriculture, industry, management of biological ecosystems), improve their material situation (safety, health, etc.) and satisfy their spiritual need for meaning in their lives and world

2 The concept of usefulness is obviously contextual and conventional, and depends on the collective interpretation games. We have to think about this usefulness not only for the short term, but also over the time scale of generations.

(mutual trust, aesthetic or religious organization of life). Human development and collective intelligence are in a reciprocal relationship.

I spoke of tribes of herders to highlight the original, founding, ancient pact that links virtual knowledge ecosystems to human populations. The talking primates cannot survive without culture; similarly, the ecosystems of ideas that give shape to this culture can only be reproduced in symbiosis with the desiring, suffering and mortal bodies of the social mammals that support them. To look at this another way, maybe we should think of the ecosystems of ideas as the ones "raising" communities of talking primates by reproducing and diversifying them...

6.1.2. *The commons: the interdependence of human populations, ecosystems of ideas and biological ecosystems*

The symbiosis between knowledge capital (ecosystems of ideas) and cognitive labor can be viewed as an expanded loop of interdependence that includes the biological ecosystem.

Since the early 21st Century, in the conversations that are weaving together the new global public space, people have been speaking of a *commons.* This rather broad term designates both public goods whose consumption by some people takes nothing from others − such as sunsets and useful knowledge − and shared resources that could be depleted by overexploitation or damaged by lack of maintenance by some members of the communities involved – such as irrigation systems and public libraries[3]. This economic concept originally designated the unappropriated part of an ecosystem of a human community that used it for direct harvesting (hunting, gathering and wood cutting in forest) or herding (in pasture). British historians often speak of the "enclosure movement", led by noblemen and large land owners starting in the 16th Century, the main effect of which was to reduce the British commons drastically and pave the way for capitalism.

The link between the concept of the commons and that of the ecosystemic environment has been confirmed in the present day. Drinkable water, breathable air, a livable climate and biodiversity are surely all common goods, and we urgently need to find appropriate methods of management for them. In this case, it is not only fences around private properties that are threatening the sound management of the commons of the biosphere, but also national boundaries.

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3 See Elinor Ostrom and Charlotte Hess (eds.), *Understanding Knowledge as a Commons: From Theory to Practice* [OST 2006], p. 9.

There is another commons that is as global and essential to organized human life as the diversified balance of the biosphere: that of knowledge. To avoid any misunderstanding, I should say that I do not mean only scientific knowledge sanctioned by the academic establishment, but also the knowledge and know-how of many traditions or communities of practice[4]. In addition to their global transversality and the fact that they are an infrastructure essential to social life, I would like to point out a third characteristic shared by these two major types of commons: they are dynamic, evolving, interdependent systems made up of large numbers of autopoietic cycles and intertwining feedback loops. Indeed, the shared knowledge of human societies forms something like an inclusive environment within which many ecosystems of ideas interact. Like collective intelligence, of which it is one aspect, the community of knowledge may be viewed at many levels, from the small work team or personal social network to the entire species, including businesses, schools and universities, cities and regions, social media and virtual communities on the Internet.

I would now like to examine not only the similarities between ecosystems of ideas (the noosphere as manifested in the information economy) and biological ecosystems (the biosphere), but also their differences and their looped co-production. Interaction with the biological ecosystem is obviously not unique to hunter-gatherer or agricultural societies. Industrial and post-industrial economies are also ways of managing and transforming the "nature" of the biosphere: what changes is the quantitative scale (much more massive) or the degree of refinement (bio- or nanotechnological) of its transformation and harvesting. This being said, one of the main differences between the biological ecosystem and the epistemic ecosystem is that the former provides us with drink, food, clothing, warmth and shelter (i.e. material, concrete things), while the latter provides us with information or even just methods of interpreting information. This observation needs to be corrected immediately by adding that most of the materials we extract from the biosphere can only be harvested through the mediation of our knowledge of it and our technical know-how on using it[5]. Granted, some of our shared knowledge (for example, literature and psychology) is not directly related to the exploitation of animal and plant species, the oceans, the soil and the subsoil. But knowledge is

4 On the concept of the community of practice, see the work of Étienne Wenger [WEN 1998], and on the more general concept of the ecology of practices producing its unique ways of knowing that cannot be reduced to official science, see Isabelle Stengers, *Cosmopolitics* [STE 2010].

5 I do not want to defend here the existence of an exclusively determining symbolic infrastructure as opposed to an ultimately determining material infrastructure, but rather the perspective of a systemic interdependence of all the layers of information nature. On the key role of geographic and bio-geographic factors in human history, see the fascinating book by Jared Diamond, *Guns, Germs and Steel* [DIA 1999].

interrelated in the complex, interdependent network of culture, so that in the end the knowledge ecosystem as a whole contributes to the mapping of our material interactions, guiding our maintenance of the biological ecosystem and our modeling of our harvests of its flows and stocks[6]. The two major types of commons are thus closely interdependent.

The collective capital represented by the biological ecosystem is in fact defined by the epistemic ecosystem that enables us to analyze, maintain, improve and exploit it. We do not live in the same "nature" as hunter-gatherers because we do not decipher it according to the same codes and we exploit it in very different ways. As for the common capital of knowledge, it only becomes meaningful in the network of material, economic, technical, and other interactions we maintain with the biological ecosystem. Humans are in a way the central interface where the biological and epistemic ecosystems, the biosphere and the noosphere co-define each other. Seen from another perspective, our common capital of knowledge is the cognitive medium that gives us access to our physical/biological environment.

6.2. Toward scientific self-management of collective intelligence

6.2.1. *Political economy and collective intelligence*

The information economy largely inherits its objectives from the political economy. Economics deals, in general, with the mechanisms for the production, exchange and consumption of value in human societies. This science of exchangeable "goods" continues a whole tradition of ethical thought. For example, before *The Wealth of Nations*, Adam Smith wrote *The Theory of Moral Sentiments*[7]. Prior to the development of political economy, Medieval Latin theology at the time of Duns Scotus already saw itself as pragmatic, as the art and science of the production of "good" in the world[8]. In the writing of Adam Smith, the market is seen as a kind of autopoietic collective intelligence. Due to the spatial and temporal scale of this intelligence, and because humans are not equipped to integrate large quantities of disparate data into a coherent whole, the holistic or ecosystemic functioning of the market usually remains unknown to its agents (sellers and buyers); hence, the famous "invisible hand" of the market.

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6 Claude Lévi-Strauss often pointed out the role played by classifications of the natural physical environments of cultures in the formation of their social, religious, and other categories, see *The Savage Mind* [LÉV 1966].

7 See [SMI 1776, SMI 2007].

8 See *Prologue de l'Ordinatio* [DUN 1999].

In a famous passage of *Grundrisse*, Marx speaks of a mysterious "general intellect" that seems to be based on Aristotle's agent intellect[9], Rousseau's general will and Hegel's objective mind: "The development of fixed capital indicates to what degree general social *knowledge* has become a direct force of production, and to what degree, hence, the conditions of the process of social life itself have come under the control of the *general intellect* and been transformed in accordance with it" (the words in italics are in English in the German text)[10]. Since fixed capital essentially designates the lasting material infrastructures of production, in particular machines, Marx seems to be saying here that the level of knowledge − or collective intelligence − achieved by a society, in being materialized in the complexity of its machines, organizes and reorganizes the process of production and, consequently, social functioning in its entirety. The concept of machine could obviously be extended today to include communication protocols and software, and the "process of production" could also be extended to processes of communication and distribution[11].

Beginning in the 1930s, Hayek, even more explicitly than Smith, analyzed the market as a system (an imperfect system), coordinated everywhere (but not centralized), for transmitting information on the knowledge, needs and behaviors of its actors[12]. A computer scientist would recognize this as a system of coordination among agents possessing the same privileges but carrying different data. It should also be pointed out that while Hayek was a fierce defender of private property in general, he considered knowledge to be a common good. This is why he was in favor of the liberalization of intellectual property.

Starting in the 1960s, many economists began to speak of an information economy, and even a knowledge-based economy, to describe the contemporary economy. Fritz Machlup (1902-83), an economist of the Austrian School who made his career in the United States after fleeing the Nazis in 1933, was probably the first economist to undertake a thorough study of the production and distribution of knowledge as a specific economic sector[13]. After Machlup's work, the second extensive study specifically dealing with the information economy (as opposed to the "material" economy) was carried out by Marc Porat and Michael Rubin in 1977.

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9 The agent intellect, which Medieval commentators such as IbnSina, IbnRoshd and Maimonides considered to be common to all of humanity; on this point, see my *Collective Intelligence* [LÉV 1997].

10 Karl Marx, *Grundrisse* [MAR 1973], p. 706.

11 On the concept of collective intelligence in Marx, see also the analysis of cooperation in Chapter 13 of Book I of *Das Kapital* [MAR 1867].

12 See works by Hayek already cited [HAY 1937, HAY 1979].

13 See *The Production and Distribution of Knowledge in the United States* [MAC 1962] and *Knowledge, Its Creation, Distribution, and Economic Significance* [MAC 1982].

Porat is also credited with coining the term *information economy*[14]. During the same period, Czech philosopher Radovan Richta (1924-83) was one of the first generalist thinkers to describe, in a multidimensional and interdisciplinary way, the new era marked by the extension of intellectual labor and the acceleration of scientific and technical development[15]. Richta is also credited with the famous expression “socialism with a human face”, one of the phrases used in the Prague Spring in 1968.

Building on Simon’s work[16] and game theory[17], the new school of *cognitive economics* represented in France by Bernard Walliser, takes the cognitive activity of economic agents as the starting point for its theories. It seeks to explain the economy as a whole, including the role of institutions, through games of coordination and convergence[18]. At the other end of the political spectrum, the work of Yann Moulier Boutang on “cognitive capitalism” attempts to describe (from a Marxist, but enlightened and critical, perspective) the new “mode of production” based on creativity and the intensive use of knowledge, and is thus consistent with work on the knowledge society[19].

The increasing importance of research on cooperation in the maintenance and management of shared knowledge capital was emphasized by the awarding of the Nobel Prize for Economics[20] to Elinor Ostrom[21] in 2009. Finally, I must mention one of the foundational works in the recognition of a new economic era based on information management, *The Information Age*, by sociologist Manuel Castells, published at the end of the 20th Century[22].

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14 See *The Information Economy* [POR 1977]

15 In particular in *Civilization at the Crossroads* [RIC 1969], which he edited.

16 See *Models of Bounded Rationality* [SIM 1982]. Herbert Simon, a pioneer in artificial intelligence and the detailed study of cognitive phenomena in economics, received the Nobel Prize in economics in 1978.

17 This can be traced back to von Neumann and Morgenstern [NEU 1944].

18 See *Cognitive Economics* [WAL 2000].

19 See *L’Abeille et l’Économiste* [MOU 2010] and *Le Capitalisme Cognitif* [MOU 2007], [FOU 2007] in its augmented second edition, which includes the remarkable article by François Fourquet, “Critique de la raison cognitive” p. 265-276, in which he argues that the economy has *always* been an information economy.

20 Actually, the Sweden Prize in Economic Sciences in Memory of Alfred Nobel.

21 See Elinor Ostrom and Charlotte Hess (eds.), *Understanding Knowledge as a Commons: From Theory to Practice* [OST 2006].

22 [CAS 1996].

6.2.2. *The autopoiesis of collective intelligence*

As we have seen, there has been a whole tradition in political economy that revolves in one way or another around the question of collective intelligence, a tradition passing through Hayek and going back to Adam Smith, which analyzes the market itself as a particular form of collective intelligence. Other economists consider the shared capital of knowledge and its collaborative management as an essential dimension of economic prosperity. Many economists, sociologists and philosophers have perceived the emergence of a new knowledge economy since the 1960s. Human development in general, and economic prosperity in particular, require the intensive use of knowledge. In other words, the collective capacity to create, exchange, assimilate and apply knowledge is one of the main engines of development. This is the watchword of the knowledge society. Finally, as we saw in section 4.2, the new field of knowledge management (KM) is being actively explored in management sciences, and since 2005 there has been a shift toward the open, collaborative and "bottom-up" forms of KM developing in the social media.

The period beginning in the 1960s was marked by the proliferation of electronic media world-wide as a result of the acceleration in the pace of production and obsolescence of knowledge, the international explosion (still under way) of universities, the ongoing growth in the volume of information exchanged and stored and, accordingly, the critical role of knowledge and information management in economic, social and cultural life. The more the success (whatever its definition) of a community depends on its creative management of knowledge − as is the case today − the more crucial the capacity to think together becomes[23]. Consequently, there is a causal relationship between the effectiveness of a community's collective intelligence and its capacity to solve problems of human development according to its own point of view. I would wager that, in the global civilization that is now emerging, collective intelligence − or wisdom − will be recognized increasingly explicitly as the driving force of human development, and human development − the improvement of people's lives and the fulfillment of their potential − will be seen as the essential condition for the growth of collective intelligence[24]. I therefore postulate that there is an intrinsic relationship between collective intelligence and the information economy, both in the general meaning of this term and in the special sense of a traditional monetary economy especially oriented toward the processing of information in the knowledge society. From the more general perspective, the two terms are almost equivalent: for each form of the information economy there is a specific corresponding organization of the collective cognitive system. *The*

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23 Yochai Benkler discusses networked social production; see *The Wealth of Networks: How Social Production Transforms Markets and Freedom* [BEN 2006].

24 Figure 5.1 can also be read as a description of the internal dynamics of collective intelligence.

information economy is to human symbolic cognition what ecology is to the biosphere. From the more limited perspective, which is also more practical, the power or richness of collective intelligence is becoming the main factor of success in the information economy[25]. In this case, the main aim of collective intelligence is creation, invention, discovery, innovation and learning, i.e. everything that contributes to maintaining and growing the shared capital of knowledge, which in turn sustains human development[26].

6.3. Flows of symbolic energy

6.3.1. *The problem of the general equivalent*

We have seen that, unlike the animal societies that preceded them in evolution, human societies maintain complex cultural worlds − ecosystems of ideas − that connect large numbers of symbolic systems: languages, technologies, kinship systems, religions, laws, political systems, organized knowledge, skill traditions, music, literature, etc.[27]. These symbolic systems communicate to conduct (as we say a copper wire conducts electrical current) the meanings that connect and support speaking beings. These meanings go through interlinked cycles that disintegrate or become amplified depending on whether they are approaching or moving away from the constraints of viability and balance of the ecosystems of ideas in which they participate.

If we want to study this economy or ecology and trace its circuits of transformation and exchange in a shareable way, we must assume that in all the transformations and movements of meaning, *something*, some value, a force of attraction or repulsion[28], is preserved, created or lost. If this were not the case, we would not be able to talk about ecology or economics. No systematic or general knowledge would be possible, because no evaluation, no measurement, no proportion, no transformation, no exchange could be established. What then is the nature of this equivalence relationship − which is something like a currency of

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25 This basic capital could result from interaction among the six capitals in the model in Figure 5.1.

26 I am referring here, among other possible references, to my philosophical book *Collective Intelligence* [LÉV 1997], to the more economical synthesis by Surowiecki, *The Wisdom of the Crowds* [SUR 2004] and to the multidisciplinary collection *Collective Intelligence: Creating a Prosperous World at Peace*, edited by Marc Tovey [TOV 2008].

27 See Chapter 3 and section 6.4.

28 Empedocles, in his poem, speaks of the love (attraction) and strife (repulsion) that drive the four elements.

meaning − among the forms of symbolic human life? What is this energy whose circulations and metamorphoses generate the evolving diversity of cultures?

6.3.2. *The power of mana*

Nietzsche, and after him Foucault, spoke of the circulation of this power, which they saw as directed naturally toward growth. I will explore this question by drawing on another tradition, that of French anthropology going back to Émile Durkheim (1858-1917) and Marcel Mauss (1872-1950), and its most distinguished contemporary representative, Claude Lévi-Strauss (1908-2009). In Lévi-Strauss' remarkable *Introduction to the Work of Marcel Mauss*, which summarizes the main teachings of his predecessor, the master of structuralism presents the hypothesis that any society can be analyzed as a complex symbolic system of circulation and exchange, producing "the fundamental terms of an equilibrium, diversely conceived and differently realized according to the type of society under scrutiny"[29]. I want to emphasize here the concept of equilibrium, which clearly shows the analogy with the approach used in the natural sciences, and in this context refers to the dynamics of an economy or an ecosystem. For Lévi-Strauss, one of the goals of scientific anthropology is to describe social functioning as "a system, among whose parts connections, equivalences and interdependent aspects can be discovered"[30]. His approach in scientific anthropology is not far from that of the semantic information economy. If the very essence of the social system is symbolic exchange and its interlinked cycles of reciprocity, then the parts of the system should be as mutually comparable, substitutable and transferable in our scientific models of culture as they are in culture itself.

Inspired by advances in linguistics (which he continually cites as an example of scientific process in the human sciences), fascinated by the birth of information theory and cybernetics[31], confident about the contribution computers could make to research in the social sciences[32], and firmly convinced of the unity of human nature,

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29 *Introduction to the Work of Marcel Mauss* [LÉV 1950], p. 39.

30 *Introduction to the Work of Marcel Mauss*, p. 38. This unity of symbolic exchanges was recently pointed out by Henri Atlan in *De la Fraude, le Monde de l'Onaa* [ATL 2010], which clearly shows the circulation between exchanges of words, monetary exchanges of economic goods and relationships mediated by technology.

31 In a note in his book on Mauss, p. 70 (and in many other places), he cites the major works of Wiener (*Cybernetics* [WIE 1948]) and Shannon (*The Mathematical Theory of Communication* [SHA 1949]). He often cites Von Neumann and Morgenstern, *Theory of Games and Economic Behavior* [NEU 1944], for example in "Social structure", in *Structural Anthropology* [LÉV 1963], p. 337.

32 For example, as early as 1951, in the article "Langage et société" (reprinted in

Lévi-Strauss maintained that it was possible to discover regularities in the symbolic universe. If I translate Lévi-Strauss's conviction into my own language, it would mean that unity of the human sciences is possible. It should be possible to reduce the objects and operations of the systems of symbolic exchange that constitute human cultures to a small number of operations and universal types specific to the ecology of ideas − or the information economy − opened up by language. Just as physics has its elementary particles and chemistry its elements, just as all the diverse forms of life are encoded using the four nucleobases of DNA, just as a language can "say anything" by combining a couple of dozen phonemes according to complex rules at many levels of articulation, just as the various languages of the world use common syntactic universals that define the human capacity to articulate thoughts, in the same way, every culture must combine a finite number of symbolic universals according to shared rules to produce the inexhaustible combination of arrangements, rearrangements and permutations that generate cultural diversity.

The Elementary Structures of Kinship (1949) is Lévi-Strauss's response to *The Elementary Forms of the Religious Life* (probably Émile Durkheim's masterpiece, published in 1912). The lineage is obvious in the quest for the elementary, and it continues in the study of the relationships among elements. Since social reality is a structure of exchange – exchange of women, exchange of goods, exchange of messages, but always exchange of value – it is essential to understand the nature of this value that can take so many different forms. In *The Gift*, Mauss, returning in a sense to before the separation of the disciplines of the human sciences, shows that the cycles of circulation of gifts in certain primitive societies constitute a "total social fact". The value transferred in operations involving gifts, in Mauss's analysis, is indissociably moral, economic, political, legal, religious, etc. *The Gift* thus gives us a glimpse of an elementary, or fundamental, operation that did not emerge from any particular sphere of cultural life, but that weaves together the social fabric in its entirety.

The quest to identify the universal operation of symbolic life repeatedly encounters the strange concept of *mana*. Indeed, Mauss and Durkheim, in their explanations of religion, magic or gifts, use a variety of terms borrowed from indigenous languages – *mana*, *hau*, *wakan* and *orenda* – terms that all have the same general meaning: a vital elementary energy or power of a magical or religious kind. Taking up the concept of mana, Lévi-Strauss claims that all cultures – including the most evolved and the most contemporary – have concepts of this kind and that they correspond less to "archaic beliefs" than to the idea of a neutral symbolic value that precedes any qualification. In French, for example, the word *truc*, according to etymologists, is derived "from a medieval term which signifies the lucky move in

Anthropologie Structurale, p. 70 [LÉV 1958]), he criticizes Norbert Wiener for underestimating the possible computerization of the social sciences.

games of skill or games of chance, that is, one of the precise meanings given to the Indonesian term in which some see the origin of the word 'mana'"[33]. As for the French word *machin*, behind it there is "machine and, further back, the idea of force or power"[34]. In his reflection on mana, Lévi-Strauss distances this term from its association with "primitive mentalities". It is no longer the multiform spiritual force that animates the cosmos of the archaic societies described by Mauss and Durkheim, but a symbolic value that has not yet been qualified, *a quantum of informational energy*. The function of notions like mana is "to enable symbolic thinking to operate despite the contradiction inherent in it"[35]. Since any symbolic value has meaning only in exchange, it would therefore designate an indeterminate capacity for exchange, an unknown in the relationship system. Not such-and-such a value, but *value itself*, a "floating signifier", to use Lévi-Strauss's term. Mana is in a sense "whatever", *x*, the fundamental variable for the calculation of exchanges in the information economy: something as its monetary value.

At this point, I myself am taking up the concept of mana, which the author of *The Savage Mind* took from Mauss and Durkheim and gave another meaning, and I am making an additional hermeneutic translation by posing the question of measurement. If the quantum of symbolic energy were to be measured, the unit of measurement – the currency of account – would have to transcend the established (conventional) social distinctions between economic value, moral value, political value, religious value, aesthetic value, etc., precisely in order to be able to describe the circulation among the different spheres of value. Let us return to the classical example of the gift. At least at first glance it involves a double transfer of value: a transfer of economic value in one direction and a transfer of sociopolitical value – prestige – in the opposite direction. The act of the gift itself establishes a difference of potential, an imbalance, an asymmetry (debt, difference of prestige) that calls for new flows of mana, complementary movements that can be direct, transitive or deferred along invisible, complex paths. Cultural life can be described as a symbolic economy – or ecology. Thus we can justifiably say that peoples that practice potlatch are circulating mana in their society by exchanging their ritual gifts, not because their "belief" in the existence of magical/religious forces associated with the gifts is "true", but because this circulation of energy in a network of semantic transformations provides the thread that weaves the fabric of the human society.

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33 *Introduction to the Work of Marcel Mauss* [LÉV 1950], p. 55

34 *Ibid*. [LÉV 1950], p. 55

35 *Ibid*. [LÉV1950], p. 63.

6.3.3. *The complete circuit of information*

The economy of material goods is only part of the circuits of the symbolic economy of exchanges of qualities and quantities of all kinds in a complex system of reciprocal cycles in a metastable equilibrium. The classical monetary economy is fuelled by an open totality that it fuels in turn. Contemporary research into the close correlation between social capital (sociopolitical values) and education level (cognitive values), on one hand, and economic prosperity (market values) and public health (well-being values) on the other, seems to confirm that all the types of values are expressed and exchanged within a single symbolic ecology.

What should this mana, this energy, this affective current that flows and is transformed in the transverse circuits of the symbolic ecology be called? Always identical under the infinite multiplicity of the changing meanings it carries or crosses, this strange fluid may be called the *force of meaning* or *symbolic energy*, or in more traditional economics language, *service*, *value* or *good*. We may also conceive of it as a force that shortens (attraction) or lengthens (repulsion) the links connecting the nodes of the semantic sphere: the energy of meaning distorts a semantic topology.

Indigenous peoples called this joker or chameleon that takes on different qualities depending on the semantic zones in which it circulates *mana*. We can also draw analogies with the energy of karmic causality in the traditional philosophies of India, which clearly cuts across established separations. Traditional Chinese philosophies also recognize a unitary life force, whose unceasing flow crosses the cosmos, the meridians of the human body and the library of scholars simultaneously: the *qi* that links yin to yang, and sky to earth.

Rather than use the term *mana*, *qi* or *symbolic energy* for this currency or general equivalent of symbolic exchanges, I have chosen to call it *semantic current*, because the type of calculable modeling that characterizes the information economy calls for a neutral expression.

6.4. Ecosystems of ideas and the semantic information economy

As we saw in the introduction to this chapter, the semantic information economy must be distinguished from the information economy in the narrower sense used by economists[36]. Economists study the role of information and knowledge in the traditional monetary economy: the production and communication of information as

36 See Porat, *The Information Economy* [POR 1977], or Machlup, *Knowledge, Its Creation, Distribution, and Economic Significance* [MAC 1982], for example.

a sector of the economy or the contemporary economies of the most developed countries, which are based on the optimal use of information and knowledge. In contrast, the semantic information economy is concerned with the modeling of social processes of symbolic cognition, in the sense of the dynamics described in Figure 5.1.

6.4.1. *An "eco" paradigm for thinking about semantic information*

6.4.1.1. *Etymology and general approach*

To understand the semantic information economy, we need to remember the etymological meaning of the word *economics*. In Ancient Greek, *oikonomia* means law or rule (*nomia*) of the house (*oikos*). The word *house* here should not be understood only in the sense of materials, physical space and architecture. The "house" whose laws the science of *oikos* aims to understand is a *symbiotic unit*, a network of interdependent, perishable coexistences whose survival and growth depend on following certain rules. Eco-nomics and eco-logy are the two major sciences of the "house". For both, the rules governing them ultimately involve (i) mechanisms of growth and differentiation and (ii) constraints on viability. In continuity with these sciences, the economics of semantic information aspires to the level of the new object now observable in the digital medium of human symbolic cognition. The goal of this general economics is to model, observe and understand the functioning of the "houses", the information environments and digital environments inhabited by creative conversations. Thus, the agents of the semantic information economy are also its inhabitants, and it is impossible to dissociate the two, except conceptually.

The semantic economy provides a dynamic representation of the circuits of production and use of information in shared meaningful contexts. As the agents of this economy (the creative conversations) are also its inhabitants, however, its modeling only takes on its full meaning in a reflexive loop, a little as if the informational "house" that contains them were holding up a metalinguistic mirror of the actions of communities in real situations and the effects of those actions on the communities.

6.4.1.2. *Distinction between unity and uniformity*

The ecosystem paradigm of the semantic information economy offers many advantages for the study of human symbolic cognition. The first is that it highlights the unity of the human phenomenon. As we saw in Chapter 5, sciences such as economics, sociology and psychology each study an aspect of cultural life. Specialization is obviously indispensable for any scientific work. It imperceptibly directs thinking toward the reification of divisions originally created for reasons of method or practical utility, however, and we come to believe that there is objectively "an economy" (for example), when originally we only intended to analyze the *economic dimension* of the "total social fact"[37]. I therefore do not believe that it is this useful disciplinary division that prevents effective cooperation among the human sciences, but rather the absence of a principle of modeling or a common metalanguage that would enable the different subjects to come together and coordinate their activities. There is a caveat. Unification does not mean uniformity. This is where the second advantage of the ecosystem paradigm becomes evident: the concept of an ecosystem makes it possible to think simultaneously about interdependence in a single territory (unity), the diversity of species (multiplicity) and evolution (change). When we talk about the unity of an ecosystem, we mean that changes affecting one species affect the others. Changes have impacts on various balances, over complicated cycles, at many temporal and spatial levels. The fact that the Atlantic Ocean or the Amazon rainforest forms an ecological *unit* in no way implies that they are biologically *uniform*; quite the contrary. The functioning of an ecosystem implies dynamics of interrelations within the diversity of organisms and species. What would we think of a biologist who attempted to explain a whole ecosystem by studying only the plants? Or one who placed insects and birds at the center of the forest? Or one who only looked at mammals? Well, this is exactly how things stand in the study of human societies, because each discipline only explores a certain kind of idea, a certain portion of the general cycle of the transformation of information.

While studies today are most often limited to analyses of small bits of the disciplinary circuits as divided up by the human sciences, the perspective opened up by the semantic information economy makes it possible to follow the totality of the cycles of transformation in the symbolic universe. By taking all the objects of the human sciences as its field of observation, the information economy could redistribute the bodies and functions of culture and reveal its living unity and abundant diversity. That would in no way prevent its researchers from defending rival theories or studying different objects.

6.4.2. *Ecosystems of ideas in epistemology*

The ecological paradigm emphasizes the evolving, systemic, self-organized nature of distributed cognitive processes. The notion of an evolving ecosystem of ideas, which is very close to our concept of the semantic information economy, was developed by important contemporary thinkers. Alfred North Whitehead (1861-

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37 The "total social fact" is a well-known expression from Marcel Mauss, which he developed in *The Gift*, initially published in *L'Année Sociologique*, Paris, 1923-1924. See the collection of articles in *Sociologie et Anthropologie* [MAU 1990].

1947) devoted his books *Science and the Modern World* and *Adventures of Ideas* to the subject[38]. In *Les Idées*, Volume 4 of *La Méthode,* Edgar Morin analyzed ideas as living entities in ecological interaction[39]. In the same vein, the great epistemologist Karl Popper (1902-94) postulated the existence of three distinct worlds: (1) that of material phenomena; (2) that of mental states; and (3) an objective universe of scientific ideas, where problems, theories and empirical tests come together and vie with each other. According to Popper, scientists' problems, conjectures and refutations are part of an evolving dynamic in which problems may be seen as environments in transformation, new hypotheses as cognitive changes, and refutations as agents of selection[40]. This "World three" of intelligence, which stands above the worlds of souls and matter but obviously draws from them, leads us to think of distributed human cognition as the circulation of information between (1) material phenomena, (2) mental states of talking primates and (3) a world of objective ideas that follows symbolic, conventional rules.

In comparison with the theories I have cited, the modeling of ecosystems of ideas based on the IEML semantic sphere is distinguished by its calculability and its much more precise relationship with observable phenomena. This modeling is calculable because the ecosystems of ideas, properly encoded in information circuits between USLs, become completely explicit and can be used in open source, shareable computer simulations. The phenomena represented by these semantic circuits are none other than the public data of the Web. Here again, the relationships between URLs (the "physical" addresses of data on the Web) and USLs (metadata or semantic forms of ideas in IEML) are completely explicit and can be represented by functions[41]. The formal modeling of ecosystems of ideas in the Hypercortex coordinated by the IEML semantic sphere will be dealt with in Part Two of this book. Before coming to that, I would like to discuss the general characteristics of ecosystems of ideas in terms of the research program on the semantic information economy. This will permit me to review certain concepts discussed in Chapters 2 and 3 and thus dissipate any remaining theoretical misunderstandings that could interfere with the reader's comprehension.

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38 *Science and the Modern World* [WHI 1925], *Adventures of Ideas* [WHI 1933]. On Whitehead, see Isabelle Stengers, *Penser avec Whitehead, Une Libre et Sauvage Création de Concepts* [STE 2002].

39 See Edgar Morin, *La Méthode* [MOR 1977-2004].

40 Karl Popper's summary work, *Objective Knowledge*, is characteristically subtitled "An evolutionary approach" [POP 1972].

41 For example, functions of categorization, evaluation and contextualization; see Chapter 13.

6.4.3. *General characteristics of ecosystems of ideas*

6.4.3.1. *Ecosystems of ideas live in interdependence with human populations*

Ecosystems of ideas can only endure, reproduce and evolve in symbiosis with societies of talking primates. A car, a poem, a queen or a company has an ideal dimension, because such entities cannot exist in the cognitive systems of other primates and because they play an active role in human society. There is no queen for an ant as there is for a subject of the United Kingdom. The ant certainly has a form of phenomenal inner life that allows it to reflect visual, auditory, tactile and olfactory forms. But the ant does not obey a queen (the category itself depends on complex systems of cultural categories); it is controlled by muscle reflexes responding to the sensory reception of pheromones, somewhat as our neurons, taken in isolation, respond to electrical and chemical excitation in ways that are complex but reflexive, almost automatic. Thus an ant no more has ideas than a neuron does. Ideas exist in the metareflexive loop opened by linguistic symbolization, of which only human beings participating in a culture are capable.

6.4.3.2. *The world of ideas is not separate from the sensory world*

Ideas belong fully to nature. Of course, they are not material things (at the same level of encoding as bodies or neural dynamics)[42], but nor do they exist “elsewhere”, as if the ideal world were “another world” completely separate from the sensory world. I say that ideas participate fully in nature[43] because they exist among the information circuits generated by the cognitive activities of living human beings; activities that they in turn condition.

Plato, the great inventor of the world of ideas, contrasted *eidos* (“idea”) with *eidolon* (“image”), and intelligible reality with illusory perception. The Greek language, however, reveals the proximity of idea and image: both are “forms”. The former is a structure grasped by reason, the human discursive faculty, *logos*; while the latter is a structure apprehended by the senses. We know today that discursive cognition and phenomena are closely intertwined and interdependent. Even the most abstract concept only becomes meaningful within a logical, semantic and, especially, pragmatic ecosystem in which sensory intuitions abound. Likewise, there is no perception that is not primed by expectations, projections and hypotheses. The phenomena we perceive are thus saturated with concepts, ideas and theories, and they are scripted through our narratives. The sensory images of our everyday experience are organized by learning, habits and categories; a whole cognitive and cultural infrastructure.

42 On the levels of encoding, see section 2.3.

43 But it is obviously an information nature; see Chapter 2.

The same brain, at the same instant, computes abstract meanings and sensory images, the meaning of a text and the radiance of a smile. The living idea that emerges in our cognitive systems thus interweaves categories, emotional intensities and sensory data in a single complex information circuit.

The ideas of the semantic information economy link sensory data and discursive cognitive processes. Modeled in IEML in the Hypercortex, ecosystems of ideas circulate a symbolic current between a virtually infinite semantic sphere, on the *logos* side, and the practically unlimited multimedia memory of data on the Web, on the sensory side. I will go into greater detail on the Hypercortex of the semantic information economy, which weaves together discursivity and sensory activity, in Part Two of this book. For now, let us bear in mind that the semantic information economy implies no metaphysical separation. It does not choose mind (i.e. symbolic manipulation) over matter, or matter over mind. It models their reciprocal implication, the indissoluble link that reflects the symbiosis between societies of talking primates and their information economy.

6.4.3.3. *Ecosystems of ideas evolve*

Ecosystems of ideas are constantly evolving. Memetics[44] tends to focus on a short-term selection of small units: the ideas that reproduce are those most capable of attracting the attention of humans. Thus memeticists often cite the example of hit

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44 The term *meme* was coined by Richard Dawkins [DAW 1976] on the model of *gene* to designate a self-reproducing cultural entity that circulates among humans. Memetics, which is based on Dawkins's hypothesis (see Robert Aunger, ed., *Darwinizing Culture: The Status of Memetics as a Science*, with a preface by Daniel Dennett [AUN 2000]), and Dan Sperber's ecology of representations (*Explaining Culture: A Naturalistic Approach* [SPE 1996]) are among the schools of thought that have most explicitly adopted the ecosystem paradigm for the study of culture. Focusing only on memes cannot provide an adequate explanatory framework for an economy (or an ecology) of culture. Myriads of small, self-reproducing memes are not sufficient to explain the Temple of Shiva in Chidambaram, the Zhuangzi, the Sistine Chapel, the Napoleonic Code, the Constitution of the United States or the Theory of Relativity. Only the cultural equivalents of organisms, i.e. complex ecosystems of ideas evolving interdependently, can account for the forms of the life of the mind, their persistence and their metamorphoses. In addition, according to memeticists, memes – or representations – directly reproduce in the brains of humans, i.e. in biological organisms, like viruses, and not in a cultural equivalent of organisms. While ideas are maintained by the mental states of subjects who themselves are embodied physically, however, they do not reproduce directly in brains. Cultural memes and biological brains simply do not belong to the same layer of information encoding (see section 2.3). Finally, unlike molecular biology, which has deciphered the genetic code, memetics has deciphered no "memetic code" or alphabet of representations.

songs, refrains and jingles that we are unable to get out of our heads once we have heard them. I would tend, instead, to emphasize the long-term (the unit of time being a generation), macro-level selection of ecosystems of ideas. Cultural evolution selects the ecosystems of ideas that enable the human populations that maintain them to better survive and prosper in a given historical and geographic context. Of course, according to this approach, there are no "good" ecosystems of ideas – much less "good" ideas – in an absolute sense. The competitive advantage one idea has over another is necessarily related to its role and its interactions in a given ecosystem: one idea is "better" than another insofar as it is more cooperative in the ecosystem in which it participates, i.e. if it increases the reproduction of ideas in the same culture. Neither general relativity nor human rights would have been good ideas in Pharaonic Egypt.

Certain ideas can be very successful in the short term (they are reproduced massively in minds) even though they drag the populations that adopt them into economic impoverishment, military disaster or cultural sterility in the long term: we could say that they are not *sustainable*. Moreover, an ecosystem of ideas that gives a competitive advantage to the population that maintains it in a given historical context could cause it to lose that advantage in a different context. For example, the writing, architecture, religion and political system in Egypt in the time of the Pharaohs gave the populations living on the shores of the Nile a competitive advantage over the nomadic and less organized tribes around them. After 3,000 years of successful symbiosis with a human population, however, the ecosystem of ideas of Pharaonic Egypt was not able to withstand[45] its encounter with Greek, and then Roman, civilizations, both of which were based on other writing systems, political systems and religions.

6.5. The semantic information economy in the digital medium

6.5.1. *The prophets of media and the "global brain"*

In the past 40 years, and increasingly in the past 15 years as a result of the development of the Internet and growing recognition of the knowledge economy, and independently of the work of anthropologists, epistemologists and economists, there have been many books on a semantic information economy describing the functioning of human societies in terms of a distributed cognition that is reflected and unified in the digital medium. As early as 1964, Marshall McLuhan wrote: "If we expanded our central nervous system to the electromagnetic technology, it is only one step more for the transmission of our consciousness also into the world of the computers", and "our current translation of our entire lives into the spiritual form

45 Hieroglyphic writing was no longer practiced in the 4th Century.

of information seems to make of the entire globe, and of the human family, a single consciousness"[46].

I myself came to the semantic information economy through the investigation of collective intelligence, i.e. the structure of the collective cognitive system, or cognitive ecology, formed by human culture in its media environment[47]. The emerging collective intelligence of the digital network has also been discussed by Joël de Rosnay (the cybiont)[48], Kevin Kelly (the hive mind)[49], Derrick de Kerckhove (connected intelligence)[50], Francis Heylighen (the super-brain)[51], Howard Bloom (the global brain)[52], Steven Johnson (emergent intelligence)[53], Howard Rheingold (smart mobs)[54], etc. Although the terms vary, a common theme seems to emerge. These authors have done a lot to draw public attention to the fundamental stakes of the new medium of digital communication. Unfortunately the models presented are frequently based on biology, technology or systemics, but without much depth from the perspective of the human or cognitive sciences. They rarely include the inherently symbolic, linguistic and meaning-creating – or hermeneutic – nature of culture, in their analyses of the "global brain". To sum it up in one sentence: if the digital medium with its binary electronic flows does indeed constitute a kind of planetary fractal brain, we still do not have the symbolic system – the metalanguage of explication – that would give that brain something like the power of speech, and thus reflexive consciousness. As we will see in Part Two, while we may speak *poetically* (as do Teilhard de Chardin and Marshall McLuhan) of a

46 See in *Understanding Media*, the chapter on computers, p. 464, in the 2003 critical edition edited by Terrence Gordon [MAC 1964]. Here McLuhan expresses his intuition (correct, in my opinion) regarding the direction of the evolution of the emerging global civilization. However, I will not adopt the concept of a "single consciousness", a phrase that should be understood in a poetic sense rather than literally.

47 See *Les Technologies de l'Intelligence* [LÉV 1990], *Collective Intelligence* [LÉV 1997], *Qu'est-ce que le Virtuel?* [LÉV 1995], in which I introduced the concept of Hypercortex, and *World Philosophie* [LÉV 2000], which predicts a reflexive actualization of the noosphere in the digital medium.

48 See *Symbiotic Man* [ROS 2000].

49 See *Out of Control: The New Biology of Machines, Social Systems and the Economic World* [KEL 1994].

50 See *Connected Intelligence* [KER 1997].

51 See "The World-Wide Web as a super-brain: From metaphor to model" [HEY 1996].

52 See *Global Brain: The Evolution of Mass Mind from the Big Bang to the 21st Century* [BLO 2000].

53 See *Emergence: The Connected Lives of Ants, Brains, Cities and Software* [JOH 2001].

54 See *Smart Mobs*: *The Next Social Revolution* [RHE 2002]. Howard Rheingold (@hrheingold on Twitter) is a pioneer thinker on the digital revolution and virtual communities. His most recent work is on digital literacy.

superconsciousness or global consciousness, the only possible consciousness of human collective intelligence is, strictly speaking, the one that is reflected in the individual consciousnesses of living people.

6.5.2. *Semantic information economy and the commons in the digital medium*

Let us now suppose that *public* digital data[55] have in one way or another acquired the status of a commons. How could this commons be managed sustainably? What would an information economy capable of using, cultivating and developing such a commons be like?

The new economic conditions created by the digital medium can be summed up in two main points. First, once information is created it can be duplicated and transmitted at negligible financial cost. Second, all the agents of the information economy have virtual access to the other agents (and, increasingly, in P2P mode). The consequences of these two fundamental features of the new digital economy are twofold:

– First, an original, good piece of information that exists in a single copy at a single Web address is potentially available everywhere in unlimited quantities at negligible cost[56]. Under these conditions, the consumption of information is not destructive, and its appropriation is not exclusive. The open-source software movement, copyleft and Creative Commons licensing[57] have begun to give legal form to this concept of non-exclusive appropriation. Of course, it is important to clearly distinguish between duplication and transmission, on one hand, and creation, on the other. Creation requires hard work, the physical maintenance of creators, a long process of training, and political, social and educational infrastructure – all of which are far from free. This is why the debate on intellectual property in the digital world revolves around a way of freeing the reproduction, use and communication of information, a way that does not kill the goose that laid the golden egg of the original creation. One of the problems in the management of shared information goods may be formulated as follows: how can we optimally use information that has already been created to promote human development, while not drying up – and even stimulating – the source of creation?

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55 I am emphasizing the word *public* in order to preserve all legitimate rights of *privacy*.

56 The cost is obviously not zero. It is necessary to maintain and update software, servers and networks. In addition, the operation of the digital medium requires the consumption of raw materials and energy.

57 See Lawrence Lessig (inventor of the Creative Commons license), *Free Culture* (freeculture.org) [LES 2004].

– Second, the existence of any good, shared information online can be known by all agents, ideally instantaneously. The market for information in the digital medium tends toward transparency. Even in the case of material goods or traditional services, information on prices, quality and characteristics of products is becoming increasingly accessible. This information is also widely discussed in the creative conversations of consumers, designers, producers, marketing experts, etc.[58] The rules regarding face-to-face commerce in material goods and services are thus also changing, since every market has a corresponding information market in the digital medium that, as in a fair or bazaar, often takes the form of a conversation.

There is so much information available in the digital medium that the biggest obstacle to accessing it is, in fact, this very abundance: how do we find the needle of relevant information in the gigantic haystack of digital data? Another way to view the problem is in terms of the measurement of value. Since all information goods are technically abundant once they have been produced (the supply is practically infinite), we can no longer measure value by scarcity or the simple tension between supply and demand. Since the availability of information is no longer a constraint to be overcome, shared information goods gain and lose value mainly according to their meaning and relevance for the communities – or creative conversations – that use them. For example, they can lose value when the knowledge in them becomes obsolete. Conversely, they can gain value through the proliferation of interpretations, resulting in increased interest, or because translation makes them relevant to a broader audience. From an economic point of view, we can say that the value of semantic information depends on the service rendered, which is necessarily contextual. In any case, its value for some will not be the same as its value for others, and this value will increasingly be measured collaboratively in creative conversations[59]. To avoid a loss in value of its main good, the information economy must become a semantic information economy. Since the value of information depends on its meaning, the information economy must be capable of modeling the meaningful contexts and practical environments in which meaning is determined. We therefore have to imagine a socio-technical mechanism capable of answering the user's key question: where is the information that has the greatest value for me?

For the information economy coordinated by the IEML semantic sphere, the measurement of the value of intellectual or cultural goods and the formalization of the contexts in which these goods are evaluated must be left open to the greatest possible number of (self-managed) collective interpretation games, while the way is

58 This was clear by the end of the 20th Century; see Levine, Locke, Searls and Weinberger*: The Cluetrain Manifesto: The End of Business as Usual* [LÉV 1999].

59 We see this in the increasingly refined collaborative systems of filtering and recommendation in the digital medium. See Herlocker *et al.*, "Evaluating collaborative filtering recommender systems" [HER 2004].

paved for exchanges and collaboration among these games through the use of a shared framework for modeling and calculation. We can already glimpse the actors in these many different games grouping themselves in virtual communities of producers, consumers, marketers, readers, viewers, publishers, fans, critics, authors, artists, researchers, students, teachers, patients, doctors, etc. To each type of collective interpretation game there is a corresponding specific semantic universe (a certain way of organizing or "tagging" the shared memory), as well as a unique model for the measurement of value. Each creative conversation has its own ecosystem of ideas. We can imagine that creative conversations will ensure their sustainability by establishing circuits for redistributing value (monetary or other) to creators as well as to those who operate and maintain the communication infrastructure. Through the common grid of the IEML semantic sphere, collective interpretation games could enter into explicit relationships of cooperative competition and could exchange and recombine elements of their universes and their rules, while reflecting the values, choices and interests of infinitely diverse communities. I propose to consider the collective interpretation games of creative conversations as the varied, evolving and changing agents of the semantic information economy, since it is they that produce, transform and distribute value. There would thus be, in the virtual universe of human memory, as many games of collective intelligence interacting as there are creative conversations endeavoring to optimally use and enrich the common resource from original perspectives.

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In Part 2, I will go into detail on the reflexive modeling of human cognitive activities in a digital medium perfected in the Hypercortex by the IEML semantic sphere.

PART 2

Modeling Cognition

“There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy”

William SHAKESPEARE, *Hamlet*, I, 5.

“In the nature of the one, which is like space, are manifested the many philosophical systems of the discriminating intellect. All are reunified in the spirit of awakening of the great perfection. Like the sky, it embraces everything, and it opens up to become the vast place of origin of all phenomena.”

LONGCHENPA, *The Natural Freedom of the Nature of Mind*[1]

“A harmonized collectivity of consciousnesses, equivalent to a kind of superconsciousness. With the Earth not only covered by myriads of grains of thought, but wrapped in a single thinking envelope until it functionally forms but a single vast grain of thought on the sidereal scale. The plurality of individual reflections being grouped and reinforced in a single unanimous act of reflection.”

Pierre TEILHARD DE CHARDIN, *The Human Phenomenon*

1 Tibet, 14th Century.

Chapter 7

Introduction to the Scientific Knowledge of the Mind

7.1. Research program

7.1.1. *Profession of pragmatic faith*

The aim of my research program is to increase human potential in general and the human capacity for development in particular. The justification for the model presented here is pragmatic: its function is primarily to support the goal of cognitive augmentation of the species. I therefore make no claim to deducing my hypotheses from absolutely true axiomatic principles or infallible logical reasoning. I think my hypotheses are relevant because of their results: they establish a reasonable basis for scientific knowledge of the mind, knowledge that as much as possible uses the new digital possibilities for ubiquitous recording and calculation.

7.1.2. *Initial questions*

The Internet is already enhancing our individual and collective cognitive processes: it gives us access to huge quantities of multimedia data in real time, expanding our capacity for memory and perception. It also enables us to communicate and coordinate ourselves to a degree unknown to previous generations. Although the digital medium is gradually gathering in all the works of the mind accumulated by humanity over the centuries[1], although it contains the vast

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1 For a computer engineering perspective, see [SAL 2008].

majority of our contemporary thought, and although it has become the preferred context for our exchanges and transactions, it still does not offer us a readable image of the functioning of our collective intelligence. Yet all the information is there, ubiquitous, ready to be processed by means of constantly increasing calculating power. The data can certainly be found and analyzed at the level of documents or well-organized series of documents (for example, by ontologies), but their overall cognitive dynamics remain opaque. How can we model the cognitive processes of online creative conversations while improving their knowledge management? How can we transform the Internet into a rigorous observatory of economic, social and cultural phenomena that promotes human development? In short, how can we use all the resources of the digital medium to enhance collective intelligence?[2] The answers to these questions, which I have been asking since the early 1990s, obviously require a scientific theory of human collective intelligence. Before the IEML model presented in this book, we had no such theory.

7.1.3. *Instruments*

Since the late 20th Century, it has been clear to me that the development of the digital medium has been creating new conditions for the scientific modeling of symbolic cognition. The modeling tool is no longer “the computer”, but the interconnected set of symbol-manipulating automata, an evolving society of agents that is rapidly growing. The data to be manipulated to simulate cognition are no longer contained in one clearly delimited database; they spring up in the huge multimedia hypertext of the Web: a global reservoir accessible anywhere, fed constantly by the multifaceted activities of Internet users and myriads of distributed input devices. Thus my research has dealt with a way of modeling human symbolic cognition that would make full use of this instrument of observation and calculation now available to us.

During the Renaissance, in the new communication environment opened up by printing (an instrument for reproducing and disseminating ideas), the invention of the telescope and the microscope (material instruments of observation) and calculus (a symbolic instrument of computation) expanded the horizons of cosmology and physics. Similarly, the digital medium’s potential for communication, recording and distributed calculation enables us today to expand the horizons of the cognitive sciences. At the same time, we need to envisage improving the technical tools through science: improving the scientific modeling of cognition could give the digital medium the transparency and reflexivity it still lacks in 2011, at the time I am writing.

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2 On the concept of collective intelligence, see [KAP 2009, KAP 2010, LÉV 1994b, NGU 2009, TOV 2008].

7.1.4. *Subject-object*

One of the first questions that arose for me was that of the subject of cognition. Who or what is thinking? One of the first answers that comes to mind is “the brain”. This, however, was not the answer I opted for. While I do not doubt that the brain is a biological medium essential to human cognition, modeling “the brain” and modeling human symbolic cognition are two different things. Even if we only consider the physical/biological medium of symbolic cognition, an isolated brain, or even a human body, is insufficient. The production of symbolic thought requires at least a *society* in a natural and technical environment. A society most often exists at the confluence of several cultural traditions. There is therefore no *individual* subject of cognition that is not immersed in broader sociocultural cognitive systems from which this individual subject receives languages, customs, values, tools, etc. Although it is manifested in a personal reflexive consciousness or intelligence that is indisputably individual, symbolic cognition is necessarily inscribed in a collective cultural field. I consider the human brain to be a basic cognitive processor, but I believe that symbolic cognition emerges only from the interconnection of brains implementing cultural “programs” in a coordinated fashion. In the rest of this book, I will call the network of human brains that cooperate in using symbolic systems based on a material culture the *Cortex*.

The main *object* of my scientific quest, like the *subject* that is capable of knowing this object, is none other than the mind – human symbolic cognition considered in its dynamism and its specific content, independently of its technical/biological media (although, obviously, such media are a necessary condition for its very existence). The distributed socio-semantic processes designated by the word *mind* include infra-personal, personal, collective, conscious and unconscious cognitive processes on all time scales, with the understanding that symbolic (and therefore cultural) systems operate on all levels and at all scales[3]. Throughout this text, the word *mind* designates *the sphere of communication between the functions of symbolic cognition*. As we will see, the IEML model of the mind ensures the computability and interoperability of these functions.

7.1.5. *Method and result*

The initial postulate of my whole undertaking is that *the mind lends itself to scientific modeling*. This means that, through inevitable abstractions and

3 It seems to me that my approach is compatible with the so-called “4E” (“Embodied, Embedded, Enactive, Extended”) philosophy of cognition as illustrated by Harry Halpin, Andy Clark and Michael Wheeler in their article “Towards a philosophy of the Web: Representation, enaction, collective intelligence” [HAL 2010].

simplifications, it is possible to describe the human mind using a coherent system of calculable functions. Starting from this original intuition, my research involved developing a formal model of the mind that met the requirements of contemporary scientific method and that as much as possible used the reservoir of data and calculating power of the digital medium. When I obtained a *Canada Research Chair in Collective Intelligence* at the University of Ottawa in June 2002, I threw myself body and soul into an extended research process, a kind of intellectual marathon that, at the time, I never imagined would last 10 years. I was working under exceptional conditions: my teaching load was reduced and I had guaranteed funding, which I have mainly used for expert collaborators. During these 10 years, in order to solve problems encountered along the way, I had to improve my knowledge and skills in computer science, mathematics, linguistics and graphic design. I read articles in the cognitive sciences, but also many on philosophy, mainly the classic texts of various traditions. As I explained in the introduction to this book, throughout these years, five or six key elements (sign, being, thing, virtual, actual, emptiness) served as my Ariadne's thread. I represented and combined them in all sorts of ways using a range of software until I obtained a satisfactory version of the IEML language, which will be described in Volume Two. It goes without saying that this research was carried out "organically", with countless trials and errors, periodic returns to the same problems slightly modified or refined, and no guarantee that I would finally reach a favorable outcome. The main result of my work is a scientific advance in the study of human symbolic cognition: the development of the IEML semantic sphere – a system of coordinates for representing the mind as a unique, infinite nature describable in calculable functions. This semantic sphere is the mathematical/linguistic framework of a digital *Hypercortex* that will make it possible to observe and simulate human cognitive processes.

The presentation below is a simplified logical reconstruction of my research process rather than a detailed history of my trials and errors. The constraints of print publishing oblige me to present this work in two volumes, but readers should understand that the two volumes form a whole and that many aspects of IEML language will only be revealed in Volume 2, in particular the dictionary, the rules of grammar and the semantic topology. The complexity of the model I am presenting here necessitates a certain amount of repetition: each chapter concentrates on one specific aspect, but refers to certain elements of the whole in order to make it comprehensible. The introduction to Part 2 presents a synopsis of the model that will be developed in the rest of Volume 1. The reader will be able to refer to it when an overview is required.

7.2. The mind in nature

7.2.1. *The uni-duality of communication nature*

The nature whose structure I am now going to describe is neither absolute nor eternal. The word *nature* here is a technical term whose limits are defined by two conditions of validity. First, this nature emerges through symbolic cognition. It thus does not pre-exist our species in the course of biological evolution. I have no idea what this nature would be independently of its reflection in human consciousness. Second, the nature I am going to discuss appears to human knowledge from a *scientific perspective*. The meaning of the expression *scientific knowledge* is precisely the question in Part 2, and it will be revealed gradually. I want to emphasize from the outset that forms of knowledge other than scientific knowledge can obviously lead to other representations of nature and other visions of the world in general, all of them just as relevant as mine *in their own domains of validity*.

7.2.1.1. *Virtual and actual spheres of communication*

I am starting from the principle that nature is communication, i.e. that messages carrying information are exchanged in it. We can distinguish two main spheres of communication: actual ("matter" in ordinary terms) and virtual ("mind" in ordinary terms). By *actual* I am referring not to any particular substance, but to the sphere of communication in which messages are perceptible phenomena. Similarly, by *virtual* I do not mean a substance, but rather a sphere of communication whose messages are intelligible (and thus invisible) forms or concepts. Concepts are received, manipulated and transmitted through processes of symbolic cognition. Virtual and actual imply each other, since the *medium* of invisible messages – or signifieds – can only be visible or perceptible in general. Signifieds are necessarily presented to our senses through perceptible signifiers, whether through direct perception or in imagination, fiction or dreams. At the same time, the perceptible forms of the phenomenal world can only appear to us carried by the medium of symbolic cognition because when these forms are apprehended they are necessarily categorized and integrated into some narrative or theory: they have a meaning (see Table 7.1). Thus, in the virtual sphere of communication – or the nature of the mind – the (semantic) messages are invisible and the media are visible. On the other hand, in the actual sphere of communication – or material nature – the messages are visible and the media (the processes of symbolic cognition) are invisible.

	Virtual	**Actual**
Invisible	Message	Medium
Visible	Medium	Message

Table 7.1. *Medium and message in the nature of communication*

7.2.1.2. *Actual space–time*

The science of material nature situates communication between perceptible phenomena in a system of space–time coordinates. Leaving aside relativistic effects and string theory, actual space is presented here in a three-dimensional geometric form, while time is presented as a pure linear or sequential succession. This space–time of science is a useful convention for the coordination of human activities and the functional (mathematical) description of communication among material phenomena. The system of space–time coordinates is in no way a spontaneous datum of experience. It is obviously a relatively recent acquisition of cultural evolution, whose main advantage is that it leads to universal, calculable, interoperable representations of physical phenomena. Scientific and technical activity has conquered or constructed this space–time through many centuries of labor, and it has gradually been integrated into daily life and common representations through techno-social institutions such as clocks, calendars, time zones, maps, GPS, laboratories and networks of measurement. Hypothetically, in the material nature described by science, communication takes the form of causal circuits. As complex as they may be, these circuits are formed entirely within the system of space–time coordinates. Consequently, a cause necessarily precedes its effect. Goal-oriented, or teleonomic, behaviors do exist, but they emerge from feedback loops or automatically executed programs, and can therefore always be reduced to temporal sequences in which causality (and therefore communication) circulates from the past to the future.

7.2.1.3. *Virtual space–time*

Let us now imagine a science of the mind. What would the system of coordinates, the basic framework of communication of the virtual sphere, look like? It is clear, to begin with, that three-dimensional geometric space is not adequate for the localization of concepts. No one can say where justice or truth is located in three-dimensional space, although we can point to physical places and times in which these concepts are actualized. Nor can we say that they are located in our brains, since no close observation of these brains will ever show anything but neurons, circuits of excitation and discharges of neurotransmitters in synapses. We will never observe concepts. I admit that it is impossible to think about concepts without a working brain, but we cannot deduce from this that concepts are *located in* the brain (in the sense that we say that the neurons are located in the brain). Neurons and concepts belong to two different spheres of communication. In the rest of this book, I will show that a system of coordinates of the mind must be presented as a hypercomplex network of interrelated concepts. For example, in this system of coordinates, the concept of justice is related to the concepts of injustice, balance, equality, law, decision, innocence, guilt, retribution, etc. The concepts are interconnected in relationships of meaning in a fractal tangle of semantic circuits with a structure that is very different from that of the geometric space that coordinates the actual sphere.

What about time? It is clear that the universe of meaning is not organized according to a simple sequential temporality. Although thoughts follow one after another sequentially in our experience, each thought, at the moment it occurs, also resonates with previous thoughts along complex semantic and affective circuits. In the mind, communication drives the transmission and transformation of meaning. Its operation is not causal but interpretative. Symbolic cognition sets down, organizes and reorganizes relationships of meaning in a dynamic interpretive memory within which experiences of life and learning in turn act on our understanding – and therefore the meaning – of past events. In the world of ideas, the virtual past of memory can be affected by its future. Distinct from material causality, *narrative* time governs the development of meaning. The virtual time of memory – the dynamics of meaning – is woven, unraveled and rewoven in hypertextual narrative patterns. Semantic communication propagates simultaneously in the multiple branching of the narratives and theories that structure the reticular universe of symbolic cognition. Far from being sequential or simply tree-like, the channels that carry semantic communication are organized in rhizomes that sprout and branch out in all directions of the mind. While in terms of the visible medium of the mind (see Table 7.1), the reading and writing of signifiers there is always a "before" and an "after" on an irreversible sequential line, the invisible message of meaning is organized in rhizomes in the living duration of memory.

7.2.1.4. *The interdependent co-emergence of the virtual and actual spheres*

Since nature is communication, we must now consider the relationship between the virtual and actual spheres of nature. As we have seen in Table 7.1, the medium of each of these spheres is the message of the other. On the one hand, the virtual world of meaning cannot exist without the biological medium of signification – actual phenomena. On the other hand, the perceptual phenomena of the actual sphere are defined by processes of symbolic cognition that actively construct the meaning of these phenomena, even when the perceptual forms are experienced as the direct result of pre-existing realities. There is no physical nature[4] without conceptual categorization or affective polarization, and no spiritual or intellectual world without perceptible signifiers or a biocosmic medium. In the nature of communication, mind is not the opposite of matter, but its partner: virtual and actual, noumenon and phenomenon, physical sphere and metaphysical sphere co-emerge interdependently, with each actively needing the other in order to exist. With the complex uni-duality

4 It should be noted that from an etymological perspective, *physical nature* is a pleonasm, since in Greek, *physis* actually means nature. In ancient Greek thought, *physis* (nature) was contrasted with *nomos* (law, human convention).

of communication nature established, we now need a description of mind that is as scientific as the description of matter that has been achieved in physics, the molecular sciences and biology.

Before going any farther in this direction, let us pause for a moment at the mysterious crossroads where virtual and actual communicate and exchange with each other: the human presence.

7.2.2. *The uni-ternarity of communication nature*

The human species is at the "center" of nature as described here because it is thus far the only conscious carrier of the ideal forms that exist in the virtual sphere, and the only species capable of contemplating these abstract forms and using them skillfully to act in the actual sphere. We are able not only to say and understand that "this" represents "that", but also to manipulate "this" and "that" in complex and systematic ways while maintaining the trace and the active memory of the correspondence between "this" and "that". In addition, we know that there is "someone", an interpreting subject, for whom "this" represents "that". In fact, without such an interpreter, it would be impossible to conceive of a correspondence between a signifier and a signified. Meaning cannot be something objective that resides simply in material phenomena. To fully exist, the virtual sphere of meanings requires cultural conventions, symbolic systems and socialized individuals capable of interpreting signs according to the appropriate conventions. In my technical vocabulary, I say that our species carries the ternary relationship sign (S)/being (B)/thing (T), i.e. that it produces and reproduces interpreters (B) for whom there are signs (S) evoking concepts and referring to (virtual or actual) realities (T) according to contexts and "rules of the game" that are infinitely varied. The human interpreters are capable of playing in all kinds of ways with the interpretive triad being/sign/thing. This basic generator of meaning is what creates the specificity of the human presence.

In the nature of communication, the human presence ("now") simultaneously generates two temporalities: one that links perceptible phenomena in matter, and one that links ideas in the mind. Through sensory-motor experience, presence changes into sequential time in the actual sphere. Through the semantic experience of symbolic learning and thought, presence changes into hermeneutic and narrative memory in the virtual sphere. Presence is projected into the geometric space of the physical cosmos in the actual sphere, and into the semantic topology of the world of ideas in the virtual sphere. The nature of communication in its totality, both actual and virtual, emanates from the human presence.

This presence that mediates between the “Heaven” of symbolic cognition and the “Earth” of material bodies directs the “ascending” currents of virtualization and the “descending” currents of actualization. In the center, the communicative presence animates an ontological “breathing”: in the movements of “breathing in” – or virtualization – phenomena signify, and in the movements of “breathing out” – or actualization – meanings are manifested and embodied. Virtualization reflects visible light into invisible forms and actualization projects the invisible light of ideas into the sensory world. At the nexus of this reciprocal translation, presence functions as an affective Moebius strip that reciprocally transforms the medium into the message, and the visible into the invisible. The human presence appears at the center of nature like a source of non-dual existential light, impossible to grasp, preceding the distinction between visible and invisible, virtual and actual.

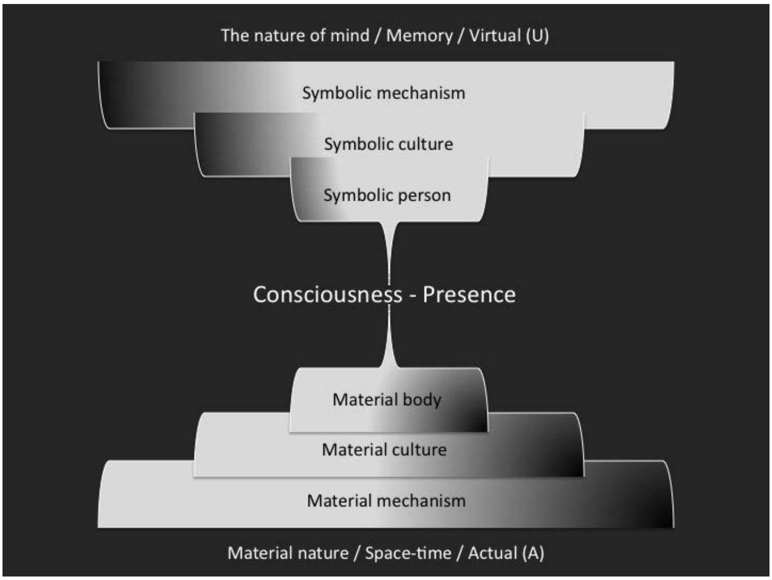

Figure 7.1. *Nature of information and communication: mind, presence, matter*

Figure 7.1 shows the double series of concentric translucent spheres that reflect and reveal the existentiating light of presence. In the sphere of the actual, the burning nucleus is made up of a transitory human organism and its sensory-motor activities. Within this nucleus, communication is dense and rapid. The living human body is itself surrounded by a second concentric sphere, a hot magma made up of other human bodies, tools, machines, buildings, infrastructure, media and networks with which it interacts and which organizes its relationship to the material world. The techno-cultural ecosystems of this second concentric sphere are obviously very varied and constantly evolving. A third, relatively cold sphere surrounds the magma of material culture: the cosmic envelope. This material cosmos is primarily made up of the terrestrial biosphere (the least cold layer of the envelope) and, beyond it, physicochemical layers, within which there are levels of astronomic, planetary, molecular, atomic and quantum complexity. For our physical science, there is a single universal material cosmos that envelops material cultures (and, through these cultures, human bodies). Science describes the cosmos through calculable functions, using the system of space–time coordinates that unifies it. At the same time, however, it is understood that the complexity of the physical cosmos is inexhaustible by our finite science.

Let us now analyze the virtual sphere, which has the same structure in three concentric envelopes as the actual sphere. The burning nucleus of the virtual sphere is a hypercomplex metaphysical form: intelligence, or the individual mind, which may be defined as a process of construction of memory driven by personal learning. Within this nucleus of individual intelligence, communication is dense and rapid. Individual intelligence is dependent on the human body of the actual sphere. The hot magma of collective intelligence surrounding the nucleus is made up of "language games", symbolic systems and cultural conventions in which the individual intelligence participates. This second concentric sphere of evolving symbolic systems represents the immaterial dimension of culture and corresponds to the magma of material culture in the actual sphere. Symbolic systems organize the relationship of the individual intelligence to the world of ideas and enable it to coordinate its learning and memory with other individual intelligences. The hot magma of the evolving symbolic systems is itself contained in a colder sphere: the envelope of the mind, in Figure 7.1, designated the "symbolic mechanism". This envelope contains the potential for symbolic manipulation carried by the human species and the set of the ecosystems of ideas generated by this potential. Its temporality – that of memory – distinguishes it radically from the temporal phenomena of the physical cosmos.

Although it is possible for purposes of analytical description to distinguish zones, spheres and levels in nature, I would like once again to emphasize its unity: mind and matter are spheres of communications and their respective concentric sub-spheres are inextricably contained in each other. In addition, the virtual and actual spheres are interdependent. At the center of nature, the human presence simultaneously illuminates the visible and the invisible; it implies one in the other and it reciprocally explains matter and mind, geometric space and the complex topology of semantic circuits, sequential time and interpretive memory.

Physical nature and the nature of the mind are two interdependent images of one and the same nature of information and communication. Just as the physical cosmos can be described in calculable functions using a system of space–time coordinates, the world of human ideas can be described in calculable functions using a system of semantic coordinates: the IEML semantic sphere.

7.3. The three symbolic functions of the cortex

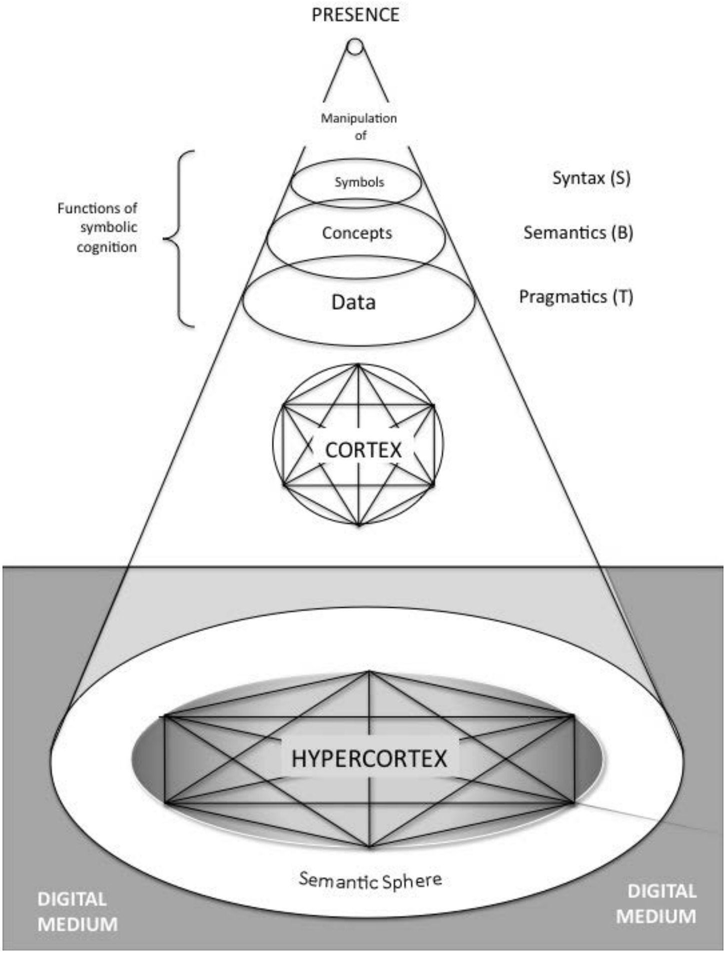

Figure 7.2. *Projection of the cortex in the digital medium*

How does the human presence generate the world of ideas, which is unknown to other animals? To answer this question, we have to go into the "factory of the mind", which I call the *Cortex*. The term *Cortex* here is a technical term that designates the actual dynamics of symbolic communication among the brains of living human beings. It should be kept in mind that the Cortex is not a static entity, but a dynamic process. Collective human intelligence emerges from the interaction between the Cortex and nature. The symbolic cognition specific to human beings is additional to the non-symbolic cognition the human species shares with the other animal species and it reorganizes that non-symbolic cognition. The operation of the Cortex, the symbolic dimension of human cognition, may be described in terms of the dialectical interaction of three types of manipulation: (i) manipulation of symbols, or signifiers, which corresponds to the syntactic function; (ii) manipulation of concepts, or signifieds, which corresponds to the semantic function; and (iii) manipulation of data, or referents, which corresponds to the pragmatic function. The Cortex in Figure 7.2 shows the dialectical unity of these three functions.

7.3.1. *The syntactic function*

We can only think or form representations of general categories by using systems of symbols: languages, writing systems, icons, etc. I should point out here that symbolic forms can appear to any of our senses or to any combination of these senses. Communities of the deaf have developed sign languages. Systems of religious symbols and rituals in general can involve songs, dances and "multimedia" physical environments of all kinds. The point to remember is that the abstract thought that is specific to humans necessarily has to operate through signifying sensory representation. The human mind is capable of processing these signifiers in very elaborate ways. It is the syntactic function of symbolic cognition that expresses our capacity to break down, arrange and rearrange complex signifying structures.

We know that human beings are capable of respecting the syntax of very complex languages through imitation, even without having formally learned their grammars. The existence of the syntactic function also explains our ability to use abacuses and number systems, and therefore to perform calculations with numbers. If we consider operational movements and tools as symbols to be combined, the syntactic function also explains the technical development that distinguishes humanity. Finally, social games with varied symbols and complicated rules are practiced in all cultures, whether these games are "purely playful" or are "serious", such as family, political, legal and economic games.

7.3.2. *The semantic function*

The manipulation of symbols is obviously not a goal in itself. Its role is to support the semantic function, the manipulation of concepts, signifieds and categories. This manipulation of concepts is not limited to logical reasoning, but also includes games of opposition, complementarity, analogy, derivation and linguistic composition between the signifieds, including all the refinements of dialogue and narration. The semantic function explains both our capacity to produce and to comprehend (in the etymological sense of "take together") conceptual architectures that can be indefinitely complex. We can transform arrangements of symbols, so we can also carry out all kinds of transformations on the architectures of concepts represented by these arrangements. Just as the syntactic function is based on the discipline of *grammar*, the semantic function has often been studied under the term *dialectic*, in the sense of a very general ability to organize relationships among concepts. Dialectical ability involves breaking down, synthesizing, transforming and ordering signifieds in relevant structures.

7.3.3. *The pragmatic function*

7.3.3.1. *Interpretation, memory, action*

The manipulation of concepts is not a goal in itself, either. The very concept of the *relevance* of conceptual architectures implies a situation, real or fictional, in which signifieds are related. Concepts categorize sensory data according to a practical intention, whether the data are perceived, remembered or imagined. Just as symbols are used for manipulating concepts, concepts are used for manipulating data or percepts. The pragmatic function accompanies the immersion of the thinking subject in the temporality of memory and action. With regard to memory, perceptual data are organized according to their conceptual meaning and their affective value for the subject. To navigate in memory, the pragmatic function draws a rhizomatic graph of conceptual and affective relationships among perceptual data. With regard to action, the pragmatic function categorizes percepts according to the subject's goals and maintains compatibility with the subject's emotional and conceptual memories. As the name indicates, the pragmatic function aims primarily for effective action. However, just as in medicine the effectiveness of the treatment is subordinate to the accuracy of the diagnosis; the effectiveness of the action of the pragmatic function is subordinate to the refinement and relevance of the conceptual and affective *interpretation* of the data.

7.3.3.2. *Ideas*

By categorizing percepts and attaching an affective value to the categorized percepts, the pragmatic function produces ideas. Ideas are organized in ecosystems.

They are connected by the semantic relationships of their concepts and the sensory relationships of their percepts, and they exchange their affects. We can thus analyze ideas in three interdependent components:

– a sensory datum, or percept (T);

– an affect (B); and

– a concept (S).

7.3.3.3. *Pragmatics and general rhetoric*

Just as the art of the syntactic function is grammar and the art of the semantic function is dialectic, the art of the pragmatic function is rhetoric. Rhetoric, in fact, includes both an art of memory and an art of effective symbolic action. Rhetorical skill organizes data to be retained, both for the orator and the audience. If the ideas are not imprinted in the mind of the orator, how can they be in the minds of the audience? It is by controlling the ideas in memory on the basis of their conceptual, emotional and perceptual dimensions that rhetorical skill ultimately controls the data of the situation. We can generalize from special rhetoric (the art of persuasion) to an expanded rhetoric that uses social conventions, as well as the ideas and emotions of a community, to ensure the maximum effectiveness of symbolic action.

7.3.4. *The sign (S)/being (B)/thing (T) dialectic of symbolic cognition*

The syntactic capacity to manipulate symbols serves the semantic capacity to manipulate concepts, since we cannot apprehend abstract categories except through the medium of signifiers. In turn, the semantic function serves the pragmatic function of manipulating data (or percepts), since concepts qualify and designate realities, organize memory and, through the affective force of ideas, act on social contexts. Furthermore, memory, semantically organized by the pragmatic function, obviously serves as a medium for syntactic function, since we could not retain and manipulate so many symbols if they had no conceptual and practical relevance. In a sense, the pragmatic function is central, since the semantic and syntactic functions are only justified by their pragmatic use. In another sense, however, the semantic function is the highest, since there would be no pragmatic function at all if the concepts were not there to give meaning to data and situations. The percepts and the affects of ideas draw their meaning from the concepts. Finally, we can consider the syntactic capacity to manipulate signifiers as the root or source of symbolic cognition, since without it we would be reduced to animal cognition: there would be no language, technology, culture or reflexive intelligence. We therefore have a ternary dialectic – sign (S)/being (B)/thing (T), each pole of which is both clearly distinct from the other two, since it occupies a different function, and is absolutely dependent on the other two, since none of the three functions can carry out symbolic cognition separately. This tripolar dialectic should be thought of in its generality as a symmetrical interaction among three roles, which may be played by different conceptual actors depending on contexts, disciplines or intellectual tradition. The linguistic version of this tripolar dialectic connects the signifier (S), the signified for an interpreter (B) and the referent (T).

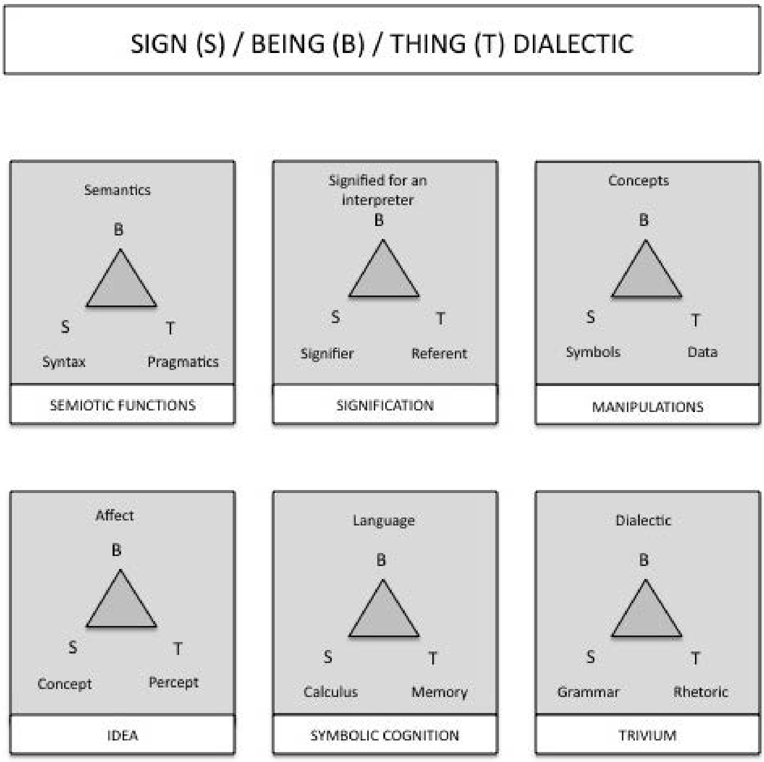

Figure 7.3. *Sign/being/thing dialectic in symbolic cognition*

Figure 7.3 provides some variations on the tripolar dialectic of symbolic cognition[5]. We can see that the syntactic function permits the manipulation of symbols, expresses the computational faculties of human cognition and is studied in the generalized art of grammar. The semantic function controls the manipulation of concepts, explains the faculties of linguistic representation of human cognition and is studied in the art of the dialectic. Finally, the pragmatic function produces ideas, controls the manipulation of data, organizes interpretative human memory and is

5 We will study others in Volume 2 of this book.

studied in general rhetoric[6]. The S/B/T dialectic of ideas (concept/affect/percept) is internal to the pragmatic function.

It should be noted that the virtual/actual dialectic is itself indissociable from the sign/being/thing dialectic. Indeed, only symbolic cognition, because it is reflexive, can distinguish between the concrete actuality of bodies and events inscribed in the space–time continuum and the virtuality of possibilities, abstractions, concepts and ideas envisaged by the mind.

7.4. The IEML model of symbolic cognition

7.4.1. *The semantic sphere: the mathematical basis of the IEML model of the mind*

In constructing the IEML model of symbolic cognition, I had to meet two major requirements. First, the model obviously had to take into account the functioning of the human Cortex, respecting its major connections and its in principle unlimited capacity for the manipulation of symbols, concepts and data. Second, my model had to make maximum use of the calculating power, ubiquity and interconnection of the digital medium. This second condition meant not only that each of the major functions of symbolic cognition actually had to be calculable by logical automata, but that they had to be interoperable. In the IEML model, this general interoperability is provided by the semantic sphere, which operates as a universal system of mathematical coordinates of the mind.

7.4.2. *The Cortex, the Hypercortex and the semantic sphere*

The Hypercortex must be clearly distinguished from the semantic sphere. The Hypercortex is a technical mechanism capable of reflecting a simulated image of the cortical process of symbolic cognition. This image is thus, like the Cortex it reflects, a dynamic, evolving process. The semantic sphere is the system of mathematical coordinates, the virtual grid used by the Hypercortex to reflect the image of the Cortex. The relationship between the semantic sphere and the Hypercortex is therefore a relationship between a scientific instrument of observation (the Hypercortex) and the projection system by which it is organized (the semantic sphere). In short, as suggested in Figure 7.2, the Cortex is the dynamic object

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6 On the subject of the trivium (grammar, dialectic, rhetoric) as the backbone of the Western intellectual tradition from Ancient Greece until the 16th Century and beyond, see [MAC 1943]. On the parallels between the trivium and the major articulations of semiotics and linguistics, see [RAS 1990].

reflected by the Hypercortex against the background of the semantic sphere, while the digital medium is the almost-unlimited source of the data and calculating power used in the process of reflection.

7.4.3. *The Cortex, the Hypercortex and the mind*

I would now like to distinguish between the mind and the Cortex. The Cortex designates the process of symbolic communication among human brains that supports actual collective intelligence. This collective intelligence is augmented by the media and systems of signs developed in the course of cultural evolution. The human mind has always included a dialectic between its Cortex and the intellectual technologies available to support, augment and reflect its symbolic functions (we only have to think of the role of libraries). While the emergence of the digital medium is very recent on the scale of human history, it is nevertheless a sign of a convergence, an accelerated evolution and reciprocal multiplication of multimedia capabilities and symbolic codes. The role of the semantic sphere is to bring consistency to this movement in order to augment the Cortex. Once the semantic sphere enables the Cortex to be reflected in a Hypercortex that presents it with the scientific image of its own functioning, its operations will become both more precise and more powerful. The Hypercortex mobilizes the media, systems of signs and intellectual technologies that have always augmented the Cortex, but it does so by making maximum use of the calculating power, ubiquitous communication and access to data that characterize the digital medium. The mind – that is, human cognitive power seen from the theoretical perspective of its open evolution – therefore results from a reflexive dialectic between the Cortex and the Hypercortex.

7.4.4. *General structure of the IEML model*

In order to provide the Cortex with the mirror in which it will be able to observe its hypercortical image, the scientific theory of the Cortex and the technical plan of the Hypercortex must follow the same general model of the mind. Without structural isomorphism between the functions of the Cortex and those of the Hypercortex, the latter would not reflect actual symbolic cognition and the Cortex would not be enhanced by a new reflexive capacity on the scale of collective intelligence. That is why the IEML model of the mind is transversal to the Cortex and the Hypercortex.

Figure 7.4 shows a dialectic in six sections, with the three lower (actual) sections representing the Cortex and the three upper (virtual) sections representing the Hypercortex. On the left, the two *sign* (S) sections represent the syntactic function. In the center, the two *being* (B) sections represent the semantic function. On the right, the two *thing* (T) sections represent the pragmatic function. Since I have already talked about the dialectic of the Cortex and the Hypercortex and the three functions of the mind in general terms, I will now focus on the three virtual areas of the Hypercortex, i.e. on the automatable representation of the syntactic, semantic and pragmatic functions of the mind. Since the IEML model of the mind must be calculable, I will borrow a metaphor for its general structure from computer science.

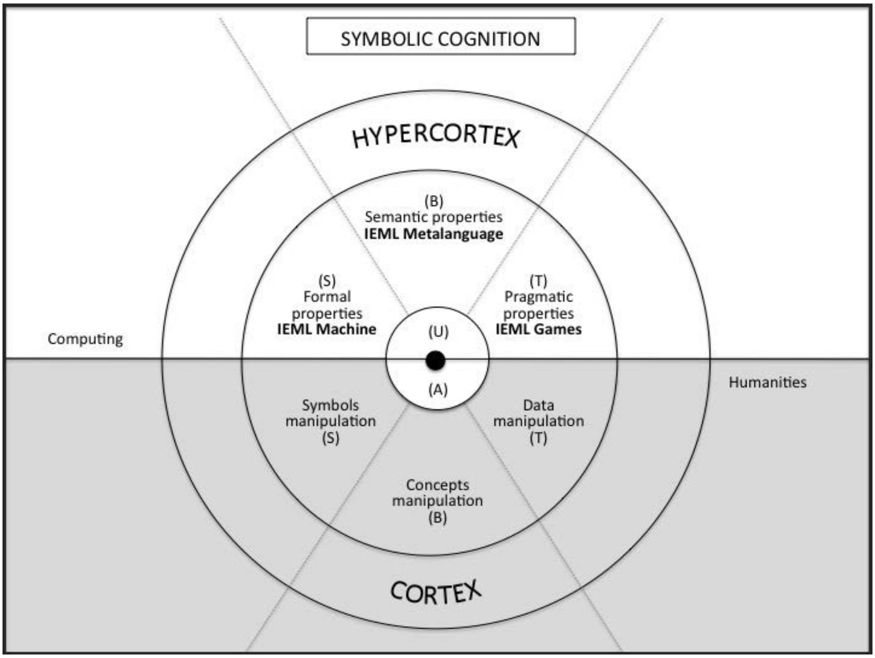

Figure 7.4. *The IEML model of the mind*

S: The function of manipulation of symbols is modeled in an abstract semantic machine, the syntax of IEML, which has been demonstrated to be capable of computing the giant graph of the semantic sphere.

B: The function of manipulation of concepts is modeled in a calculable metalanguage based on the syntax of IEML. The grammar rules and dictionary of this metalanguage function as a linguistic operating system of the machine: they translate the paradigmatic and syntagmatic graphs of the IEML semantic sphere into natural languages.

T: The function of manipulation of data is carried out by the applications of the IEML semantic machine, which are called IEML games or collective interpretation games. These games make it possible to freely organize the digital memory according to the universes of discourse and values of creative conversations: they produce interoperable ecosystems of ideas.

7.4.5. *IEML as machine: formal properties*

7.4.5.1. *Toward a universal semantic calculus*

Contemporary computers are already capable of automatically manipulating symbols and data. What has not yet been achieved, in my view, is the capacity to automatically manipulate concepts on a large scale, systematically and interoperably, i.e. across disciplinary, cultural and linguistic differences. The possibility of automatically manipulating concepts using a general method (rather than a multitude of *ad hoc* methods, as is done today in 2011) would open the way to a universe of automatic manipulation of data according to their meaning. Let us assume that the data would be categorized according to universally calculable semantic metadata. Then a society of automata (interoperable "services") could interpret and filter the digital data using the mechanism provided by these metadata. The problem thus is to design a method of encoding concepts that would make a universal semantic calculus possible. Such a problem is particularly difficult to solve for two reasons. First, machines are notoriously blind to semantics: computers only "understand" the syntax and formal rules for manipulating symbols. Second, the natural languages in which concepts are normally encoded are irregular: there is no point trying to find a systematic, calculable correspondence between syntactic forms and conceptual meanings. I solved this problem by inventing a symbolic system in which syntactic functions and semantic functions are strictly parallel: all the semantic relationships among concepts encoded in IEML correspond to calculable syntactic relationships among IEML texts.

7.4.5.2. *The three modules of the IEML machine*

The IEML semantic machine consists of three modules.

– First, a generative syntax produces a regular (in the mathematical sense) language in which each text (each USL) is the variable of a transformation group. This means that texts in the regular IEML language can be produced, recognized and transformed automatically.

– Second, an algorithm uses the grammar rules and multilingual dictionary of the linguistic operating system of IEML to assign a meaning in natural languages to the IEML texts (the USLs).

– Third, all semantic relationships (paradigmatic and syntagmatic) between USLs are calculated automatically using a giant hypercomplex graph in which each node and each link is translated into natural languages: the semantic sphere. Like the

USLs that are the nodes and links, the circuits that make up the semantic sphere are the variables of a transformation group. This means that the circuits of the IEML semantic sphere can be produced, recognized and transformed automatically. The formal properties of IEML include a "semantic topology" defining the circuits of the semantic sphere and their transformations[7].

As it supports a model of the mind, the IEML semantic machine generates a virtual universe that is practically infinite and inexhaustibly complex. It also supports a *scientific* model of the mind, so this machine fulfills strict conditions for symmetry and calculability.

7.4.6. *IEML as metalanguage: semantic properties*

7.4.6.1. *STAR: The linguistic operating system of the IEML semantic machine*

The IEML syntax, which I have already described, can be considered an automatic writing system, and the IEML semantics, which I will now discuss, may be considered a linguistic interpretation of that writing. The linguistic operating system of the IEML machine is called STAR (Semantic Tool for Augmented Reasoning). The role of STAR, which is no small thing, is to provide the IEML machine with data in natural languages that will enable it to produce the meanings of the USLs. These meanings are based on (i) the paradigmatic relationships among the terms in the multilingual STAR dictionary; and (ii) on the STAR grammar rules that define the syntagmatic relationships among these terms in the USLs. Its mechanical syntax (the semantic machine) and its automatic semantics (STAR) make IEML a calculable metalanguage that can be used as a bridge language between natural languages in the digital medium. Any IEML text can be converted automatically into a semantic network that is readable in natural languages, and vice versa. *This means that an IEML text written using an interface in the writer's own language will be able to be read in all the languages supported by the multilingual IEML dictionary* (at this time, the IEML dictionary supports only French and English).

7.4.6.2. *IEML as a human language*

Envisaged as a language, IEML lies at the intersection of human languages and computer languages. Like human languages, it is primarily suited for the expression of signifieds or concepts. As we will see, the structure of IEML has many similarities with that of natural languages. Its grammar has layers of increasing complexity: phonemes, morphemes, words, sentences, texts, etc. Its terms and

7 The mathematical definition of semantic circuits as well as the proof of the calculability of their generation, transformation and measurement, will be presented in Volume 2 of this book. Meanwhile, see [LÉV 2010b].

propositions are distributed in verbal, nominal and auxiliary classes. Finally, its textual units can play many distinct grammatical roles: subject, object, genitive, etc. Unlike other human languages (whether natural or artificial), however, the semantics of IEML is entirely calculable in the form of circuits of paradigmatic and syntagmatic relationships, and its expressions can be the operands of unions, intersections or differences (it is a symmetric transformation group). I should add that the IEML language is not made to be spoken, but rather to be read and written using an interactive computing platform, with access to relevant data, and the availability of all kinds of interfaces[8] that this requires.

7.4.6.3. *IEML as a computer language*

Like computer languages, IEML can be manipulated automatically. IEML is neither a data format (such as PDF, HTML, XML, RDF or OWL) nor a programming language. It is not a data format, because its main purpose is to express concepts; it is a real language, with verbs, nouns, cases, sentences, etc. To clarify: there is a word in IEML for *justice*: *k.o.-n.o.-'** but there is obviously no translation of the word *justice* in XML, RDF or OWL, because XML, RDF and OWL are not languages but data formats[9]. Moreover, IEML can be used with any data format imaginable[10]. It is not a programming language, since its purpose is not to give instructions to a logical automaton. On the other hand, since IEML is calculable, the texts (USLs) and corresponding semantic circuits can be generated and processed at will, using existing programming languages. However, this does not in any way exclude the possibility that programming languages or user-friendly applications for non computer specialists could be designed especially for the manipulation of IEML texts (USLs) and semantic circuits.

7.4.7. *IEML as a universe of games: pragmatic properties*

7.4.7.1. *The hermeneutic functions and the production of ideas*

The main IEML applications are collective interpretation games (CI games). These games automate the production of ecosystems of ideas using hermeneutic functions (see Figure 7.5). As we saw above[11], an idea can be modeled by the combination of a concept, an affect and a percept. The collective interpretation

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8 These interfaces can be in natural, iconic or visual/tactile languages, 3D simulation, augmented reality, etc.

9 The lack of a distinction in English corresponding to that between the French *langue* and *langage*, and the use of the word *language* to designate data formats may lead to confusion.

10 There is already a parser for IEML expressions, which automatically translates USLs into XML format; see [LÉV 2010d].

11 See section 7.3.3.2.

games represent the concept by a USL, the percept by a URL and the affect by a semantic current in the circuits corresponding to the USL. The production of ideas can be broken down into two operations: (i) categorization connects a USL to a URL; and (ii) evaluation determines the semantic current. It is understood that the same data (the same URLs) can be categorized and evaluated differently using many different hermeneutic functions.

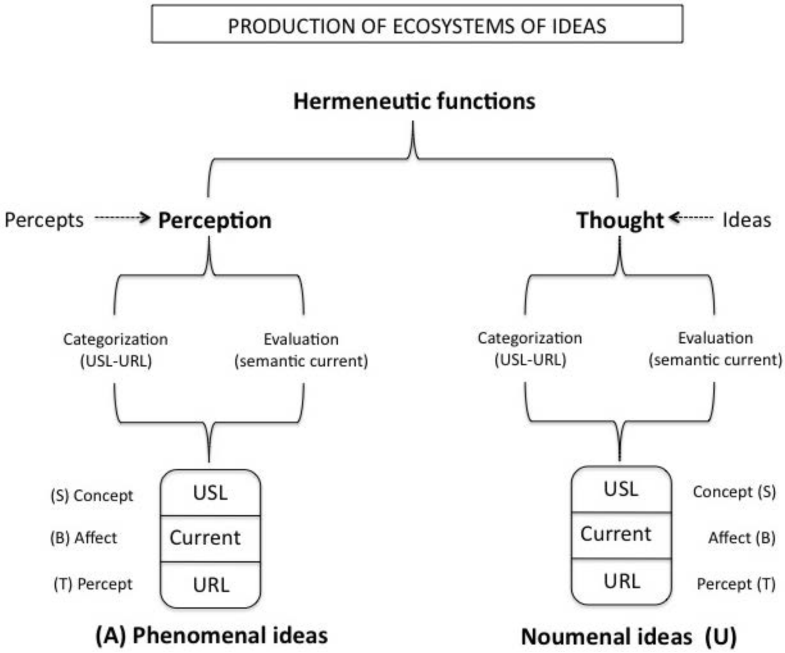

Figure 7.5. *Collective interpretation games and their hermeneutic functions*

We can distinguish two major types of hermeneutic functions:

– those whose input variables are data (addressed by their URLs) not categorized in IEML; and

– those whose input variables are ideas categorized in IEML by USLs.

Functions whose input variables are data may be considered functions of perception, and their products, phenomenal ideas (or actual ideas).

Functions whose input variables are ideas may be considered functions of thought, and their products, noumenal ideas (or virtual ideas). A function of thought corresponds to a theoretical or narrative interpretation of phenomenal ideas.

7.4.7.2. *The interoperability of IEML games*

It should be recalled that USLs are automatically translated into circuits of the semantic sphere by the IEML machine and that all ideas can thus be associated in meta-circuits conducting the semantic current. In addition to their functions of "writing" circuits of ideas on the voluminous mass of data, the CI games will obviously have functions of "reading" enabling searching, filtering and navigating in a hermeneutic memory holding a multitude of ecosystems of ideas. Although their rules may be different, all the CI games are interoperable because they exist in the shared universe woven by the circuits of the semantic sphere. The hermeneutic functions operate on the same types of variables: URLs for the addresses of data, USLs for the addresses of concepts categorizing the data, and flows of current in the semantic circuits corresponding to the USLs to evaluate the data. We can thus imagine game engines that are compatible and capable of calling upon a large number of interoperable hermeneutic services, so that the players can join forces and compose games at will.

The users of the IEML semantic sphere can participate simultaneously in many CI games with different rules of perception and thought. In a sense, each person and each IEML game organizes the semantic sphere and, beyond it, the digital data of the Web, from a distinct perspective. I note once again that good and evil, loss and gain, creation and destruction of value are variables in IEML games. These variables will be defined in different ways by different games. As it is modeled in the IEML semantic sphere, augmented collective intelligence is thus both decompartmentalized (through semantic interoperability) and radically polycentric (because of the existence of an open/multitude of distinct CI games). The digital medium is today fragmented by competition among commercial platforms, difficulties of automatic translation between natural languages and the large number of incompatible systems of metadata and ontologies. The semantic sphere could transform the digital medium into a perspectivist memory, however, a hermeneutic monadology in which creative conversations will be able to interpret each other freely and collaborate effectively without giving up their original points of view.

7.4.7.3. *IEML games and knowledge management*

The IEML system of semantic coordinates makes it possible to have transparent communicative interaction among individuals, among creative conversations organized in CI games, and between games and individuals. A CI game functions as a social system of knowledge management, an abstract machine that permits the players to produce and collaboratively weave a shared memory in the form of an ecosystem of ideas. The actual individuals, who remain the ultimate sources and destinations of all collective intelligence, will be able to influence the games in which they choose to participate in order to optimally accumulate and use their own memories. "Personal interpretation engines" will permit them to dynamically organize their personal knowledge management[12] and guide their learning while participating in different games, thus exploiting the cognitive interoperability provided by the semantic sphere.

7.5. The architecture of the Hypercortex

Figure 7.6 presents the general architecture of the Hypercortex. In the back, ubiquitous multimedia interfaces establish the relationship with the Cortex. On the left, the IEML semantic sphere represents the virtual "wing" of the Hypercortex. On the right, the Internet (the logical sphere) represents its actual "wing". In the center, creative conversations control and coordinate the activity of the two "wings". In front, the reflexive consciousness of their collective intelligence is aimed at the synergy of actual collective intelligence and human development.

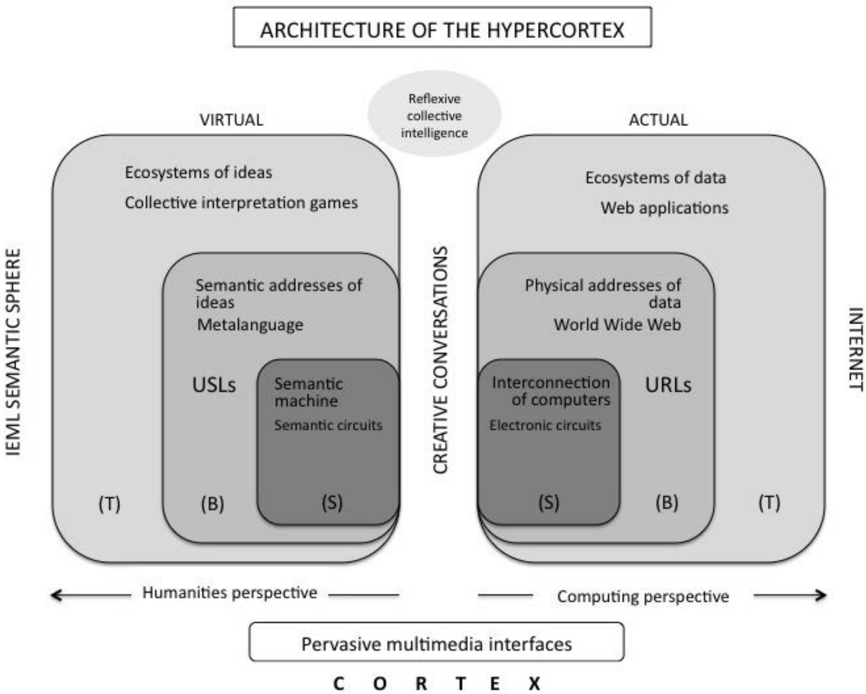

Figure 7.6. *General plan of the hypercortex*

12 On personal knowledge management, see section 4.2.1.

7.5.1. *The Internet*

With the Internet:

– (S) The mechanical heart of the Internet is the global network of interconnected computers: an actual society of automata that manipulate symbols. With its system of physical addressing of local calculators, the Internet functions as a big global logical machine capable of distributing its calculations over all the electronic and optical processors that possess IP addresses.

– (B) Surrounding the Internet's society of automata is the Web's system of physical data addresses (URLs). As it is a universal addressing system, the Web makes it possible to interconnect all data. It makes all digital data into a single multimedia hypertext document that is constantly growing and being reorganized.

– (T) Web applications, the production tools and vehicles for navigating in the voluminous hyperdocument, organize ecosystems of data suited for use in creative conversations.

7.5.2. *The IEML semantic sphere*

Let us begin by defining the IEML semantic sphere: it is a specialized system of mathematical coordinates for markup and simulation of ecosystems of ideas. By extension, we will consider the semantic sphere to contain everything it organizes. It forms the virtual "wing" that balances the actual "wing" of the Hypercortex:

– (S) This is the heart of the semantic sphere is the IEML machine. It is a society of virtual automata capable of producing, transforming and measuring the circuits of the semantic sphere.

– (B) Surrounding the IEML semantic machine is the system of virtual addressing of the IEML metalanguage: each USL encodes a distinct concept. This system of semantic addressing processes the concepts as variables of a symmetric transformation group and organizes their interconnection in semantic circuits. The concepts form the nodes, and the syntagmatic and paradigmatic relationships among concepts form the links of this gigantic network. Since each concept is translated into natural languages, the IEML metalanguage functions as a bridge language between natural languages and symbolic systems.

– (T) Finally, collective interpretation games enable creative conversations to create and manage their ecosystems of ideas. Ideas are created by folding back the IEML metalanguage onto the Web, i.e. by categorizing data (URLs) using concepts (USLs). The interpretive operation that produces ideas also determines the semantic currents that connect the URL–USL pairs. Out of the interoperable set of ecosystems of ideas emerges a monadological hermeneutic memory in which all semantic perspectives are symmetrical.

7.5.3. *Interdependence of the semantic sphere and the Internet*

The virtual and actual "wings" of the Hypercortex are in a relationship of dialectical interdependence and mutual reflection. The semantic sphere is dependent on the Internet, because the IEML semantic machine is activated by the actual logic circuits (electronic, optical, etc.) of the Internet, since the USLs have Web addresses and the collective interpretation games are Web applications. It goes without saying that the virtual semantic sphere of IEML needs the processors and storehouses of the actual data of the Internet. At the same time, the semantic sphere operates as an automaton, reading/writing semantic circuits on the fluctuating mass of data. Using this symbolic automaton, creative conversations transform the opaque "grey matter" of the Internet into a Hypercortex capable of reflecting collective intelligence.

7.5.4. *New perspectives in computer science and the human sciences*

The project of building the Hypercortex implies a significant shift in research and teaching in computer science as it is practiced in the early 21st Century. Since the late 1950s, artificial intelligence (AI) has always been considered the most "advanced" perspective in computer science. The contemporary undertaking of the Web of data can be considered the extension of the AI project to the new environment of the Web. I think research and teaching in AI, which is still indispensable, should be included within the broader perspective of augmented intelligence (collective and reflexive intelligence), of which the Hypercortex is now emblematic.

It will likely be in the human sciences that the most radical questions will be raised. Research and teaching in these fields will sooner or later have to draw conclusions from the following three facts: (i) an enormous mass of data on society and culture is increasingly available ubiquitously in the digital medium; (ii) accessible calculating power is constantly growing; and (iii) with IEML, we now have a theoretical tool that enables us to exploit the growth in online data and calculating power to methodically observe the object of the human sciences, symbolic and social cognition. The Hypercortex should be seen as a project for a great observatory for the humanities and social sciences, comparable to the cyclotron for physicists or the conquest of space for space agencies. Adoption of this new instrument will significantly increase the potential of the "sciences of the mind" while solving the huge problems of knowledge management they face today as a result of their disciplinary and theoretical fragmentation.

7.6. Overview: toward a reflexive collective intelligence

The overview in Figure 7.7 corresponds to the central "vanishing point" in Figure 7.4 and to the "head" in Figure 7.6. I will use it in the rest of this volume as a conceptual map in order to situate the themes of the chapters. The map illustrates the reciprocal dynamics of information between the actual collective intelligence that determines the effective human development of a community (cortical cognition, at the top in the diagram) and the scientific image of this actual intelligence as reflected in the Hypercortex (at the bottom). The symmetrical reflexivity between cortical and hypercortical cognition is organized by creative conversations.

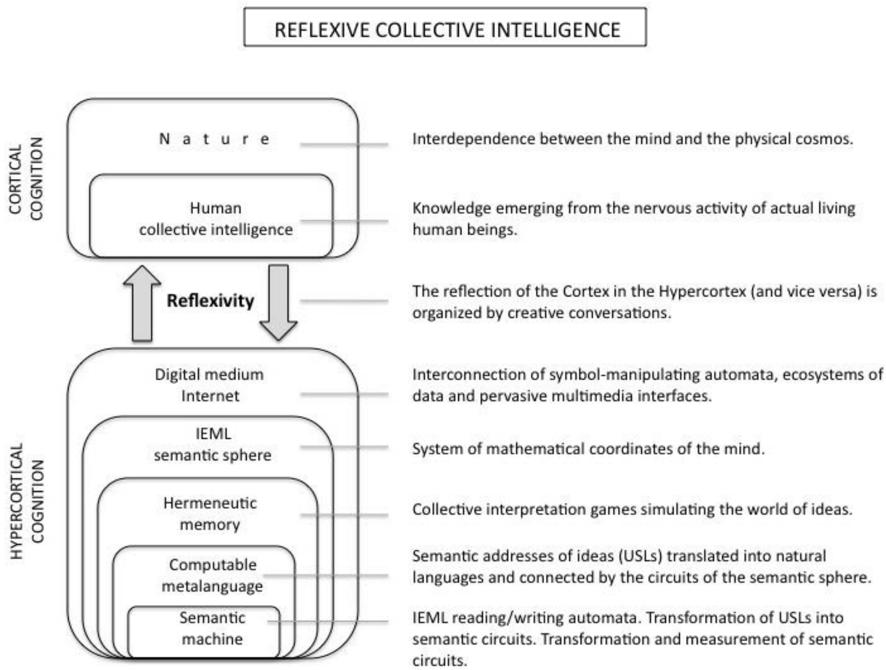

Figure 7.7. *Overview*

The Hypercortex can be considered an instrument for the scientific observation of collective human intelligence, which belongs to the nature represented in Figure 7.1 and reflects that nature in its own way. The aim of the entire IEML undertaking is to create the conditions for the scientific observation of collective human intelligence. Why? Because only scientific knowledge of this collective intelligence can lead to its systematic, rational augmentation and thus, ultimately, to the acceleration of human development. With respect to the humanist credentials of such a research program, it should be clear that the observation of collective intelligence can only be reflexive observation – i.e. self-observation – guiding the autonomous development of the communities concerned.

With respect to the scientific credentials of the research program based on IEML, the knowledge obtained by hypercortical observation is hypothetical, transparent and calculable. It is hypothetical since it is based on freely chosen interpretation functions, the effects of which can be explored at will and can be challenged at any point. It is transparent since the data on which it is based are public and the functions using these data are explicit and interoperable. Finally, this knowledge is hypothetically calculable, since it is based on a system of coordinates – the semantic sphere – especially designed to simulate human symbolic cognition automatically.

The digital medium, with its flows of data, its distributed calculating power and its ubiquitous multimedia interfaces, provides our observation instrument with its fundamental technical support. The semantic sphere is contained in the digital medium. As we saw above, the formal or mechanical nucleus of the semantic sphere, the IEML semantic machine, calculates its generation, transformations and measurement. The metalinguistic dimension of the semantic sphere makes it a universal system of semantic coordinates, capable of addressing and interconnecting concepts expressed in natural languages. The metalanguage can thus serve as a common semantic grid for a hermeneutic memory in which creative conversations freely drive and maintain their ecosystems of ideas through collective interpretation games. It is precisely these ecosystems of ideas that represent the collective intelligence of creative conversations.

The flight of the Hypercortex is headed toward the vanishing point of a collective human intelligence that is increasingly conscious of itself and its interdependent links with nature.

Chapter 8

The Computer Science Perspective: Toward a Reflexive Intelligence

8.1. Augmented collective intelligence

On the conceptual map of the subjects discussed in Part 2, Figure 8.1 examines the technical envelope of the Hypercortex (the digital medium, the Internet). From my point of view, the question that needs to be answered is the following: how can computers optimally contribute to the reflexivity of collective intelligence?

This chapter poses the question of the best possible use of the automated manipulation of symbols, in particular for computer engineers. I will point out the limitations of the models of cognition provided by classical artificial intelligence (AI) and contrast them with the research program in augmented collective intelligence, the cutting edge of which is the construction of the Hypercortex.

With respect to the means for automating cognitive operations, I do not question the usefulness or effectiveness of exploring decision trees, automated reasoning or statistical and probability calculation. I believe that the potential of these techniques could be increased, however, if they were used within the framework of a system of semantic coordinates, such as the IEML semantic sphere, which makes it possible to represent an unlimited variety of cognitive processes by calculable functions within a single transformation group. The use of IEML for encoding meaning would permit the automated manipulation of semantic qualities and relationships in a much more refined fashion than the automated reasoning techniques in use today allow.

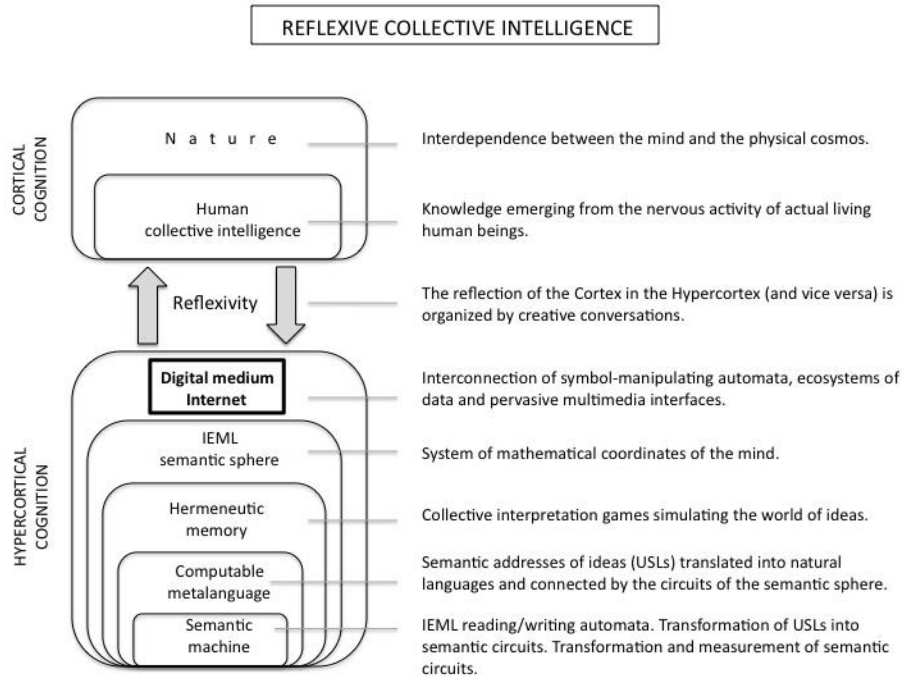

Figure 8.1. *Position of Chapter 8 on the conceptual map*

With respect to the purpose of automatically manipulating symbols, I feel, like Douglas Engelbart, that augmenting human intelligence is more important than replacing it. I also feel, like Seymour Papert, that helping individuals and communities to increase their knowledge of their own mental operations is still the best way to enhance their cognitive potential, and thus that the priority should be to augment the reflexive dimension of intelligence. Finally – unlike certain extremist currents in AI involving the "global brain" and "singularity"[1] – I do not believe that a conscious reflection of collective intelligence could exist outside the actual consciousnesses of living human individuals. The Hypercortex will not function as an autonomous subject conscious of itself, but as a mirror of processes of collective intelligence whose images will only be perceived by people.

1 See [KUR 2006].

8.1.1. *A new field of research*

One of the main hypotheses of the research program presented in this book is that the level of human development of a community and the cognitive power of the creative conversations that drive it are interdependent[2]. Since digital technologies offer us increasingly effective means for augmenting our individual and collective cognitive processes, it has become essential for us to understand precisely through which technical and cultural factors this augmentation could occur. The augmentation of collective intelligence through digital networks is clearly a new area of scientific research[3], as shown by the abundant literature on knowledge management (KM)[4] and the interest in social computing and the social media seen in many sectors of the economy and society[5].

After remaining in the shadows until the early 1980s, the perspective of augmented collective intelligence has proven its value since the appearance of personal computing and the Internet. Its main pioneers are Paul Otlet (in the 1930s)[6], Vannevar Bush (beginning in the 1940s)[7], Joseph Licklider[8] and Ted Nelson (in the 1960s)[9], who had, each in his own way, foreseen and theorized the availability of all information online in the form of hypertext and hypermedia networks.

Douglas Engelbart may be considered the main founder of this new area of research around augmented cognition. He was one of the first to understand the

2 On the theme of human development, see section 5.1.

3 See Brigitte Juanals and Jean-Max Noyer (eds.), *Technologies de l'Information et Intelligences Collectives* [JUA 2010]; Epaminonda Kapetanios, "On the notion of collective intelligence: opportunity or challenge?" [KAP 2009]; Nguyen Ngoc Thanh *et al.*, *Computational Collective Intelligence, Semantic Web, Social Networks and Multi-Agent Systems: First International Conference* [NGU 2009] (the latter is concerned more with the collective intelligence of software).

4 See works already cited by Nonaka, Wenger, Dalkir and Morey *et al.*: [DAL 2005, MOR 2000, NON 1995, WEN 1998].

5 I am speaking here of an intrinsic interest in the subject, since it presents a great many economic, social and cultural opportunities (e.g. Rheingold, Weinberger, Tapscott, Pascu, Shirky and Li [LI 2008, PAS 2008, RHE 2002, SHI 2008, SHI 2010, TAP 2007, WEI 2007]). There is also a "reactive" interest that comes from the threat that the new forms of communication pose for the economic models and institutional structures suited to the old forms of communication.

6 See section 4.3.2 and works already cited [OTL 1934, OTL 1936].

7 See the famous article "As we may think" [BUS 1945].

8 Joseph Licklider was one of the first to foresee the development of electronic mail and virtual communities. See "Man–computer symbiosis" [LIC 1960].

9 See *Literary Machines* [NEL 1980].

importance computers would have in increasing the creative capacities of individuals and groups[10]. In the 1960s, digital calculators were still huge, extremely costly machines stored in refrigerated rooms, with scientists in white coats feeding them data on piles of punch cards. Almost no one imagined that computers would become communication tools. At that time, however, Douglas Engelbart was working to develop collaborative devices using digital technology and the interfaces (mouse, windows, icons, hypertext) that would become popular in the mid-1980s and practically universal in the early 21st Century. At a conference on philosophy and computing where this pioneer was a special guest, I had the privilege of discussing augmented collective intelligence with him. He confirmed that, to him, collective intelligence was a program of scientific and technical research, but added that this did not necessarily imply wholesale approval of all views of collective intelligence. If collective intelligence is understood in this way as a program of research, its opposite is not collective stupidity, but actually AI.

Historically, the aim of AI from the second half of the 20th Century was to *simulate*, or even surpass, *individual* cognitive performance by means of an information-processing automaton. In contrast, the research program on augmented collective intelligence initiated by Douglas Engelbart and a few others aimed to *increase* the cognitive performance of individuals and *groups* by means of a *communication environment* filled with information-processing automata. The research on AI did indeed lead to interesting theoretical advances in the cognitive sciences and numerous useful technical innovations. In fact, what is now called AI covers most of the technical advances in computer science, such as pattern recognition, automated problem-solving, automated reasoning – including probabilistic reasoning – machine learning and natural-language processing[11].

The technical, cultural and social evolution of the past 30 years – personal computing for everyone, the Internet, the Web, social media and "augmented reality" through wireless devices and mobile access to the digital medium – has massively confirmed the relevance of the program on augmented collective intelligence. Although AI technologies function perfectly and are used almost everywhere, we do not primarily call on computers to think for us or imitate our intelligence, but rather to augment our capacities for communication, collaboration, multimedia creation and navigation in fictional worlds.

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10 See his pioneering work *Augmenting Human Intellect* [ENG 1962] and the historical book by Thierry Bardini on Engelbart's work, *Bootstrapping, Coevolution, and the Origins of Personal Computing* [BAR 2000].

11 See Stuart Russell and Peter Norvig, *Artificial Intelligence, A Modern Approach* [RUS 2010]. Peter Norvig was director of research at Google in 2010.

8.1.2. *A direction for cultural evolution in the long term*

The visions and laboratory work of the pioneers from the 1930s to the 1960s only began to become a social reality with the invention of the personal computer at the end of the 1970s and the success of intuitive "look and feel" interfaces in the mid-1980s (Apple's Macintosh dates from 1984). In this way computers became tools of communication and multimedia creation for everyone, whereas until the 1970s they were just arithmetic and logical calculators reserved for scientists, statisticians and managers of big companies.

Thanks to the invention of URLs[12], HTTP[13] and HTML language[14] (based on SGML[15]), Tim Berners-Lee brought the communication possibilities opened up by the interconnection of computers to the general public[16]. In standardizing addresses, the exchange of hypertext links and the description of Web pages, these "linguistic" inventions led to the explosion of social use of the Internet starting in the mid-1990s.

The invention and development of the Web should be seen as part of a long-term techno-cultural trend, and there is no indication that this trend will not continue and even accelerate in the centuries to come. I will cite only three important authors. Henry Jenkins, one of the best analysts of contemporary popular culture, proved in *Convergence Culture* (2006)[17] that collective intelligence, and participatory culture, were the main directions in which contemporary digital communication was evolving. Tim O'Reilly, publisher, conference organizer, great agitator of the high-tech world in the United States and inventor of the term *Web 2.0*, explicitly relates the whole issue of innovation in digital communication to the concepts of collective intelligence and collective mind. Finally, the influential Clay Shirky has clearly shown in his last two books *Here Comes Everybody* and *Cognitive Surplus* that the decrease in transaction and communication costs brought about by the Internet is enhancing our capacity for collaborative creation[18]. As the title *Cognitive Surplus* suggests, we need to think about the digital medium in terms of cognitive augmentation.

If I had to define the direction of research on augmented collective intelligence in a few words, I would characterize it as the development of new universal

12 Uniform Resource Locator.

13 HyperText Transfer Protocol.

14 HyperText Markup Language.

15 Standard Generalized Markup Language, the main inventor of which was Charles Goldfarb.

16 See Tim Berners-Lee, *Weaving the Web* [BER 1999].

17 See *Convergence Culture: Where Old and New Media Collide* [JEN 2006].

18 See [SHI 2008, SHI 2010].

symbolic instruments designed to exploit the calculating power and dynamic, interconnected nature of the new writing media. Icons, hypertext links, windows, spatial/visual tracking devices, standards for document communication and description are some of these new symbolic instruments. This research program is an extension, in the new digital communication environment, of the process of increasing the power of human language that began with the invention of writing (3000 BCE) and continued with the creation of the alphabet (1000 BCE), the widespread use of printing (1450) and the electrical media (19th and 20th centuries). The semiotic tools of today – languages, intermedia symbolic systems and software – are increasingly closely intertwined with individual and collective cognitive mechanisms, multiplying and transforming the human capacity to create meaning.

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The purpose of this chapter is to trace a clear, reasoned direction for research on augmented collective intelligence at the beginning of the 21st Century. The research program proposed here is based on achievements that are already available (interactive multimedia and augmented reality environments, web of data, AI and ubiquitous computing[19]) and points unequivocally to the new symbolic territories to be conquered: the Hypercortex, containing an information economy coordinated by the IEML semantic sphere. I will often point to certain limitations of AI. I have no criticism of AI as a body of knowledge, techniques and methods. On the contrary, I feel we will have increasing need for the resources provided by this leading discipline of computer sciences, and to me it seems impossible to create a Hypercortex reflecting collective human intelligence without relying massively on the resources of AI. However, I question the philosophy of AI with respect to the ultimate purpose of the automated manipulation of symbols (to create intelligent, even conscious, machines) or with respect to the exclusivity of certain technical means of modeling cognition (exploration of graphs, automated reasoning, statistical and probability calculation).

8.2. The purpose of automatic manipulation of symbols: cognitive modeling and self-knowledge

8.2.1. *Substitution or augmentation?*

Popular fantasies and science fiction films often feature machines that have gained their autonomy and attempt to dominate humans. Similarly, in the 20th Century, journalists loved to report chess battles between grandmasters and computers – especially when the machine won. This type of story struck a chord

19 Also known as pervasive computing.

with the public: “computers have become more powerful than man”. While it is true that the human species is increasingly dependent on the machines it manufactures and uses, it is absurd, however, to seriously imagine any kind of independence of machines with respect to humans.

Do we say that “man has been surpassed by machines” when a car, a train or an airplane travels faster than a human on foot? No, because it is clear to everyone that the human is being transported by the machine rather than surpassed by it. The same is true at another level for the automated manipulation of symbols. In mechanizing certain cognitive operations, calculating automata “transport” human intelligence in a faster and more powerful system for managing information, communication and thought.

Even if the program that beats a grandmaster at chess uses some of the heuristic shortcuts of human players, it mostly owes its effectiveness to its brute calculating power. It explicitly simulates the consequences of millions of possible moves, one by one, which, admittedly, no human player can do, but which does not really correspond to our intuitive concept of intelligence.

Starting from a detailed analysis of several examples, I showed in my 1992 book, *De la Programmation Considérée comme un des Beaux-arts*[20], that expert systems – or knowledge-based systems – function more as media for distributing expertise, modifying the cognitive ecology of the environments in which they are implemented, than as AIs purely and simply replacing experts. In one of the four examples analyzed, I myself played the role of cognitive engineer, helping some experts to formalize their empirical knowledge in the form of machine-executable rules. I observed that the process of knowledge engineering I was carrying out with the experts allowed them for the first time to explicitly envisage their own decision-making process and finally to perfect their methods. For the users, the system functioned as a checklist, a support for practical learning and a decision-making aid in complex cases. All this had nothing to do with some omniscient machine replacing the human. In short, although in the late 1980s people were still talking about AI to designate knowledge-based systems, actual practice was tending instead toward augmented intelligence. My approach is confirmed by the fact that knowledge-based systems are today generally regarded more as tools for KM or decision-making aids than as AI programs.

In short, for the research program on augmented intelligence, the main purpose of the automation of symbolic processing is not to obtain machines that “think for us”, but rather machines that increase our individual and social power in information processing, communication and reflection. The IEML-based Hypercortex we are

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20 See [LÉV 1992b].

discussing with regard to the future development of augmented intelligence is thus not a rival of the Cortex. On the contrary, cortical intelligence is augmented along the autopoietic loop[21] that reflects it in the Hypercortex. As for the Hypercortex, it has absolutely no autonomy and no meaning outside this Cortex–Hypercortex loop controlled by creative conversations (see Figures 7.4, 7.6 and 7.7).

8.2.2. *Modeling of separate or connected intelligences?*

The two research programs – augmented intelligence and AI – claim to model human cognitive processes. Since its beginnings in the mid-1950s, AI has proposed to simulate *separate* individual intelligences. The augmented intelligence of the early 21st Century, on the other hand, because it is willing to be informed by the traditions of the arts, humanities and social sciences, knows that there is no point in trying to model human symbolic cognition without including the conventional and collective dimension of symbolic systems.

As I demonstrated in Chapter 3, human symbolic cognition is essentially – and not just accidentally – cultural. Symbolic systems only exist at the social level, so any modeling of human intelligence that aims for a minimum of completeness and coherence must tackle collective intelligence. To clarify: individuals are obviously intellectual actors and it would be absurd to absolutely disallow modeling of their cognitive processes. Individual intelligence cannot, however, draw its coherence from itself[22]. It deals with signs that belong to conventional symbolic systems and thus only exist fully at the collective level: languages, disciplines, rituals, etc. It is ultimately meaningful only in social interaction and on a cultural horizon. From the point of view of its modeling activity, augmented intelligence therefore does not consider individuals as autonomous, separate intellectual centers, but rather as agents who are coordinated within one or more collective intelligences. This obviously does not prevent augmented intelligence from working for the benefit of its individual users, for example, to perfect their personal KM and to augment the reflexivity of their intelligence.

We must not simply contrast individual intelligence and collective intelligence. Instead the modeling of a centralized, separate individual intelligence must be contrasted with the consideration of individual intelligences that are very real but

21 Autopoietic means “self-producing”.

22 Let us recall in passing that for the great Russian psychologist Lev Vygotsky (see his major work *Thought and Language* [VYG 1986]), thought that develops within the individual is, from a genetic point of view, an internalization of dialog. I already alluded to it in section 3.6. Clinical psychology and the various schools of psychoanalysis take the internalization of social relationships even further.

whose activity only becomes meaningful in interdependence with the thinking societies and shared symbolic systems that must be the main targets of the modeling. It is precisely the role of the IEML semantic sphere to serve as this background of interdependence against which any process of symbolic cognition stands out.

The classic AI program is a closed system. It can be represented by a database to which rules of inference are applied. It should be remembered that this approach was stabilized from the 1960s to 1980s, a time when the Web did not yet exist and social computing was only envisaged by a few pioneers. Updated in the context of the Web by the ontologies of the web of data, the traditional method of AI consists of organizing automated reasoning (controlled by logical rules) using fact bases. The existing fact or data bases are, however, fragmented in their conceptual organization and the many available ontologies (sets of logical rules describing the conceptual structure of a field) are often incompatible. It is also somewhat worrying that the most advanced features of the web of data[23] in 2011 (ontologies formulated in OWL) are ultimately only adaptations of rule-based systems from the 1980s. It should also be noted that the web of data project – which is the heir of classical AI in this respect – does not explicitly aim to provide a reflexive scientific model of collective human intelligence. Is it not because of its philosophical roots in classical AI that the web of data is stymied by the multitude of incompatible ontologies and has been unable to achieve the same success as the “Web of pages”?

Thus, although our ultimate goal is certainly the same (to augment collective human intelligence), my vision differs from that of Tim Berners-Lee (the contemporary leader of the web of data project) on the fundamental point of addressing in the digital medium. Tim Berners-Lee feels that URLs are the ultimate addressing system of the digital medium (RDF being the standard for constructing graphs from URLs) and that URLs must be semantically opaque because of the way they are constructed. He does not believe it is possible to construct a system of semantic coordinates of the mind, addressing concepts transparently. I feel, on the contrary, that while URLs are indispensable for addressing data, we need a system for addressing metadata, a system that is transparent to semantic calculation – USLs – to create a real reflexive model of collective intelligence[24].

I am here proposing a research and development strategy distinct from that of AI. It involves, first, modeling the processes of symbolic cognition using a universal

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23 What is known as the web of data, linked data or the semantic Web covers a set of standards (RDF (Resource Description Framework) and OWL (Ontology Web Language) in particular) and methods, which I will not go into here. To learn more, see [BER 1999, FEI 2007, HEN 2008].

24 I wish to thank Harry Halpin, PhD, who helped me define as clearly as possible the difference between the web of data research program and that of the Hypercortex.

system of semantic coordinates[25]. Second, drawing on the tradition of augmented intelligence, the Hypercortex coordinated by the IEML semantic sphere is certainly connected to the web of data, but its approach is radically oriented toward the reflexive modeling of collective interpretation games in dialog in the open, social, conversational digital environment.

8.2.3. *Conscious machines or machines that mirror collective cognition?*

A certain extreme view of AI[26] proposes to build machines that not only behave intelligently but are actually conscious. Similarly, certain futurists feel that the global brain represented by the Internet could soon become conscious. Contrary to these trends, I am proposing a research program on augmented intelligence that aims to make real human individuals more conscious of their own individual and collective cognitive processes. This program involves using the Hypercortex to create a scientific observatory of the cognitive processes of creative conversations and a tool for dialog among these conversations. Like Nova Spivack[27], I feel that the collective intelligence of the human species could one day become conscious. Like him, I think this will only come about through suitable reflection of the functioning of the Hypercortex[28] in the consciousnesses of biologically embodied human beings, rather than through some supposed machine consciousness.

8.2.3.1. *Embodiment*

It may be useful here to recall two classic criticisms of the research program to create conscious machines put forward by Hubert Dreyfus and Joseph Weizenbaum.

The philosopher Hubert Dreyfus[29] starts from a phenomenological analysis of human consciousness. The knowledge we have of our psychological state is situated

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25 In my article "The IEML research program: from social computing to reflexive collective intelligence" [LÉV 2010a], there is a more extensive discussion of the relationship between the IEML research program and the web of data project sponsored by the WWW Consortium. I will simply point out here that, in practice, the two approaches are complementary: the ontologies can be expressed in IEML, and URLs could encode USLs. It is thus possible to develop the Hypercortex by capitalizing on all the efforts that have been made as part of the work on the web of data. I would simply like to point out here the theoretical differences between of the two approaches.

26 Represented, for example, by Ray Kurzweil; see [KUR 2006].

27 http://www.novaspivack.com/uncategorized/will-the-web-become-conscious.

28 Nova Spivack talks about a Metacortex and not a Hypercortex, but the basic idea seems to be the same.

29 Hubert Dreyfus, *What Computers Still Can't Do: A Critique of Artificial Reason* [DRE 1992].

in a physical environment (at least in the background) polarized by desires, expectations, intentions, fears, etc. This structure of human consciousness is thus rooted in corporeal animal experience, and symbolic discursivity is never absolutely separate from this primordial experience. In short, the computers cannot be conscious because they have no bodies. According to Dreyfus, the fact that computer programs can be executed independently of their material implementation confirms the disembodied nature of AI and therefore the impossibility of it ever achieving consciousness.

The criticism of Joseph Weizenbaum[30], who is himself a famous practitioner of AI, takes a completely different tack. Weizenbaum starts from Turing's definition, according to which we will have achieved true AI when a human is unable to determine whether he or she is conversing (in writing) with a machine or another human[31]. In fact, in 1966, Weizenbaum had produced an AI program (ELIZA) that generally gave users the impression of conversing with a human psychotherapist. Since this illusion was created by means of a relatively simple program, whose author acknowledged that it consisted of only a few pages of code, it became obvious to Weizenbaum that attributing consciousness or even intelligence to a machine was nothing but an anthropocentric projection. Even much more sophisticated AI software differs from ELIZA only in its degree of complexity, not its nature; attributing conscious intelligence to them would still be a form of projection.

To come back to the augmented intelligence program, the ultimate basis of the intelligence of the Hypercortex is the intelligence of the biological Cortex and, with this cortical intelligence, the activity and sensitivity of the living bodies of human beings immersed in the environment of the biosphere on which they are dependent. The only real media of reflexive consciousness are living human bodies: this is the philosophical premise of the research program on augmented intelligence. With this clearly stated thesis, this program opens up a research direction that is more useful for sustainable human development than that of the conscious machine, but also, in scientific terms, bolder and more productive.

8.2.3.2. *Know thyself*

Rather than working to create conscious machines, augmented intelligence works to equip human intelligence with a better knowledge of its own cognitive processes. Ultimately, its aim is to increase the reflexivity of human intelligence. This approach is consistent with that of Seymour Papert, a major player in AI and

30 Joseph Weizenbaum, *Computer Power and Human Reason: From Judgment To Calculation* [WEI 1976].

31 See the famous article by Turing "Computing machinery and intelligence" [TUR 1950].

one of the founders of the MIT Media Lab. In 1980, in *Mindstorms: Children, Computers, and Powerful Ideas*[32], Papert showed that controlling or programming symbol-manipulating automata could have remarkable cognitive benefits. By giving us back an explicit image of our own way of thinking in the form of the execution of programs we have designed, computers provide us with the means to improve our thinking. Papert's findings are clearly in line with the augmented intelligence research program, for which the best way to develop human cognition is to help it to know itself. In entering a reflexive, or self-referential, loop, intelligence embarks on the path to open learning. The automation of symbol manipulation is thus used to enhance individuals' autonomy and cognitive power and their creative conversations. This approach is obviously in line with one of the oldest and most universal precepts of philosophy. Is there any need for a lengthy justification of the Socratic adage to "know thyself"? This imperative is the foundation of most of the great wisdom traditions, as well as of Greek philosophy. The main difference here is that it is addressed to collective human intelligence in the new digital medium of its development.

8.2.3.3. *Reflexive consciousness and computation of meaning*

If our aim is not to create conscious machines, how should we understand the claim that the Hypercortex coordinated by the IEML semantic sphere computes meaning?[33] Once again, the goal is not to construct a machine capable of consciously understanding the meaning of linguistic utterances. The semantic sphere will coordinate automata that will increase our capacities for exchanging and manipulating linguistic utterances – utterances that we, embodied and conscious living beings, will understand.

In the project of the Hypercortex based on IEML, the very mechanical "understanding" required of the machines is thus limited to three main processes. First, automata process texts encoded in IEML. Second, they establish the correspondence, in both directions, between IEML texts and semantic circuits that are readable in natural languages by creative conversations. Third, these automata transform, travel and measure the circuits of the semantic sphere. It should be kept in mind that the set of nodes (IEML texts) and the set of circuits (connecting the IEML texts) of the semantic sphere are two transformation groups in functional correspondence. Therefore three types of manipulation can be automated in a

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32 [PAP 1980].

33 I will discuss the question of the automated calculation of meaning in the conclusion of this book, where I will answer the classic objection that meaning is not calculable because it depends on context. It is true that meaning depends on context. What marks the cognitive model of the Hypercortex is precisely that it formalizes this context at the four levels of language, utterance, enunciation and narrative.

coordinated fashion: (i) manipulation of the nodes; (ii) manipulation of the semantic circuits between the nodes; and (iii) manipulation of the automated correspondence between nodes and circuits.

By automating these calculations, the IEML Hypercortex will help creative conversations conceive relevant semantic circuits for structuring data and the appropriate collective interpretation games that will use these circuits. The Hypercortex will also assist them in navigating the flows of data channeled by the circuits and evaluated by the games. Ultimately, the Hypercortex will involve them in a process of constant improvement of their semantic circuits and their collective interpretation games.

This is therefore not a matter of giving the semantic automata an actual consciousness of the meaning of the natural languages, although their sophisticated behavior might lend itself to such an anthropocentric projection. Living individuals have already ensured that natural languages are rooted in concrete human experience. Since the meaning of utterances in natural languages is already actualized in any human consciousness, there is no need to artificially reproduce this actualization using our semantic machinery. The computation of meaning therefore designates mainly (and this is already considerable!):

– the group structure of IEML texts and semantic circuits;

– the various possibilities for calculating semantic distance based on this structure;

– the reciprocal translation between IEML and natural languages[34].

8.2.3.4. *The Hypercortex: serving reflexive intelligence*

I will now summarize the goals of contemporary augmented intelligence. At a time of quantum computing, photonics, nanorobotics, societies of agents and augmented reality, a distributed environment rich in robots and interconnected software agents is becoming the most suitable medium for distributed human cognition. In this ubiquitous computing environment, the augmented intelligence program does not aim to simulate individual intelligence, but rather to develop the reflexive powers of symbolic cognition both individually and collectively. The project of building the Hypercortex is therefore not about giving the omnipresent media environment a centralizing "AI", but rather using the new massively distributed software ecology to create and share meaning peer-to-peer in order to improve individual and collective capacities to produce, manage and appropriate

34 I am speaking here only of meaning at the level of language and utterances. For meaning at the level of enunciation and narrative in context, see the collective interpretation games described in Chapter 13 and the general conclusion in Volume 2.

knowledge. The techno-cultural basis of this plan for omnidirectional cognitive growth is the new symbolic system, IEML, designed from the outset to use the calculating and communication power of the digital medium to increase the reflexivity of collective intelligence.

8.3. The means of automatic manipulation of symbols: beyond probabilities and logic

Having discussed the goals of augmented intelligence, I now come to the technical means. The basis of my argument is as follows: the traditional arsenal of AI – exploration of graphs, automated reasoning and statistical and probability calculation – are necessary for augmented intelligence, but they are not sufficient.

8.3.1. *Exploration of graphs*

Graph theory is one of the foundations of computer science, as it is of many areas of engineering concerned with building and maintaining networks. It is also beginning to be recognized as fundamental to many other areas of research, including the human sciences, from linguistics to sociology[35]. The IEML semantic topology[36] provides a new framework that can be briefly summed up in the following four points:

– the nodes and links of the graphs of the semantic sphere have meanings, labeled in STAR- (Semantic Tool for Augmented Reasoning) IEML by USLs[37];

– there is a transformation group[38] on the USLs;

– the transformation group on the USLs leads to the existence of a transformation group on the semantic graphs labeled by the USLs;

– there is an automatable correspondence between the USLs and the semantic graphs. Not only are the nodes of the IEML semantic graphs labeled by USLs, but each distinct USL label itself corresponds to a distinct semantic graph. This means that each node and each link of the semantic sphere projects an image of its meaning

35 I dealt with this point and indicated the main authors on the subject at the beginning of section 9.4.1.

36 See Volume 2 and [LÉV 2010b].

37 Remember that the USLs are valid IEML texts or expressions and that IEML is a regular language in Chomsky’s meaning of the term.

38 The concept of a transformation group will be developed philosophically in section 9.4 and mathematically in Volume 2. See the article in Wikipedia for an introduction: http://en.wikipedia.org/wiki/Group_(mathematics).

in the graphs of the semantic sphere. The topology of the semantic sphere is self-reflexive.

It is due to this self-reflexive property that the IEML semantic sphere can be used as a system of coordinates for symbolic cognition. Within this system of coordinates, the automated paths in graphs, the automated reasoning (which attributes truth values to the nodes or determines the energy of semantic currents), like the statistical and probability calculations, then gain power and take on new meanings. My proposal is not intended to denigrate networks but, on the contrary, to increase the power of models from graph theory, using a semantic transformation group.

8.3.2. *Limitations of statistics*

In the exact sciences, Claude Shannon was the first researcher to suggest a precise, i.e. calculable, definition of information. As we will recall[39], he says that the quantity of information carried by a message depends on the improbability of the message. This definition, while it is precise and true, only concerns the *quantity* of information. Although it is perfectly valid from an engineering perspective, we all know that the relevance of information depends much more on its meaning and its value in a human context than on the improbability of its symbolic structure calculated according to purely statistical criteria. This is the first limitation of statistics. It is precisely the relevance of information that the IEML collective interpretation games are intended to explicate and make calculable[40].

The second limitation: a system of semantic coordinates cannot be based on statistics. As I will show in the next chapter on the formal properties of IEML, the system of coordinates must be an algebraic transformation group with strong internal coherence. This in no way invalidates the value of statistical calculations. On the contrary, the availability of a system of semantic coordinates will make it possible to generate statistics that are even more useful and meaningful. I am thinking, for example, of the statistics on current flows in the semantic circuits and the links between these flows and data.

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39 See the last paragraph in section 2.2.2.

40 In the collective interpretation games, ideas are represented by the triad (URL, C, USL). The URL represents the address of the data on the Web. The USL represents the address of the metadata in the IEML semantic sphere. C represents the polarized intensive value (positive or negative) of the semantic current. See Chapter 6 for a general philosophical approach, and section 7.4.7 for an overview of the CI Games. See sections 13.7 and 13.4 for a detailed technical approach.

8.3.3. *Limitations of logic*

Logic formalizes reasoning on propositions about which it does not necessarily have anything to say. The meaning and effectiveness of knowledge in human experience is not its concern. When Wittgenstein, at the end of the *Tractatus*[41], declared that "what we cannot speak about we must pass over in silence", we must hear this as an admission of an inability to express what makes human existence meaningful in scientific terms. But can science in its creative development be reduced to a series of logical propositions corresponding to "objective facts" and the application of valid reasoning to these propositions? I do not think so. It is true that logic only allows the stringing together of "tautologies", since its function of faithful transmission of truth values ("Garbage in, garbage out", as computer programmers say) does not permit any true creation. Perhaps this is one of the reasons Wittgenstein began to feel, toward the end of his career, that logic might not be all there was to language. Human symbolic cognition generates an unlimited number of language games, of which logical reasoning, though important, is only one specific case.

Austin[42] showed clearly that many of the practical functions of natural language follow rules other than those of logic: orders, promises, verdicts, etc. He assigned to pragmatics the study of these non-logical uses of language, uses in context, whose purposes are other than the faithful transmission of truth values from one proposition to another. Searle[43] pointed out that speech acts are indissociable from a meaning, and thus an intention of meaning and action that is present in all linguistic expression. Intentionality and pragmatic force go beyond the logical or even narrowly semantic dimension[44] of the use of speech; they concern the enunciation considered as an event that changes the context. This is why the collective interpretation games structured by the IEML semantic topology deal with meaning and the relevance in context of formal ideas considered as enunciations[45]. Thus the IEML Hypercortex will be able to model – beyond logic – the pragmatic acts and language games that give rise to the richness of human symbolic cognition.

Freud[46] and Jung[47] showed that the ordinary human mind carries out operations of projection, inversion, displacement, metaphorization, analogical transformation

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41 See [WIT 1921] and the penultimate note in section 3.1.3.

42 Austin was already mentioned in the last note of section 3.1.3; see his *How to Do Things With Words* [AUS 1962].

43 Searle was also mentioned in the last note of section 3.1.3; see [SEA 1969, SEA 1983].

44 If we limit semantics to the content of strictly locutionary acts (independently of their illocutionary or perlocutionary force), i.e. to the grammatical meaning of linguistic utterances.

45 On this point, see section 13.5.2.2.

46 See Freud's *The Interpretation of Dreams* [FRE 1933].

and other transmutations on a daily basis. These richly diverse non-logical cognitive operations have been cultivated and theorized for centuries by poets and shamans, long before psychologists became aware of their importance.

Augmented intelligence makes a clear choice in favor of modeling the entire range of mental operations made possible by symbolic cognition, including the metamorphosis of mental functions themselves. In doing so, it is in keeping with Marshall McLuhan's defense of a tradition of the humanities that would not be reduced to dialectics, i.e. to the refinements of logical reasoning, but that would also include the complexities of grammar and rhetoric. I should note that grammar should be understood here as meaning the literary tradition in all its diversity and that rhetoric should not be limited to figures of speech or the art of persuasion, but should include reflection on the proper use of language in society[48]. In short, intelligence as reflected and augmented by the Hypercortex will be able to model many mental operations other than those of logical reasoning.

8.3.4. *Symbolic cognition cannot be modeled without full recognition of the interdependence in which it originates*

AI was basically correct in wanting to formalize human cognition using the resources now available for the automated manipulation of symbols. In its haste, however, it neglected too many factors and ignored the legitimate rights of other disciplines.

It is likely correct that the dynamics of the circulation and processing of information can be abstracted from their material implementation and studied in themselves. This was the great discovery of cybernetics[49]. Yes, it is possible to have machines carry out certain functions formerly believed to be exclusive to plants and animals. Despite this, it seems rather presumptuous to imagine that with a few logical rules in a database we can recreate the sensory-motor, dreaming and fantasizing consciousness that arises in us from the opaque flow of physiological processes. Through mortal bodies immersed in biospheric interdependence, from layer to layer of encoding[50], reflexive consciousness is deeply rooted in the totality of nature. In terms of hardware, AI has neglected the rights of the life sciences by refusing to take into account the physical/biological embodiment of human experience.

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47 See Carl Gustav Jung, *Psychology and Alchemy* [JUN 1968].

48 On this subject, I strongly recommend Marshall McLuhan's doctoral thesis, The classical trivium: the place of thomas nashe in the learning of his time [MAC 1943].

49 On this point, see section 2.2.2.

50 On this point, see section 2.3.

In terms of software, AI imagined that it would directly model symbolic cognition using automated reasoning, exploration of decision trees and statistical and probability calculation. In doing so, it neglected the cultural and social dimensions of meaning and seemed to ignore[51] the irreplaceable contribution of the hermeneutic tradition in the human sciences. There is no thought without memory, and many layers of encoding and interpretation are needed to construct a memory worthy of the name[52]!

In recognizing the rights of physical/biological nature and of the cultural, linguistic, hermeneutic and symbolic traditions, intelligence augmented by the IEML Hypercortex acquires the means to produce computational models of symbolic cognition that are both more complex and more powerful than those of traditional AI.

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51 With a few notable exceptions; see, for example, Terry Winograd and Fernando Flores, *Understanding Computers and Cognition: A New Foundation for Design* [WIN 1987].

52 The theme of memory will be discussed in detail in Chapter 13.

Chapter 9

General Presentation of the IEML Semantic Sphere

This chapter is devoted to the general properties of the semantic sphere, which serves as a system of coordinates for the IEML model of the mind. As shown in Figure 9.1, the IEML semantic sphere is essentially made up of three concentric interdependent “layers”.

At the nucleus, an automaton, the semantic machine, generates, transforms and measures the giant hypercomplex graph of the semantic sphere.

In the layer that envelops the machine, the nodes and links of the semantic sphere become the texts (USLs) translated into natural languages from a bridge metalanguage. Each distinct USL encodes a distinct concept, and the connections between USLs indicate their semantic relationships.

In the outer layer, the semantic sphere ensures the interoperability of a global hermeneutic memory. This memory consists of a world of collective interpretation games from which an ecosystem of ideas emerges.

The general properties of the semantic sphere are related to these three layers: it is a calculable (machine) network of concepts (metalanguage) that can be used as an addressing system for ideas (hermeneutic memory). This is why, before describing the semantic sphere further, I will discuss the ideas and concepts in the IEML model of the mind. Once I have done this, I will examine the properties of the semantic sphere: unity, calculability, symmetry, internal coherence and inexhaustible complexity.

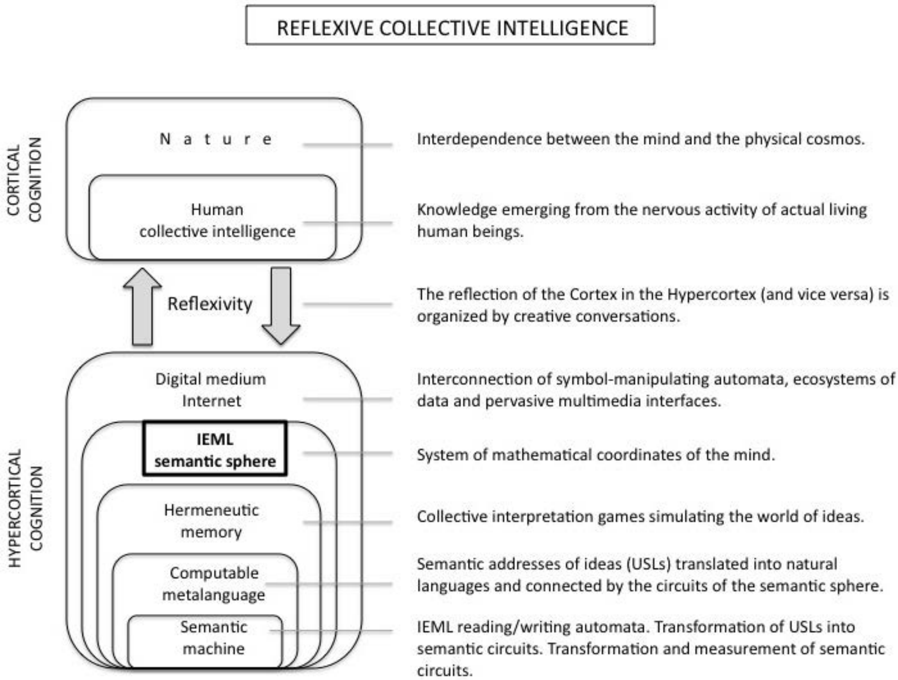

Figure 9.1. *Position of Chapter 9 on the conceptual map*

9.1. Ideas

9.1.1. *Internal structure*

Symbolic cognition is in an interdependent relationship with physical reality in all kinds of ways, since mind and matter are complementary spheres – actual and virtual – of the same communication nature. This point has been amply covered in Part One of this book and reviewed at the beginning of Part Two. Here I am concerned with the content specific to the mind. Let us consider symbolic cognition and ask ourselves what it contains. It is clear that it does not contain material objects or waves of energy, since all that belongs to physical nature. In the IEML model, the fundamental content of the mind consists of ideas. As illustrated in Figure 9.2, an idea is necessarily made up of a concept S (a general category), a percept T (a complex sensory-motor image) and an affect B (an energy of attraction or repulsion). Let us now examine these three components.

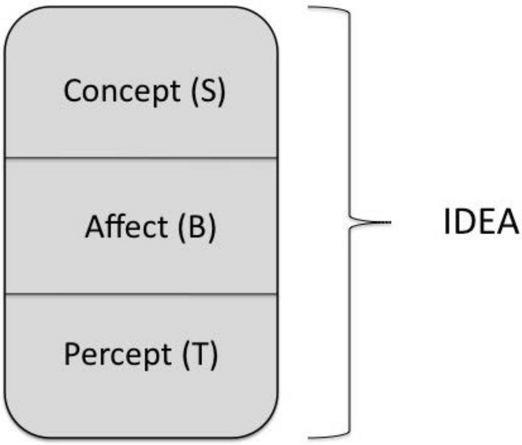

Figure 9.2. *Conjunction of a concept, an affect and a percept in an idea*

9.1.1.1. *Percepts*

As our daily experience shows, the mind contains images. These images may be visual, auditory, olfactory, tactile, gustatory or proprioceptive (felt by the body). Most often, sensory images combine these different types of sensory data. To avoid confusion with purely visual images, these multimodal sensory patterns are called *percepts* here. Percepts are associated with the "thing" (T) pole of ideas.

In the IEML model, percepts are represented by URLs, i.e. multimedia and multimodal data of all kinds found on the Web. From the point of view of the requirement of calculability of our model, the production and automated transformation of sensory or "multimedia" images present no basic problems. Methods for the automated synthesis of images, sounds and haptic data (measurement of pressure, force feedback) have been available for decades. These methods have been implemented on a large scale in scientific research and the design, illustration, music, entertainment and gaming industries. Countless Internet users (individuals, groups and institutions) produce, transform and connect the multimedia data that flood the digital medium. In addition, the means of physically addressing these data is universal and well established: URLs. While URLs are semantically opaque[1], their relationships are processed well using statistical methods (as Google does) or logical methods inherited from traditional artificial intelligence (as the web of data does).

1 See [BER 1996].

9.1.1.2. *Affects*

In addition to sensory-motor images, the mind also contains emotions or affects. These affects distribute their polarities (positive, negative or neutral) and intensities to concepts and percepts. Emotions may be conscious or unconscious, simple and raw or subtle and nuanced.

With respect to the modeling of affects or the symbolic energy of ideas, I played with specific functions of distribution and calculation of the intensity of a current in networks of ideas for a long time before deciding that a general framework of modeling did not need to establish these functions. It was sufficient that the affective dimension or the "value" of ideas be represented by a semantic current describable with two numbers. One of the two numbers represents (a) the intensity of the current and the other number represents (b) its quality or its polarity on a negative–positive scale. From there, all kinds of functions can be imagined, tested and adjusted to specific goals. Since the numbers are obviously calculable, the functional modeling of affects in the IEML semantic sphere is ensured.

9.1.1.3. *Concepts*

After percepts and affects, the mind contains concepts, since it uses language and explicitly manipulates abstract classes or categories.

The capacity exists to provide a functional, calculable description of affects and percepts in the digital medium. The biggest modeling problem I had to solve was that of the production and functional transformation of concepts. The solution to this problem has been outlined in section 7.4.5. I will return to it in more detail in Chapter 11, after discussing the specifically linguistic dimension of IEML[2].

9.1.1.4. *Internal unity*

Concepts, percepts and affects do not emerge in the mind separately from each other, but are brought together in the unity of an idea. An idea combines a concept, a percept and an affect. The simplicity and clarity of this proposition should not obscure the fact that each of the three components of an idea can be vague, dynamic (evolving), more or less conscious and, above all, complex (i.e. it can envelop a multiplicity). I should note in passing that what in everyday vocabulary is called an *emotion* corresponds in the IEML model to an idea. In fact, *emotion* in common language actually includes not only an intensity and affective polarity, but also a semantic categorization (a concept) that can be very complex, as well as physical sensations and images (a percept).

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2 A complete mathematical formalization of its production and of the production of concepts will be presented in Volume 2 of this book.

The three aspects of an idea can only be distinguished logically. In the reality of the idea, none of its components can exist without the others. The concept may be seen as the “knowledge” of the idea, a knowledge that categorizes it and situates it in a network of other categories. The affect may be considered the dynamic “will” of the idea, the force and direction (attraction or repulsion) of its tropism. Finally, the percept may be associated with the “power” of the idea. Without the sensory medium of percepts, affects and concepts would vanish.

No concept arises in the mind without emotional and sensory dimensions. Similarly, affects do not arise without sensory-motor images or concepts (as unclear as they may be). Finally, although the percept is a product of sensory-motor functions, it would have no meaning – and would even be “imperceptible” by the mind – without categorization or emotional charge. To use a physical metaphor, physical objects in movement necessarily have a spatial location, speed and mass, which can only be distinguished from each other logically. Similarly, ideas can be broken down into concept, affect and percept, although their reality and their efficacy necessarily imply the concrete interdependence of these three variables.

9.1.2. *Production of ideas*

As we have seen in the preceding chapters[3], the ideas we are concerned with here are not fixed and eternal like those of Plato, but they interact with each other through the cognitive systems that manipulate them, and evolve within ecosystems of ideas. These ideas are all the less fixed and eternal because they are indissociable from the hermeneutic functions of perception and thought that produce them.

The hermeneutic functions have been described in section 7.4.7.1. I will review them here as a reminder. As Figure 7.5 shows, ideas are made up of concepts (S: sign), affects (B: being) and percepts (T: thing) and are produced by two types of functions:

– functions of perception (A: actual) receive inputs of URLs (standing for percepts) and categorize and evaluate them to produce outputs of phenomenal ideas; and

– functions of thought (U: virtual) receive inputs of ideas and produce outputs of noumenal ideas.

I want to recall that in the IEML model, concepts are represented by USLs, percepts are represented by URLs and affects are represented by a semantic current.

3 See section 6.4, for example.

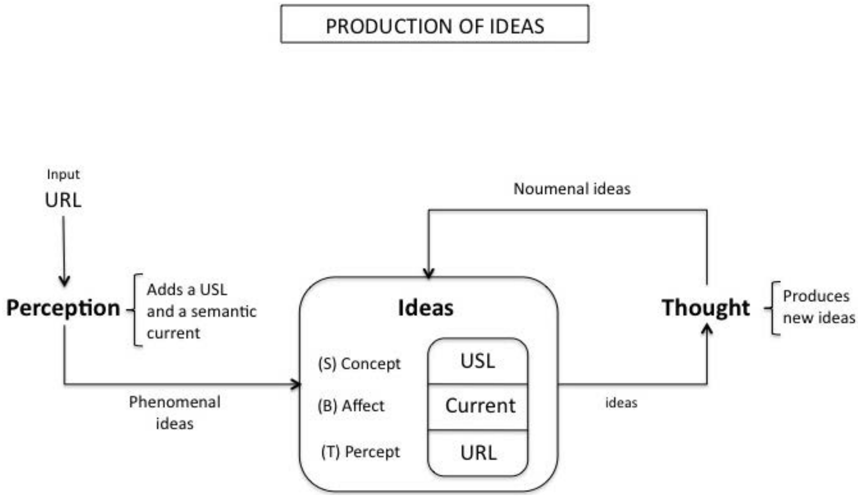

Figure 9.3. *Production of ideas*

9.1.3. *Networks of ideas*

Ideas themselves are not separate, but arise in the mind interconnected in networks of relationships. The functions of thought assemble ideas in circuits capable of conducting the affective energy modeled by the semantic current. I am making no particular hypotheses on the order, causes, reasons or nature of the relationships among ideas. They can be connected through their concepts, affects or percepts, or through any complex combination of these three types of variables.

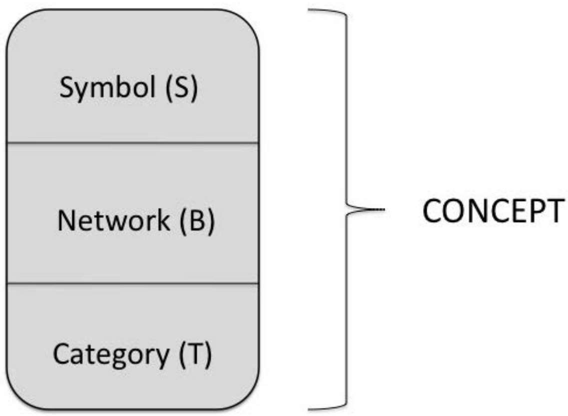

Figure 9.4. *The three components of a concept*

9.2. Concepts

Concepts can be broken down into symbols, networks and categories. It is clear, to begin with, that the mind can only manipulate concepts through symbols or signifiers. These symbols, moreover, represent abstract classes or categories. A symbol can only represent a category because a symbolic system or a language situates these categories in paradigmatic and syntagmatic networks.

9.2.1. *A concept reflects a category in a symbol*

The very existence of concepts, i.e. of explicit general categories represented by signifiers, ensures the unique nature of human symbolic cognition. Indeed it is likely that other animals have ideas, since they obviously know percepts and they categorize and evaluate their perceptions. The difference between a human idea and an animal idea is that for the human idea, the category (thing: T) is reflected in a symbol (sign: S) through a symbolic system that situates this category in a semantic network (being: B). Concepts can be considered the key to specifically human thought. As it can be considered explicitly by the mind, the self-reflecting category of the concept makes the manipulation, organization and filtering of ideas possible, not only on the basis of their affects or their percepts, but also their concepts.

9.2.2. *A concept interconnects concepts*

A concept never exists in isolation, not only because it is always integrated with an idea, but also because it is always situated in a semantic network of other concepts. On the paradigmatic axis, that of *langue*, or language, the concept is in complex relationships of inclusion, opposition, complementarity or genealogy with other concepts. For example, white is a color, it is the opposite of black and it has the same root as *whiten*. The concept of white *contains* this network of relationships. On the syntagmatic axis, that of *parole*, or speech, the concept is in grammatical relationships with other concepts. For example, *white* plays the role of modifier of the subject in the sentence “A white cloud floats in the sky”. It thus becomes an integral part of the syntagmatic network of the sentence. If the concept is itself represented by a complex expression, it *contains* the syntagmatic network of that expression. The concept thus always includes a network – or a position in a network – of semantic relationships (syntagmatic and paradigmatic).

9.2.3. *The IEML model of the concept*

As shown in Figure 9.5, in the IEML model of the concept (S) its symbol is formalized by a USL, i.e. a text in the formal IEML writing system; its network (B) is formalized by a subset of the big network of the semantic sphere; and the category it represents (T) is expressed in natural languages. The category can only be reflected in the symbol through a semantic network. The symbolic system represents the virtual dimension (U) of conceptualization, while its expression (A) represents its actual dimension. The advantage of the IEML model is that the network (both that of the semantic sphere and that of the USL) is automatically calculable based on the symbol, and the meaning of the category in natural languages is automatically calculable based on the network.

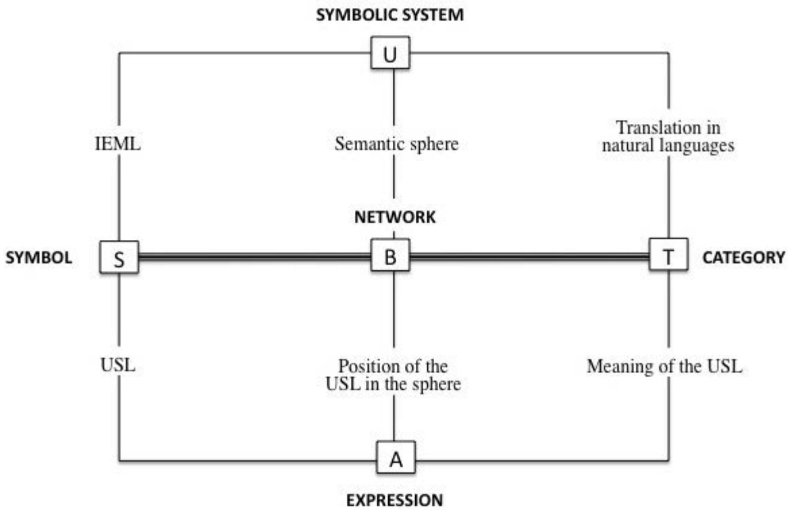

Figure 9.5. *IEML model of the concept*

9.2.4. *Addressing of ideas by concepts*

9.2.4.1. *On the relationship of ideas and concepts*

The human experience of a concept is always integrated with the experience of an idea. This means that concepts never arise in the mind separately or independently of affects and percepts.

In the material cosmos described by physical science, an object must be located somewhere in space–time (whether deterministically or probabilistically) and must have some mass or energy to exist. Similarly, to exist in the mind as described by the IEML model, a multimedia datum or a percept must occupy (probabilistically or deterministically) a semantic circuit, i.e. a subset of the semantic sphere, with some affective force.

It should be understood that a mere address in the semantic sphere – a semantic circuit – does not necessarily imply the existence of an idea. In addition to the concept that formalizes this circuit, the full existence of the idea also requires some emotional charge (formalized by a current) and sensory images or data (formalized by a URL). Some cognitive system has to have invested certain sites of the semantic sphere with percepts and affective forces for ideas to begin to develop and circulate meaning there. This is why the graph of concepts formalized by the semantic sphere is not identical to the world of ideas: rather, it represents its abstract container, or its system of coordinates, in the form of a topological grid that makes it possible to process the location of ideas in a functional and calculable way. In short, what exists in the mind is ideas. Concepts precede existence; they are virtualities of existence: places, sites or addresses in the form of circuits capable of accommodating flows of semantic current and categorizing data[4].

9.2.4.2. *Why is it the concept that addresses the idea?*

Why, in the IEML model, is it the semantic sphere that provides the nature of the mind with its basic system of coordinates? This question can be broken down into two sub-questions. First, why must the address of an idea be part of that idea and, second, why must that part be its concept and not its affect or its percept?

First, the "place" of an idea in the mind cannot be something outside the idea itself. This means that the cognitive operations that produce ideas naturally and automatically include an operation of addressing the ideas produced. It is the hermeneutic functions themselves that determine the place of the idea. In other words, the identity of the idea must imply its location, which immediately eliminates any form of container or addressing that is extrinsic, arbitrary or "material".

Second, ideas have only three aspects: their concept, their affect and their percept. The choice of concepts as the basic addresses of ideas in the mind can then be justified by a process of reasoning by elimination:

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4 Alain de Libera has examined the logical precedence of essences (which I call concepts here) over existences in the medieval philosophical tradition and the sources of this precedence in Greek philosophy. It is Avicenna (Ibn Sina) who is first credited with stressing the independence of essence in relation to existence. In the metaphysics of Avicenna, God gives beings existence by choosing from among the intellectual essences that are formal virtualities of existence and are logically anterior to existence. See *L'Art des Généralités. Théories de l'Abstraction* [DEL 1999].

– Rather than its meaning, the affect represents the energy of the idea. This energy can be formalized by two quantities: the intensity and the polarity (positive or negative) of the affect. However, the quantities are in general too limited to provide the basis for the semantic addressing of ideas.

– Nor can the system of coordinates of the mind be based on percepts, since they represent the sensory phenomena implied in symbolic cognition, and not the specifically semantic dimension of ideas. The URL that formalizes the percept provides only a physical address. Before being categorized by concepts (USLs), percepts (URLs) are semantically opaque. One of the privileges of the human mind is its freedom to creatively classify sensory data and space–time addresses. My scientific undertaking aims to extend this privilege rather than to abolish it.

– Since we cannot base the semantic addressing of ideas either on affects (quantitative) or on percepts or sensory images (opaque), all that remains is to organize the system of coordinates of the mind around the third dimension of ideas: their concepts (qualitative). Concepts (formalized by USLs) will therefore be the semantic addresses of ideas. I would like to add that, in the IEML model, each concept symbolized by a USL automatically implies a local network that is exactly situated in the global network of the semantic sphere. All local networks corresponding to USLs act as the variables of a transformation group, so the semantic sphere is the ideal candidate for the semantic addressing of ideas. Finally, the network corresponding to the USL can be used not only to address the idea but also to channel its current (the affect).

9.2.4.3. *The nature of semantic addressing*

Once again, when I say that an idea is "in" the mind, I am not talking about location as position in a tri- or quadri- or *n*-dimensional system of geometric coordinates. I mean that the concept of the idea is explicit or codified and that the code of the concept can be precisely designated as a variable of a symmetric transformation group. The IEML system of coordinates of the mind – the semantic sphere – is certainly "mathematical", but it meets conditions other than those of Euclidean geometry, its variants or its extensions. The concept is formalized as a semantic circuit in interconnection with a huge variety of other circuits within a system of coordinates woven by the semantic sphere. In the IEML model, the universal container of the mind (its fundamental place) is thus a graph made up of all possible semantic addresses of ideas, including the hypercomplex net of semantic relationships interconnecting these addresses. By formalizing the universe of concepts, the IEML semantic sphere makes it possible to precisely locate ideas and describe their relationships and the transformations of these relationships by means of calculable functions.

9.3. Unity and calculability

Having described ideas, concepts and their relationships, I can now introduce the main topic of this chapter: the general properties of the IEML semantic sphere, which is to the mind what geometric space is to matter.

9.3.1. *Functional calculability*

At the highest level of abstraction, the science of matter is based essentially on a calculable, or functional, codification of the interconnections among sensory phenomena. In the same way, a science of the mind must be based on a model that makes the calculability of the interconnections among processes of symbolic cognition possible. That is why the IEML model imposes the same requirements on knowledge of the mind as the contemporary scientific community imposes on knowledge of physical nature.

To begin with, the IEML model makes it possible to describe processes that occur in the mind using calculable mathematical functions. I adopt as my own the fundamental hypothesis of the contemporary cognitive sciences that cognitive processes must be able to be modeled by explicit mechanisms[5]. Far from being ineffable entities that are impossible to process rigorously, meaning, thought and the mind belong to nature, and it must therefore be possible to describe them scientifically using calculable methods. The requirement of calculability is self-evident. It is also justified by reasons of practicality, because it allows us to exploit the calculating power of the digital medium. There is no need to comment at length here on what has been an epistemological requirement of scientific knowledge at least since Galileo.

9.3.2. *The unity of the mind*

The originality of my approach is not based on the requirement of calculability and full explication, since this requirement is shared by the majority of researchers in the field. The uniqueness of the theoretical framework I am proposing is due to the fact that it allows us to grasp human symbolic cognition as the coherent unity of a nature. We know that, according to contemporary physics, bodies and all physical processes are interconnected (actually) in the same material nature. Likewise,

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5 On this point, see Howard Gardner, *The Mind's New Science: A History of the Cognitive Revolution* [GAR 1987], Jean-Pierre Dupuy, *On the Origins of Cognitive Science* [DUP 2005] and Margaret Boden, *Mind as Machine: A History of Cognitive Science* [BOD 2006].

according to the IEML model, all processes of symbolic cognition are interconnected (virtually) in the same nature of the mind.

Why require that the calculable functions that describe human symbolic cognition be coordinated within a common, coherent nature? The first reason is a practical one, because this type of modeling obviously favors semantic interoperability for collaborative knowledge management. But this requirement is also justified for a fundamental theoretical reason: the human symbolic faculty is unique. As the term indicates, human symbolic cognition cannot explicitly manipulate abstract classes without using some kind of language or system of symbols. In factual reality, there is no discursive thought, whether conscious or unconscious, that is not based on symbolic systems. It is, however, necessary conceptually to distinguish between the innate universal symbolic faculty[6] that is unique to humanity – the capacity to explicitly manipulate classes, general categories and abstract intellectual essences – and the expression of this faculty in specific times and places. This expression is actualized through many symbolic systems that are by definition conventional or cultural.

I would now like to consider not the many conventional symbolic systems, but the universal symbolic faculty. Since there is a symbolic faculty that is common to our species, we can assume the existence of an objective counterpart to that faculty: the set of variables that faculty produces and transforms, i.e. a universe of self-reflexive concepts capable of categorizing sensory data and emotions. I believe that we will be able to observe and study the collective human intelligence that is expressed in digital data only if we possess a mathematical formalization of this universe of concepts, including their relationships and their transformations[7]. This is precisely why I constructed the IEML semantic sphere.

9.3.3. *Requirements of calculability for a system of semantic coordinates*

In the previous section, I made a distinction between ideas (living thoughts full of emotions and sensory images) and concepts (the semantic addresses of ideas). We saw that the IEML semantic sphere – the system of coordinates of the mind – formalizes the universe of concepts as a giant semantic graph. One of the major

6 Or intellective faculty; see Book III of *On the Soul* by Aristotle [ARI 2009c].

7 The intelligible universe is a classic and very old theme of philosophy that begin with Plato. It was extensively developed by the Neoplatonist schools of antiquity, was taken up by many medieval Aristotelian philosophers, was renewed by Leibniz in the Renaissance [LEI 1704]. It was then brought back in the contemporary period by Alfred North Whitehead [WHI 1925, [WHI 1929, WHI 1933], Karl Popper [POP 1972], Edgar Morin [MOR 1977-2004], etc. For further information, see section 6.4.

technical problems I faced for years was how to produce the semantic sphere automatically – because there was obviously no question of building it by hand. If the semantic sphere was to serve as a system of coordinates for addressing the nature of symbolic cognition, it had to be huge, if not infinite. Hence the need for a machine to trace, navigate and measure it. In addition to this, one of the goals of my project was to make maximum use of the ubiquitous calculating power now available in the digital medium. One of the reasons the semantic sphere was not constructed by previous generations is the lack of automated calculating power before the 21st century. To construct this sphere, I therefore designed an abstract machine capable of fully exploiting the computational resources of the digital medium. What made it particularly difficult to design this machine for weaving the semantic sphere was the fact that the nodes and links of this net for surveying the nature of the mind were not like the points and lines of the geometry of ordinary three-dimensional space, which differ only in their positions. The vertices and edges of this gigantic semantic graph had to be qualitatively unique, distinct texts expressing distinct categories, connected by distinct relationships of meaning. I had to construct a machine that was abstract – but that could be implemented by computer programs – and that was capable of weaving the huge fractaloid hypertext network of a system of semantic coordinates and translating this network of texts into natural languages without sacrificing the deducibility, precision and algorithmic manipulability of algebra. The way I proposed to use it (to model and observe cognitive ecosystems), meant that this mathematical–linguistic "container" of the nature of the mind had to meet many requirements with regard to automation. Its circuits and the paths in its circuits had to be capable of being drawn and transformed automatically. The identification of variations by invariances, i.e. symmetries and dissymmetries on its basic grid, also had to be automated. Finally, the semantic distances and analogies between circuits also had to be able to be measured using mechanisms (i.e. programs).

I gradually discovered that the interdependent requirements of calculability I have listed converged toward the concept of a transformation group[8]. If the USLs (symbolizing concepts) and their graphs of relationships were constructed as the variables of a system of symmetric transformations, their algebraic processing and the automation of this processing became not only possible but fully satisfactory in scientific terms. Symmetry, in fact, precluded giving undue privileges to any variable: the variables of a symmetrical system are distinct but "equal" in relation to the operations that mutually transform them. That is why I arrived at a solution in which both the USLs, which are valid IEML expressions or "texts", and the circuits of the semantic sphere, whose vertices and edges are labeled by USLs translated into natural languages, are variables of symmetric transformation groups. In addition,

8 On symmetries, transformation groups and their role in the scientific process, see [BAC 2000, BUT 1991, LOC 1994, MIR 1995].

these two symmetric transformation systems, (i) the regular IEML metalanguage and (ii) the semantic sphere, are themselves in a symmetrical relationship of reciprocal transformation (see Figure 11.3). As it is deeply integrated into the basic design of the semantic sphere and the machine for tracing and surveying it, I would now like to explain the importance of this concept of the symmetric transformation group.

9.4. Symmetry

The system of conceptual addressing of ideas, i.e. the fundamental system of coordinates that is the IEML semantic sphere, is symmetrical. Just as the space containing matter is symmetrical (it is a transformation group: for example, the movements of rotation and translation are reversible), the semantic sphere containing ideas has to process all the semantic addresses formalizing concepts as interchangeable variables that can be transformed into each other symmetrically. In other words, no semantic address, no conceptual “point of view” may be favored over another; changes of address must be reversible; and these changes (formalized by algebraic operations) must be rationally constituted. This requirement responds to the general intuition that nature (whether the nature of the mind or material nature) potentially places individuals belonging to the same layer of complexity in relationships of symmetrical interconnection.

9.4.1. *Unity and symmetry*

In the course of my work, I realized that there was a profound relationship between the calculability of cognitive processes, which was one of the basic hypotheses of my research[9], and another of my basic hypotheses, that of the unity of the mind.

Let us think this through using an analogy with material nature. How is the unity of physical nature, which is one of the great discoveries of modern science[10], represented mathematically? My answer is as follows: since the Newtonian revolution (for which Copernicus, Kepler, Galileo and Descartes paved the way),

9 I want to reiterate that there is nothing original about this hypothesis. It is shared by most researchers in the cognitive sciences.

10 As opposed to the Heaven/Earth or sublunar world/celestial world fragmentation of medieval cosmology. In the finite, fragmented medieval cosmos largely inherited from Aristotle, only the celestial world could be described mathematically. Modern science unified physical nature, envisaging it as an infinite universe with no absolute center and all its parts able to be mathematically modeled. I refer once again to [KOY 1958].

everything contained in material nature has been situated or addressed, by the sciences that study it, in a single space–time continuum. This fundamental container is formalized as a system of geometric coordinates or, in contemporary physics, a system of symmetrical relationships between systems of coordinates. One of the main properties of geometric space is that it is a transformation group. Rotations, translations and mirror symmetries can be carried out on geometric figures, and these operations can be combined and reversed at will. The very structure of space is generated by these reversible and recombinable operations. It is the symmetrical properties of geometric space (the fact that it is a transformation group) that make it a *scientific* system of coordinates. If the system of space–time coordinates was not a transformation group, it would not be possible, using calculable functions, to coherently describe the trajectories of material objects, or any kind of local or temporal transformation. The transformation group ensures the "rationality" of the changes described within it. All material nature is contained in the same geometric space, whatever the number of dimensions – depending on the model – of this space. The unity of nature does not come from its being contained in the same space, as if by a bag holding a chaotic, heterogeneous multitude of things. Rather, the unity ensured by the system of geometric coordinates comes from the internal symmetry of the operations that can be carried out on its addresses. It is therefore an intrinsic unity, inherent in nature as represented by our scientific models. The system of geometric coordinates simultaneously establishes the unity and calculability of the nature it makes it possible to model. It is an abstract machine, a coherent, symmetrical structure of relationships among variables through a few recombinable operations. In a sense, geometric space is generated by this abstract machine.

There are transformation groups other than those of geometry. The operations of addition and multiplication form a transformation group on rational numbers. Another example: the operations of intersection and symmetric difference form a transformation group on the subsets of a set. In the three examples given (geometric space, numbers and subsets), there are relationships of symmetry among the variables and among the operations, and the operations can be combined, recombined and reversed at will. However, their relationships and identities are given as soon as the algebraic structure that generates them is defined. Geometric space, rational numbers and subsets of a set respectively form intrinsic units, because the operations of a group create symmetrical relationships of reciprocal generation or transformation among their variables. Group structures are so fundamental in mathematics that, despite their abstractness, they are taught in secondary school[11].

11 I learned a lot about group structures and symmetry by reading Henri Bacry, *La Symétrie dans tous ses États* [BAC 2000] and R. Mirman, *Group Theory, an Intuitive Approach* [MIR 1995].

To return to my problem: how can we scientifically represent the unity of the human mind while modeling its changing phenomena as calculable functions? As suggested above, a system of coordinates could be used to represent the unity of the mind in the form of an algebraic transformation group. With such a system, the changing phenomena of symbolic cognition can be modeled by calculable symmetric transformations on the variables of a single algebraic structure.

9.4.2. *Graph theory and the human sciences*

My emphasis on transformation groups may seem to conflict with the contemporary view that the "right" mathematical theory for modeling the cognitive sciences and human sciences is graph theory. This is not the case. As I will show, the model I am proposing combines both graph theory and group theory, because the semantic sphere is a set of graphs on which a group structure can be defined.

The idea of basing the human and social sciences – or the sciences of the mind – on graph theory, i.e. the mathematical theory of networks, is not new. It is one of the key ideas of the current in sociology that is interested in social capital[12]. It is also one of the themes developed by creative contemporary sociologists such as Manuel Castells[13], Barry Wellman[14], Bruno Latour and, with him, the actor–network school of sociology[15]. Moreover, the cognitive sciences and artificial intelligence have for a long time modeled cognitive phenomena using semantic networks and graphs in general[16]. In the same vein, Albert-Laszlo Barabasi has argued eloquently in favor of an interdisciplinary "science of networks"[17]. I am in agreement with these writers and theoretical approaches, and I fully endorse the general research program that aims to use graph theory as much as possible to study cognitive, cultural and social phenomena. The vertices – or nodes – of graphs can be used to model actors (human or non-human), and their edges – the links or connections – to model relationships among the actors. In addition, networks can be considered circuits channeling all kinds of magnitudes (information, value, prestige, etc.) according to various economic, sociological, psychological and other models. However – and this is the key point of my argument – in order for graphs to be useful in advancing knowledge, their vertices and edges must be categorized. Consequently, the human sciences have every interest in possessing a system of semantic coordinates that encodes categories or concepts so that the vertices and edges of graphs, and finally

12 See [DEG 1994, FUK 1995, LIN 2001, PUT 2000].

13 See [CAS 1996, CAS 2009].

14 See [WEL 2001, WEL 2012].

15 See [CAL 1989, LAT 1987].

16 See the works of John Sowa [SOW 1984, SOW 2000].

17 See [BAR 2002].

graphs themselves, can be processed as variables of a transformation group. This is why I am proposing the adoption of a scientific model of symbolic cognition – symbolic cognition being the common ground of the human sciences – that integrates graph theory and group theory[18].

9.4.3. *Group theory and the human sciences*

The importance of transformation groups for the scientific study of human society and the human mind has already been pointed out by major thinkers such as Jean Piaget (1896-1980)[19] and Claude Lévi-Strauss (1908-2009)[20]. Piaget showed, for example, that an "object" was an abstract cognitive construct, with the stable object emerging in the mind as the group of transformations of its appearances, i.e. as the structure that remains invariant through the variations presented by its successive aspects. Additional levels of abstraction in learning and thought are reached when different objects or areas of activity constituted as transformation groups are shown to themselves be variations of a single basic structure through morphisms that change them into one another while preserving certain of their properties. The mathematical theory that studies these transformation meta-groups – category theory – is in my view one of the areas of mathematics that has the most affinity with philosophy, epistemology and the cognitive sciences[21].

Lévi-Strauss, considered the leader of the structuralist school, devoted the major part of his work to studying operations of transformation on symbolic structures such as kinship rules, myths, rituals, aesthetic forms, social forms, etc. For example, for him a myth may be defined as all its versions in space and time. Each of the versions is only one specific variant of a single underlying structure (often a graph of relationships) and can be obtained by the transformation of another version, such as the replacement of one vertex with another or a change of the direction of a relationship. Chapter 3 of one of his most famous books, *The Savage Mind*, is in fact

18 To be complete, this model would also integrate the theory of computability and the theory of regular languages (see Volume Two).

19 See his book on structuralism [PIA 1970b]. This theme is found in most of his work on the modeling of human intelligence.

20 See *The Savage Mind* [LÉV 1966]; this is a recurring theme in all Lévi-Strauss's works.

21 On this point, see the posthumous work by Jean Piaget, with his collaborators, *Morphisms and Categories: Comparing and Transforming* [PIA 1992]. On the relationships between category theory and philosophy, see Alberto Peruzzi, "The meaning of category theory for 21st Century philosophy" [PER 2006], and for a recent application of category theory to the study and automated processing of metaphors, see Yair Neuman and Ophir Nave, "Metaphor-based meaning excavation" [NEU 2009].

entitled "Systems of transformations"[22]. At the beginning of the next chapter[23], after providing large number of examples of inversions, substitutions and transformations on the symbolic systems of various cultures, Lévi-Strauss presents the key hypothesis of his research program: "And it is groups in this sense, and not arbitrarily isolated transformations, which are the proper subject of the sciences of man". In spite of this emphasis on the concept of group, the research program of structuralism failed to fulfill the requirement I have formulated here, namely that to meet the requirements of the scientific method, the concepts or categories manipulated by human cognition should be able to be processed as variables of a universal system of calculable symmetric transformations. I contend that without this system of mathematical coordinates, without this topological net that makes the universe of concepts the fundamental place of the mind – an abstract, infinite place – it is impossible to model culture (i.e. collective human intelligence) as a scientifically knowable cosmos.

First, except in *The Elementary Structures of Kinship*[24], during the writing of which he was working with mathematician André Weil (1906-98), we do not find in Lévi-Strauss any formal definition of symbolic sets or operations on the elements of these sets. We do not find any precise mathematical characterization of the groups (are they monoids, rings, Lie groups, etc.?). The master of structuralism does talk about transformation groups on signifieds or concepts, but in spite of the number and precision of the quasi-algebraic studies he proposes in his work, the concept of the transformation group is still generally just a metaphor or a suggestive image[25].

Second, although Lévi-Strauss considers each version of a symbolic system (myth, ritual, kinship structure, etc.) as a transformation within a group, he only rarely – and allusively or ambiguously – mentions the concept of a universal

22 *The Savage Mind,* p. 75. As I have already pointed out, another great thinker in the human sciences, Jean Piaget, devoted a great deal of thought to the importance of transformation groups for the scientific modeling of the mind; see [PIA 1970b].

23 *Op. cit.*, p. 109.

24 See Lévi-Strauss, *The Elementary Structures of Kinship* [LÉV 1969].

25 This opinion is shared by Klaus Hamberger: "If the road opened up by Lévi-Strauss is to one day lead to a real science of symbolic transformations – which implies the possibility of reproducing all the results of the transformational analysis in a series of explicit, comprehensible steps – it is clear that the formal basis of such a science will be group theory. Lévi-Strauss had already indicated this orientation by using, if only for purposes of illustration, the simplest symmetric transformation group that can be imagined beyond trivial groups (of first or second order), namely the so-called Klein group of fourth order created through two transformations of period 2 (in other words, two oppositions)" [translation]. This quotation is from Klaus Hamberger, "Le continent logique. À propos de Quadratura Americana d'Emmanuel Désveaux" [HAM 2004].

semantic transformation group specific to the human species. In other words, he refuses to posit, as I do here, the existence of a coherent universe of concepts assembled by a system of calculable symmetric transformations.

We have the impression when reading his work that particular cultural areas or subsets may very well be called transformation groups, but that the hypothesis of a universal transformation group capable in principle of accommodating, translating or modeling the structures of signifieds of the whole set of symbolic systems is taboo. For example, after quoting Balzac ("Ideas are a complete system within us, resembling a natural kingdom, a sort of flora, of which the iconography will one day be outlined by some man who will perhaps be accounted a madman")[26] he declares: "But more madness than genius would be required for such an enterprise"[27]. In disregarding of his warning – although extending the path he traced – however, the transformation system on concepts modeled by the IEML semantic sphere does indeed provide an algebra (in the formal sense of the term) capable of mapping and manipulating the huge set of conceivable signifieds in a regular fashion.

9.5. Internal coherence

Like the symmetrical system of coordinates of matter, the symmetrical system of coordinates of the mind, the IEML semantic sphere, obeys a strict requirement of internal coherence that does not change with the specific characteristics of any experience. To illustrate this point: there is no "high" and "low" in the geometric system of coordinates of material nature, although all human experience attests to the importance of the distinction between high and low in daily life. Similarly, the requirement of internal coherence for the IEML semantic sphere takes precedence over all specific practical considerations. In fact, it is precisely because of the symmetry and internal coherence of the system of coordinates supplied by IEML that the scientific study of the mind is able to identify regularities and irregularities, symmetries and dissymmetries among cognitive processes.

9.5.1. *The mathematical formalization of concepts is a methodological necessity*

As the foundation of a scientifically explorable nature of the mind, I am proposing a practically infinite graph of encoded concepts that meets the requirement of symmetry of a transformation group. I am well aware – and Lévi-Strauss's words remind me – that this position will give rise to many philosophical

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26 The quotation is from Honoré de Balzac, *Louis Lambert*, translated by Clara Bell and James Waring (New York: P.F. Collier, 1900).

27 *The Savage Mind*, p. 130 [LÉV 1966].

objections. I will perhaps be suspected of excessive formalism or Platonic idealism. Some will also wonder why I do not start from empirical data on the neural, linguistic or social dimensions of symbolic cognition. With respect to Platonic idealism, I would like to point out, first of all, that my model describes a nature of the mind in which ideas are not fixed or eternal but, on the contrary, living, dynamic, evolving and interacting within cognitive ecosystems. It is only at the level of concepts, i.e. the semantic addresses of ideas, that I am proposing a system of mathematical/linguistic coordinates that serves as a fixed reference. It should also be understood that this fixed quality is quite relative because, as we will see in more detail below, the machine that weaves the semantic sphere is programmable. Second, this machine and the system of coordinates that it traces originate not from a transcendent eternity but from a formal requirement: that of making cognition describable using calculable functions within a symmetrical, coherent universe. I ask the reader to remember that this methodological approach has proven itself in the study of material nature. One of the most insightful historians of science, Alexandre Koyré[28], drew a connection between the revolution in the physical sciences in the modern period and the convergence of two currents of thought: (i) a certain "return to Plato", as indicated by the importance accorded to mathematical idealities; and (ii) the unification of an infinite cosmos, as opposed to the closed, fragmented world of medieval Aristotelianism. There is, however, a caveat! There is no question here of imitating physics, but on the contrary, of thinking scientifically – and therefore mathematically – about the inherent nature of symbolic cognition, using a system of coordinates specifically suited to this purpose, i.e. designed from the outset to capture the interconnections of meaning.

With respect to the relation of my model to empirical data (neural, linguistic, social, etc.), the system of coordinates provided by the IEML semantic sphere is explicitly presented as a useful scientific convention rather than a natural given. The role of this convention is precisely to scientifically organize empirical data, i.e. to make the best possible use of them, and not to deny them or substitute some preconceived conception for them. The objective of the system of semantic coordinates is to inscribe empirical data on symbolic cognition within a framework that makes them calculable, interoperable, comparable and meaningful. The IEML semantic sphere should as far as possible permit relevant description of empirical data. That is why this organizing grid should not only have certain mathematical properties, but should also include the main characteristics of natural languages (which we will look at in Chapter 10). We know from experience that languages are suited to the description of phenomenal data from the human perspective. This is why the IEML semantic sphere encodes concepts simultaneously as mathematical variables (belonging to a transformation group) and as metalinguistic texts (automatically translatable into natural languages).

28 See his *From the Closed World to the Infinite Universe* [KOY 1958].

I will now show that if the formal identities of concepts were extrinsically determined, either by what they represent or by the physical/biological or social mechanisms of cognition, it would be impossible to define a symmetric transformation group on the set of them, and therefore to unify the mind in a way that would permit scientifically relevant mathematical modeling. My argument is essentially as follows:

– we have seen that a system of semantic coordinates of the mind had to take the form of a system of calculable symmetric transformations;

– the only way to obtain this result is to construct an autonomous, coherent system of relationships among concepts;

– rather than adapting to some state of data or to the biological and social mechanisms that support cognition, the semantic sphere must thus determine a strict interdefinition of concepts.

For readers who have already thought about the function of systems of coordinates in scientific knowledge, this "transcendent" self-positioning of the semantic sphere will not be surprising[29].

9.5.2. *The identification code for concepts cannot be based directly on empirical data*

9.5.2.1. *Inadequacy of a neural basis*

I will first show that the system of coordinates of the mind cannot be based on neurobiological data. The nervous system, the organic medium of animal cognition, emerged from biological evolution as the producer of phenomenal forms against the ground of memory. Neural circuits implement operations of categorization on looped flows of sensory-motor data. At the level of their simplest organic inscription, these operations are implemented by neurons that process electrochemical signals: activation through thresholds, amplifications, etc. At a higher level of complexity but still in the layer of neural encoding, categorization operations emerge from the self-organized dynamics of electrochemical states in

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29 On systems of coordinates, see Peter Galison, *Einstein's Clocks, Poincaré's Maps* [GAL 2003]. On the importance of basic theoretical frameworks in scientific knowledge see Karl Popper, *Objective Knowledge: An Evolutionary Approach* [POP 1972]. It should be noted that Popper is taking up the concepts of the founders of contemporary physics, in particular Albert Einstein. On the pioneering and decisive role of theories and conceptual frameworks in the history of science, see also Thomas Kuhn, *The Structure of Scientific Revolutions* [KUH 1962].

"assemblies of neurons"[30]. These dynamics inscribe relatively stable circuits of categorization in the neural material, which are shaped by our learning. When the same words and sentences meaning the same concepts are pronounced (or even only thought) by different people, they result in the activation of neural circuits that are not only physically distinct but are also dissimilar in their formal patterns[31]. Moreover, different sentences in different languages can refer to identical concepts (I drive my car/*je conduis ma voiture*). This is why I feel that there is no functional correspondence between concepts and the dynamics of neural states that would be of practical use from a perspective of large-scale semantic encoding.

9.5.2.2. *Inadequacy of a sociotechnical basis*

In addition to their neural mechanisms, operations of categorization are also implemented in culturally determined circuits that are indissociably semiotic (networks of signs and messages), social (networks of people) and technical (physical networks). Generally, complex categorization operations can be implemented in heterogeneous networks of interconnected artifacts, institutional operations, symbolic systems, etc. This is how institutions (such as families, schools, courts and political bodies) categorize the differences they produce with regard to themselves, their members and their environment. Can the system of coordinates of the mind be based on these sociotechnical mechanisms? I do not think so, since categorization operations involving the same categories (parent, graduate, guilty, elected, etc.) can obviously be actualized by completely distinct (actual) space–time mechanisms, among which it is very difficult to establish *calculable* transformation functions. In short, the formal, or abstract, identities of our categories must be distinguished from the concrete – neural or sociocultural – mechanisms that effectively implement categorization operations in the space–time continuum.

9.5.2.3. *Inadequacy of a basis in natural languages*

Finally, a system of coordinates of the mind in the form of a calculable transformation group cannot be based on a natural language. Concepts must be distinguished from the words or sentences that refer to them in natural languages. It is clear that the same signified, or concept, can be designated by expressions from different languages (*dog*, *chien*, *kelb*, etc.). Also, there is no reason for choosing one natural language rather than another to formally encode a concept. In addition, although we obviously use natural languages to think about and communicate abstract categories, the synonyms, homonyms, ambiguities and irregularities of natural languages make it difficult to use them as tools for the scientific identification of concepts. A natural language is not a calculable transformation group on concepts.

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30 I have borrowed the term "assembly of neurons" from Jean-Pierre Changeux [CHA 1985].

31 See Terrence Deacon, *The Symbolic Species* [DEA 1997].

9.5.2.4. *Conclusion*

We want to be able to manipulate concepts automatically, transparently and symmetrically, and therefore to represent them as variables of calculable functions in a transformation group. To achieve this, we cannot base the identity, formal description or scientific encoding of concepts on (i) natural symbolic systems[32], (ii) sociotechnical mechanisms or (iii) any kind of biological circuitry. Natural languages, sociotechnical systems and neural circuits are *empirical* – thus opaque to calculation, implicit, actual – mechanisms of manipulation of *theoretical* concepts, i.e. variables transparent to calculation: explicit, virtual, formal, symmetrical, conventionally assumed. The scientific identity of concepts cannot be based directly on empirical data. But then, how can concepts be encoded in a way that is transparent to calculation?

9.5.3. *Concepts can only be distinguished through their mutual relationships*

Since concepts must be encoded as variables of calculable symmetry operations and since they cannot be distinguished from each other using empirical data – the natural signs[33] designating them or the concrete mechanisms manipulating them – I had to develop a method for distinguishing them rigorously from each other on the basis of their mutual relationships. This is why I constructed the identification codes for concepts (USLs) differentially or relationally, in a network of symmetrical relationships, and not using references to a set of phenomenal data. Since concepts are only scientifically definable through their mutual relationships, and since the parsimony principle[34] requires that the code of a concept be the same as its scientific definition, the identification code of each concept is equivalent to the node of its relationships with other concepts. It is precisely this requirement that the IEML semantic sphere meets, since it makes it possible to automatically go from a USL to a semantic circuit translated into natural languages.

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32 It goes without saying that symbolic systems are always cultural, and therefore artificial. I am using the word *natural* in the same sense as it is used in "natural language", however, a natural symbolic system as opposed to a symbolic system deliberately designed for scientific reasons and to meet scientific requirements.

33 See preceding note.

34 This principle, also known as Occam's razor from the name of the medieval philosopher and theologian who formulated it most clearly, states that theoretical entities must not be multiplied unnecessarily. This is why the code for a concept must contain everything necessary for its scientific processing, with no need to add an additional definition.

In the IEML model, a concept is thus presented *a priori* as a hypercomplex intersection of relationships with other concepts[35]. In the semantic topology of IEML, a unique circuit corresponds to each USL (to the formalization of each unique concept). This circuit connects the USL of which it is the expression to other USLs, and the interconnected expressions of USLs delineate the semantic sphere. Like Plato's ideas or Leibniz's monads[36], the concepts of the semantic sphere are mutually defining. With the IEML semantic sphere, however, we move from philosophy to science, since the strict interdefinition of concepts uses a system of calculable symmetric transformations.

Symmetry and internal coherence obviously concern only the system of coordinates for addressing ideas and the circuits that connect them. On the symmetrical ground of the system of semantic coordinates, cognitive processes draw figures ranging from the most to the least symmetrical. To make an analogy with terrestrial coordinates, the fact that the meridians and parallels trace a perfectly symmetrical grid on the sphere does not mean that the continents, rivers or paths of cyclones drawn on maps are themselves symmetrical. The cognitive functions that will be able to be automated using the fundamental grid provided by the semantic sphere will be as unique and as complex as we wish.

9.6. Inexhaustible complexity

To end this chapter, I would like to highlight the inexhaustible complexity of the functions for producing circuits among concepts. The IEML semantic sphere lends itself to the automatable tracing of a practically infinite number of distinct semantic circuits and the programming of a practically infinite number of functions describing transformations among these circuits. One of the main issues in this section is to show that although the semantic sphere is mathematically finite for purposes of theoretical calculability, it is in practice inexhaustible.

9.6.1. *The inexhaustible complexity of the mind*

I start from the hypothesis that the nature of the mind is infinite. This postulate of infinity should be considered a fundamental principle of openness, which is justified primarily by its practical conclusions. I simply wish to indicate by this that no knowledge of the mind, however scientific, comprehensive and precise it may be,

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35 If this is clear, there is obviously no reason – quite the contrary! – the nodes of the semantic sphere (representing concepts) could not be used to index phenomenal data.

36 See [LEI 1695, LEI 1704, LEI 1714a, LEI 1714b]. On Leibniz's monadology, see also Michel Serres, *Le Système de Leibniz et ses Modèles Mathématiques* [SER 1968].

will ever be complete or finished. Indeed, it is clear that scientific theories are perfectible human constructs and that our capacities of observation, measurement, memory and calculation are necessarily finite. Knowledge of the mind is in this respect, once again, exactly like the knowledge of material nature. Since all scientific knowledge of the mind depends on our theories and capacities of observation, measurement, etc., which are finite, and since the nature of the mind, by hypothesis, is infinite, it necessarily follows that scientific knowledge of the nature of the mind can only be approximate and incomplete. We can also reason as follows: since the nature of the mind is infinite, and finite human knowledge can only explore it gradually over an irreversible duration, then the sphere of symbolic cognition will always hold something unforeseen for us. Any capacity for prediction based on a finite memory of the known is structurally exceeded by a huge reserve of the unknown that will never be completely discovered. The word *infinite* has a precise meaning in mathematics and because, as we will see in this section, while the IEML semantic sphere (the system of coordinates of the mind) is huge it is not mathematically infinite in terms of calculability, I prefer to say that the IEML model of the mind permits the exploration of an inexhaustible complexity. The expression *inexhaustible complexity* suggests that missing knowledge cannot be reduced to a matter of decimal places or the best quantitative approximation: it implies the future discovery of new forms, new structures and new layers.

9.6.2. *The unlimited variety of concepts and their transformations*

My system of coordinates of the mind has to meet two apparently contradictory requirements. First, the topology of the semantic sphere has to meet the requirement of calculability. In other words, the functions of the machine that traces this semantic sphere must be able to be executed using finite algorithms in a finite time. Calculability assumes finitude. If the variables processed by my semantic machine were infinite in number, they would fall under the limit theorems of Gödel, Church and Turing[37]. That is why the semantic sphere cannot be infinite in the strict mathematical meaning of the term. In addition to this, however, the semantic sphere must meet a constraint of unlimited openness, and quite rightly so. How could a finite model represent the potential playing field of the human mind? There can be no question of in any way closing the process of creation or discovery of new concepts. I was therefore confronted with the problem of representing in a finite way a reality that is in principle infinite. To solve this problem, I adopted a model that is finite but huge, i.e. of which the order of magnitude is beyond astronomical, and is therefore equivalent to infinity on the scale of human intellectual and technical possibilities.

37 See Marvin Minsky, *Finite and Infinite Machines* [MIN 1967] and Barry Cooper, *Computability Theory* [COO 2004].

Cosmologists estimate the maximum number of particles in the material universe at 10^{80}. In his article "Computational capacity of the universe", physicist Seth Lloyd calculated that if each particle in the universe could be used as a part of a giant computer, employing the possible quantum states of the particles, that computer could only contain 10^{90} bits[38]. In comparison, the number of connections in the human brain is (only!) 10^{14}. We may nevertheless consider that the thoughts emitted by a brain correspond to configurations of connections, i.e. to a space of possibles much greater than that of the connections themselves. We can call the numbers – which are huge and, while finite, forever beyond the possibility of being written exhaustively – *cryptographic* numbers. Indeed, universes of combinatory possibilities of this type are used in cryptography to prevent codes from being deciphered by brute calculating power.

The semantic sphere generated by the IEML machinery does provide a practical approximation of infinity, since an encoded recording of all its nodes exceeds the computational possibilities of the real physical universe as calculated by Seth Lloyd by many orders of magnitude. The model provided by the semantic sphere is "bigger" than the physical universe, in the sense that it is beyond the reach of physical recording or complete writing of the list (encoded in IEML) of the vertices of its circuits. The list of distinct calculable functions capable of describing all the paths in its circuits is greater still. Indeed, let us now consider the functions that transform the semantic variables (the circuits of USLs), functions that can be compared to conceptual trajectories. Since all the circuits are already given formally by the system of coordinates, the transformations among circuits can be translated into the production of networks of circuits or the tracing of paths among those circuits. The algebraic topology of the semantic sphere permits the creation of a practically unlimited variety of calculable functions describing conceptual trajectories among semantic circuits.

In short, the cryptographic immensity of the semantic sphere is quite simply beyond the reach of the finitude of the physical cosmos. The semantic sphere provides an acceptable approximation of infinity because its total hypertext, and even more so the paths through that hypertext, will forever remain indecipherable in its entirety. At the same time, it is finite and countable mathematically, thus avoiding the limit theorems of Turing, Church and Gödel. In practice, its regular, symmetrical structure makes it available for all kinds of automatable functions. The semantic sphere is therefore indefinitely explorable by finite automata, even though its total exploration is beyond reach.

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38 Lloyd Seth "Computational capacity of the universe" [SET 2002]; see also [SET 2000].

9.6.3. *The unlimited size of concepts*

The semantic sphere is not only open in qualitative variety, since all USLs are distinct "texts"; it also accommodates as many degrees of complexity of concepts as we might want. We generally understand the terms *category* and *concept* to refer to the signified of a word or a short expression, e.g. "the equine species", "justice", "spring", "laughter", but there is no reason to limit the complexity of concepts to the signifieds of short expressions. The signified of a sentence is also a concept – a propositional concept – and can therefore be represented by a node of the semantic sphere. It should be noted that philosophers have generally focused on the referents of sentences (because the truth of the sentence depends on its referent), than on their signifieds or their meanings. The German philosopher and logician Gottlob Frege (1848-1925), whose ambition was to devise a "conceptual notation" and who is considered one of the founders of contemporary logic, distinguished between the referent (*Bedeutung*) of an expression and its meaning (*Sinn*). The classic example is "the evening star" and "the morning star": the two expressions have different meanings but the same referent (the planet Venus). The truth of a proposition is determined by its relationship to its referent: if I indeed saw Venus, it would be just as true to say that I saw the evening star[39]. However, here I am not talking about the referent, but about the meaning – the unique semantic quality – of a long linguistic expression. A paragraph, a book, an entire library, a discursive ensemble or a collection of documents can be counted as expressing "one" hypercomplex conceptual identity. It is difficult for beings whose short-term memory is as limited as ours to grasp concepts of such "size" in their unity, their internal variety and their interdependence with other concepts. Acting as an intellectual technology[40] that augments our cognitive capacities, the modeling of the mind coordinated by the IEML semantic sphere will make it possible to refine our understanding of such mega-concepts.

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As we already know, concepts are modeled by USLs, affects are modeled by semantic currents and percepts are modeled by URLs. If all the possibilities of the hermeneutic functions that assemble concepts, affects and percepts and produce networks of ideas are combined, then it is clear that the semantic sphere permits the scientific modeling of a nature of the mind with inexhaustible complexity. This is the formal translation of what in more intuitive terms could be called the unlimited

39 Gottlob Frege, *Philosophical Writings of Gottlob Frege*, edited by Peter Geach and Max Black [FRE 1952]. The original article distinguishing between meaning and denotation is from 1892.

40 On this point, see my book *Les Technologies de l'Intelligence* [LÉV 1990], as well as section 12.1, which refers to numerous sources.

openness of symbolic cognition, or the natural freedom of the mind. Understanding the mind as an open and coherent natural totality meeting the requirements of calculability, unity, location, symmetry, internal coherence[41] and inexhaustible complexity implies a profound change in our vision. It is only through such an intellectual change that we will be able to initiate a true scientific exploration of human cognition.

41 The symmetry and internal coherence of its system of coordinates.

Chapter 10

The IEML Metalanguage

Having described the main formal characteristics of the system of semantic coordinates of the mind in the preceding chapter, I will now discuss the strictly linguistic dimension of this system. Each USL, i.e. each "point" of the semantic sphere, is an IEML text that can be translated automatically into a network of concepts in natural languages. Figure 10.1 shows the place of this metalinguistic dimension in my general model of reflexive collective intelligence.

10.1. The problem of encoding concepts

In the 17th Century, the philosopher, mathematician and scientist W.G. Leibniz (1646-1716) examined the problem of the calculability of concepts understood as distinct but interdependent semantic qualities[1]. Leibniz called the system of encoding that would allow concepts to be manipulated using automata the *universal characteristic*. The system imagined by Leibniz identified primitive concepts with prime numbers, and composite concepts with multiples of those prime numbers. Since numbers are calculable, the encoding of concepts by numbers was intended to make concepts calculable. Despite this, Leibniz's universal characteristic was very unwieldy. His system had no lasting success or direct successors in its original form. We can see from the work of my illustrious predecessor that sheer calculability is

1 See the discussion of Leibniz's universal characteristic by one of the contemporary masters of knowledge representation, John F. Sowa, *Knowledge Representation: Logical, Philosophical, and Computational Foundations* [SOW 2000], pp. 6-7. See also Louis Couture, *La Logique de Leibniz d'après des Documents Inédits* [COU 1901].

not enough. It is still necessary to encode concepts so that their manipulation can be usefully automated.

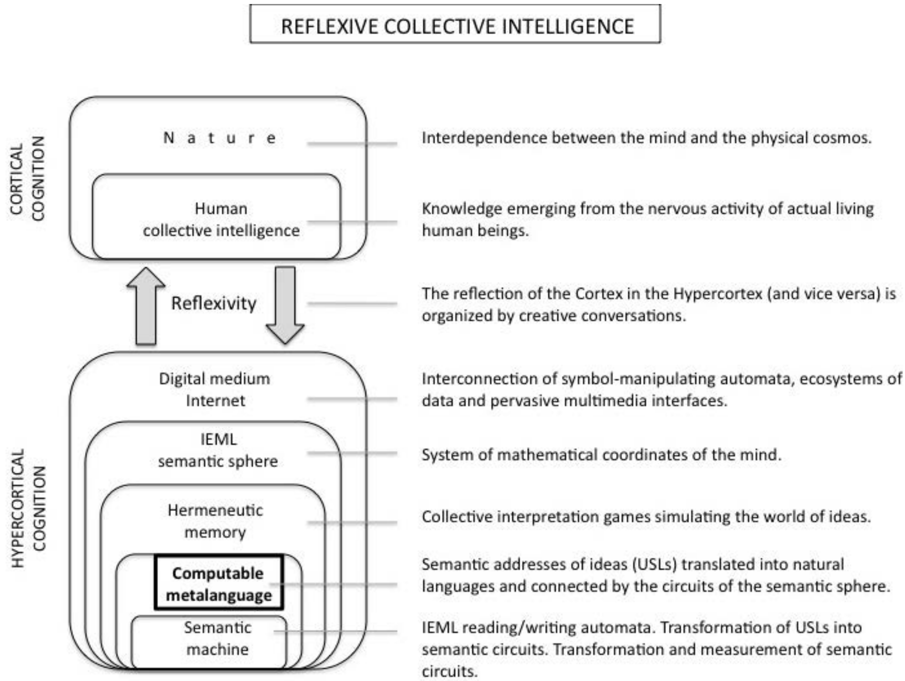

Figure 10.1. *Position of Chapter 10 on the conceptual map*

It goes without saying, first of all, that a system of notation for categories – or signifieds – will only solve the problem of calculability of concepts if its grammar is completely regular, unlike natural languages, which are full of irregularities. This is why IEML is a regular language in Chomsky's sense[2]. In addition, IEML is an ideographic system of notation, since its goal is to encode and manipulate meaning, unlike phonetic notations whose purpose is to encode sound. I note in passing that contemporary notation systems for numbers and mathematical concepts are ideographic, since they are read differently in different languages (12 is an ideogram that is read as "twelve" in English, "douze" in French, etc.). IEML also has certain features common to natural languages, in particular those that make it possible to articulate categories and utterances as freely and with as much complexity as we might wish.

2 See his *Syntactic Structures* and the article already cited [CHO 1957, CHO 1963].

I would like to elaborate on this last condition. It is a necessary condition for calculability that the IEML metalanguage for encoding concepts be a regular ideographic language. This necessary condition is not sufficient in itself. Also required is a type of encoding or notation of concepts that is compact enough, and above all isomorphic enough with the structure of natural languages, to be automatically interpretable in them. We cannot, as Leibniz did, use natural numbers (or a finite subset of natural numbers) for encoding concepts, because the structure of numbers is too different from that of languages, which are the natural tools for manipulating concepts. We know with certainty that we can calculate, not only with numbers, but with symbols in general, provided that these symbols are arranged in a regular language. To make meaning calculable, we must indeed have a regular language. Above all, however, we need a regular language designed to reflect not only the basic structure of numbers, geometric figures or logical reasoning, but also the structure of the concepts that are manipulated by natural languages and that give meaning to the numbers, figures and reasoning. We want, hypothetically, an encoding of concepts that would allow us to automate a *semantic* calculation and not only an arithmetic or logical calculation. In short, arithmetic and logical calculability is a necessary condition for semantic calculability, but it is not sufficient.

To clarify the nature of the problem, I will use an analogy with cartography. The advantage of having a system of geometric coordinates for maps is well known: it makes it possible to calculate distances and perspectives, to see at a glance the relationships between different points, etc. The advantage of having the same system of coordinates (meridians and parallels) for all maps and GPS systems is that maps (whether they focus on one aspect or another of the territory) are then superimposable and interconnectable using simple changes of scale. The calculability and universality of their system of coordinates is not the only reason for the usefulness of maps. If mountains, rivers and roads can be projected so usefully on a map with geometric coordinates, it is because there is an isomorphy between the structure of the geographic objects and that of the Euclidean geometry that is the basis of the system of geographic coordinates. Similarly, as we will see, there is an isomorphy between textual objects and semantic topology in IEML that informs the scientific cartography of those objects. Cartography (and modeling in general) implies a correspondence between the object and the map – between the phenomenon and its model – that preserves as much as possible of the relevant features of the object, in particular its transformations and relationships with objects of the same kind. That is why a calculable system of coordinates that would permit us to usefully map concepts – i.e. ultimately, the semantics of expressions in natural languages – must be able to lend itself structurally to the cognitive manipulations we carry out on texts and their meanings. To construct the semantic topology of IEML[3], I therefore adopted the following strategy: first identify the general structure of

3 See the last chapter of Volume 2 of this book and, meanwhile, [LÉV 2010b].

cognitive operations on linguistic objects, and then integrate this structure into a mechanism operating on a regular language. How do we reciprocally transform linguistic symbols in the general categories signified by these symbols? And on what universal features of the structure of languages is this transformation mechanism based? The IEML metalanguage integrates the universals of the structure of languages, which I will review in this chapter. It is precisely because IEML meets this strict linguistic requirement that the IEML semantic machine (which I will discuss in the next chapter) can automate the cognitive operations that reciprocally transform an IEML text (a USL) into its meaning.

I will first review the organization of text units in natural languages in layers, classes and roles. I will then present the two major types of semantic circuits among text units, which make it possible to express the meaning of texts: paradigmatic circuits and syntagmatic circuits. Finally, I will discuss some types of cognitive mechanisms for describing symmetric transformations between meaning (networks of categories) and text (sequences of symbols).

10.2. Text units

Linguistic objects are first presented in the form of texts[4]: meaningful sequences of symbols. Any reading or understanding of these texts implies at least three cognitive operations: first, analysis of the texts into *units* of different nested layers of complexity; second, categorization of these units in different *classes*; and, third, identification of the *roles* played by these units in the text.

The grammar of a language is a set of rules that defines explicitly what the units of the language are, distinguishes among different classes of units and describes how to correctly assemble these units by assigning semantic roles to them. It should be noted that the very concept of grammar is already the result of scientific modeling, which could only be developed on the basis of written representations of languages. The need to construct grammars was first felt by scholars in order to read and study ancient texts written in dead languages or texts that were not in the mother tongue of the readers. The grammatization of living languages has mostly developed since the widespread availability of print, mainly for political and religious reasons[5].

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4 I am using the word *text* in its most general sense: a text may be spoken, signed with gestures, etc., as well as written.

5 See Sylvain Auroux's book on the grammatization of languages, cited above, and the remarkable *Histoire des Idées Linguistiques*, which he edited [AUR 1994, AUR 1995].

10.2.1. *The layers of text units*

The organization of text units in layers, or levels of composition, is common to all languages[6].

The units at the first level are *phonemes*, the basic sounds of languages. These may vary widely from language to language: there are tonal languages, such as Chinese, and languages with non-pulmonic consonants obtained by clicking the tongue or lips, such as the Khoisan languages of southeast Africa. Generally, phonemes are divided into consonants and vowels and have no meaning in themselves.

The units at the second level are *morphemes* (root words and markers of case, gender, number, etc.). Morphemes are made up of phonemes. Unlike phonemes, morphemes have meaning. They are the first meaningful units of languages. Take, for example, the morpheme *flor*, which is the basis of words such as *flower*, *florist*, *flourish*.

Words, which are made up of morphemes, may be considered the third-level unit. For example *floret* is made up of the root *flor* and the suffix *-et*, which marks a diminutive. Words can only be perceived in writing. For a culture without writing, the distinction between word and morpheme – or between words and sentences – would have less meaning than it does for a culture where written words are separated by blank spaces.

The units at the fourth level are *sentences*, which are composed of words. In the hierarchy of levels, sentences are the first units to have a *reference* as well as a meaning. In terms of logic, sentences represent propositions. The word *flower* cannot be true or false; it can only indicate a general category. Only sentences have the capacity to be true or false, e.g. "The flower is pink", or the power to give rise to action in a context, e.g. "Go plant some flowers".

The fifth level of articulation is dialog, verse, paragraph or some other text unit made up of sentences in semantic relationships. We can continue in this way through scenes, acts and plays, or even chapters, books, and so on and so forth.

The cognitive process of interpreting texts in natural languages is based largely on the capacity to identify recursively nested text units. So we should remember that even if our regular, calculable system for encoding concepts does not include exactly the same layers as natural languages, it should at least have analogous

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6 I am generalizing here from André Martinet's double articulation theory; see his *Elements of General Linguistics* [MAR 1964].

layers. This is the case with IEML. As we will see in detail in Volume 2, in IEML the determination of the level of a text unit is based on a grammatical structure in seven layers.

10.2.2. *Classes of text units*

Another universal feature of the cognitive manipulation of texts is the capacity to distribute units of the same level among different classes. In particular, speakers of all languages are capable of distinguishing (implicitly or explicitly) between nouns and verbs at the level of morphemes or words, as well as at the level of phrases, which can be verbal or nominal. I have sometimes met extremist postmodernists who claim there are languages without verbs or without nouns, but they have never been able to cite a single example. Although the concept *word* is sometimes problematic, the fact remains that the verbal and nominal functions are universal. In all languages, verbs indicate actions ("He *gives*"), events ("It *rained*"), processes ("He *is growing*"), states or relationships between a subject and a predicate ("It *is* blue"). Nouns designate people, things, more or less abstract entities (*justice*) or qualities (*blue*). It seems that the difference between verbs and nouns has deep roots in human cognitive psychology, distinguishing between processes and entities[7]. There are, of course, other grammatical classes, such as adjectives, adverbs, pronouns, prepositions, etc. Units belonging to these other classes generally modify the meaning of nouns and verbs or else specify their relationships.

In IEML, in accordance with the universal structure of languages, there are three grammatical classes: verbs (for which the initials are U or A), nouns (for which the initials are S, B, or T) and auxiliaries (for which the initial is E). These three classes of units are distinguished only by their initial symbol and therefore can easily be recognized automatically.

10.2.3. *The roles of text units*

The same unit can play different roles. For example, in "The girl gives the boy an apple", "the girl" plays the role of subject, "an apple" plays the role of object and "the boy" plays the role of indirect object or beneficiary (dative). On the other hand, in "The boy gives the girl an apple", "the boy" is the subject and "the girl" the beneficiary. Languages use various methods to specify the grammatical roles of units, whether these units are morphemes, words or phrases. The recognition of the

7 On the cognitive foundations of grammar, see Ronald Langacker *Foundations of Cognitive Grammar* [LAN 1987].

grammatical roles played by text units is essential for understanding the meaning of a text.

Some languages use standard syntactic positions to specify the roles of their units; for example, the subject may always come before the verb, and the object after the verb. This order is purely conventional and depends on the language. Rather than use syntactic order to indicate grammatical roles, some languages use prepositions or modify words according to their role. Many languages, such as Latin, use *cases*, which are markers of grammatical roles (*rosa*, the nominative case, plays the role of subject while *rosam*, the accusative, plays the role of direct object). Finally, some languages combine the two strategies for indicating the grammatical role of units: both syntactic position and inflection. This mixed solution was chosen for IEML. Three syntactic positions, *substance*, *attribute* and *mode* (corresponding to the triplication operation that produces sequences of symbols), to which must be added auxiliaries placed in the role of mode, make it possible to automatically determine the grammatical roles of the units.

In short, in all texts in natural languages, units are characterized by their layers, their classes and their roles. Texts can only be interpreted by recognizing the units and their characteristics (classes and roles) in order to assemble them into a semantic circuit that specifies their relationships. This is exactly the same in IEML, except that the layers, classes and roles of the grammatical units can be identified automatically and their semantic circuits can be assembled just as automatically.

10.3. Circuits of meaning

10.3.1. *Langue and parole*

Since Ferdinand de Saussure, linguistics has distinguished between *langue* (language as a system) and *parole* (speech)[8]. Consideration of this now classic opposition will allow me to define two types of semantic circuits among the text units of languages: paradigmatic circuits and syntagmatic circuits.

Through its grammar, *langue* provides speakers with textual structures and markers that make it possible to break down the units, classify them and attribute roles to them. Through its lexicon, it organizes *a priori* semantic circuits among words. *Parole*, on the other hand, concerns the actualization of the textual potentialities of *langue* by speakers in concrete situations. These speakers produce utterances that are dated and situated.

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8 *Course in General Linguistics* [SAU 1959].

The grammar and vocabulary of a language are theoretically independent of specific utterances, but in reality natural languages (the precise limits of which are difficult to establish) are living, shifting, syncretic, partly chaotic systems that emerge from the acts of enunciation of their speakers. *Langue* and *parole* are in a relationship of evolving, circular co-dependence. The true creative matrix of a language is the collective intelligence of a community of speakers. Symmetrically, a language ties together and coordinates in a more or less constraining way the acts of enunciation of the community of its speakers.

Although a language imposes its constraints on a linguistic community, it is also obvious that individual speakers do not strictly obey the rules grammarians try to establish. The role of dictionary writers and lexicographers is mainly to record usage. *Langue* as an abstract structure that is fixed and clearly defined is therefore primarily an ideal type, an object constructed by the linguist's intellect or the speaker's passion.

10.3.2. *Paradigmatic circuits*

The analysis of a language involves the way it divides up the continuum of experience in its dictionary. Graphs of relationships, or structures, specific to a language are called *paradigms*[9]. Paradigms organize relationships of distinction, derivation, opposition and substitution among potential text units. Relationships of distinction can be phonological (in the case of phonemes) or semantic.

For example, the words *script*, *scripts*, *describe*, *description*, *descriptions*, *describing* belong to the set of words that have the same root, *scrib-* or *scrip-* (from the Vulgar Latin *scribere* meaning "write"). All these words are thus part of the same etymological circuit (etymology is the genealogy of words, since it implies the concepts of origin and descent). But *script* and *description* are nouns, *to describe* is a verb in the infinitive and *describing* is a present participle. The differential relationships among words derived from the same root inform the etymological circuits. The etymological circuits are paradigmatic.

A second example: "I describe, you describe, he/she/it describes, we describe, you describe, they describe" is the conjugation of the verb *to describe* in the present indicative. The conjugation itself is a paradigm: the circuit of the different forms a

9 The word *paradigm* also means "worldview" in general or "thought pattern or model in a scientific discipline" in epistemology and the history of science. The latter meaning was popularized by Thomas Kuhn in his *The Structure of Scientific Revolutions* [KUH 1962], but I am using it here in a strictly linguistic sense, as it was used by Saussure [SAU 1959] and his successors such as Louis Hjelmslev [HJE 1953, HJE 1959].

verb can take. In this example, each position on the circuit represents a different person of the verb in a given tense.

A third example: the words *red*, *green* and *blue* belong to the same class of color adjectives. “Red”, “green” and “blue” are part of a paradigmatic circuit of colors, which includes relationships of opposition (white–black), belonging (red–scarlet), mixture and transition (green = blue + yellow), etc. – a circuit in which we stop at a particular position when determining the color of something.

As a general rule, paradigms are sets of text units characterized by variations on a common semantic theme and connected by links of difference, opposition, belonging, derivation, etc. A competent speaker of a given language is capable of selecting from among those variations to compose a specific utterance. The basic idea is that the meaning of a word – independently of its enunciation – is determined by its position in a complex paradigmatic circuit made up of many types of links, i.e. by all the relationships it has with other words in the same language.

10.3.3. *Syntagmatic circuits*

In contrast with *langue*, *parole* actualizes the paradigmatic structures of a language in a given utterance that can be dated and situated and that usually has an individual author (or a collective author, but one that is addressable: a specific team, group, etc.). While *langue* concerns competence, *parole* concerns performance.

The analysis of *parole* identifies the way a particular sentence is constructed and connected in order to explicate the grammatical relationships among the words of the sentence. The relationships among the words of an utterance concern only that specific utterance. For example, the meaning that emerges from the semantic circuit between the words *thought*, *blue* and *color* in the utterance “The thought of blue has no color” belongs only to that utterance.

While *langue* is analyzed in paradigms, *parole* is analyzed in syntagms. In its temporal sequentiality, as in the linearity of writing, *parole* is a series of text units. The syntagmatic chain is constructed by the speaker or writer through choices, which are necessarily successive, in the paradigmatic structures of the language: one word rather than another, one verb tense rather than another, etc. Understanding or analyzing *parole*, however, requires us to break down the syntagmatic chain and construct a circuit among the text units of the utterance, a circuit that explicates the “deep structure” of the syntagm. For example, to understand the sentence “The girl gives the boy an apple”, “The girl” must be assigned the role of subject, “the apple” the role of direct object, etc. This distribution of roles in a syntagmatic circuit is not sufficient; each of the units must be placed in a paradigmatic circuit, in which *girl* and *boy* represent the feminine and masculine poles of gender, *apple* belongs to the paradigm of edible fruits, *gives* is the third person singular of the present indicative of the verb *to give*, *give* is the opposite of *receive*, etc.

In short, to borrow Jakobson's useful simplification[10], *langue* can be compared to a code and *parole* to a message (i.e. to a text). To understand a text, we have to analyze it into units and connect those units in two distinct circuits: (i) the syntagmatic circuit, which indicates the semantic relationships internal to the text; and (ii) the paradigmatic circuits that, through various semantic relationships, link each actual unit of the text to the virtual units that could be substituted for it. I call this operation of text interpretation *semantic inference*. As we will see in the next chapter, what distinguishes IEML is that it automates semantic inference. As it includes (a) rules for the construction of paradigmatic and syntagmatic circuits and (b) a set of circuits with predefined meanings and relationships (the dictionary), the semantic machine can transform any IEML text into a semantic circuit translated into natural language (see Figure 11.3). When it is given a text in IEML (a USL), the semantic machine breaks the text down into units, constructs the syntagmatic circuit that explicates the internal relationships of the text and traces the paradigmatic circuits linking each unit to the other units of the metalanguage, while explicating the meaning of the units and their links in natural languages. The semantic circuit corresponding to an IEML text may thus be seen as a fractaloid syntagmatic rhizome (from layer to layer), each node of which explodes in paradigmatic stars. All this will be analyzed in detail in Volume 2.

10.4. Between text and circuits

10.4.1. *What is meaning?*

According to Igor Mel'čuk, a natural language can be summed up as a set of correspondences between the meanings and the texts of the language. A language is thus a set of rules that create correspondences between a text and all possible meanings, and between a meaning and all possible texts[11]. Note that in natural

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10 See his *Essais de Linguistique Générale* [JAK 1981].

11 See Igor Mel'čuk's *Vers une Linguistique Sens-Texte*. Leçon Inaugurale au Collège de France [MEL 1997]. This lesson concludes as follows: "We have penetrated the atom and the depths of space; we have learned important things about the origins of our universe and the structure of our genes. But we have not made comparable progress in the field of information processing by the human brain. We know too little about the functioning of our reason, and yet the "reinforcement" of this organ, that is, the creation of powerful tools capable of supplementing certain essential functions of reason, is in my opinion the most urgent task of modern science. Confronting the most crucial problem of the 21st Century – the lack of

languages, a text can have many meanings and the same meaning can be expressed by many texts.

In order to understand Mel'čuk's idea, we have to answer the question "What is meaning?" as clearly as possible.

If in order to explain the meaning of a text in language A (i.e. the concept corresponding to the text), we provide a paraphrase of the text, i.e. another text in language A, or a well-structured circuit of text units of language A. The result is a definition of meaning that is rather circular, since we can always ask the question: "But what is the meaning of the texts that explain the meaning?" It seems that circularity is consubstantial with meaning in its explicit dimension. We cannot communicate or think discursively about a subjective experience of meaning without symbolizing it in one way or another.

If we translate the text in language A into a text in language B and say, "The two texts (in languages A and B) have the same meaning", we have still not isolated the meaning as a manifest entity, but have only shown that the two texts (the two signifying chains) represent the same meaning (the same circuit of signifieds, the same concept). Once again, the problem arises from the fact that the signifieds themselves (the concepts) can never be manifested directly, but only through signifiers.

The question can also be answered by saying that the meaning associated with a text is apprehended by a living human being, that it is embodied in the form of a psycho-corporal resonance by a personal vibration that is largely determined by the memory, learning and emotional and cognitive reflexes of the person who understands or perceives this meaning. But does this vibration represent the totality of the meaning or only its implicit, subjective part, the way one person embodies the meaning?

Let us recall that in the preceding chapter I postulated a universe of concepts, a coherent world of purely intellectual identities that is based only on an abstract machine for symbolic manipulation. I formulated this postulate to scientifically explain the rational faculty characteristic of the human species. We have seen that this hypothesis also allows us to avoid the insurmountable aporias that result from attempts to base a universal semantics on empirical data[12]. That is why the IEML

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natural resources on Earth for a population that is growing – we have an acute need for a *superbrain*, i.e. machines capable of thinking on a scale that humanity alone could never achieve. We need models, and good models, of human thought" [translation] It seems to me that the Hypercortex theorized in this book corresponds to this superbrain.

12 See section 9.5.

model formalizes a "virtual" face of meaning, which is transparent to calculation, explicit and theoretical, as the counterpart to its "actual" face, which is opaque, implicit or empirical. On this virtual face, the identity of a concept is a unique node of relationships among concepts – a network[13]. Let us therefore adopt a working convention whereby the meaning of a text *x* of language A is the semantic circuit *y* (the combination of the syntagmatic and paradigmatic circuits) that the structure of language A permits us to infer from text *x*[14], a circuit that could then be translated into languages B, C, D, etc.

In the case of IEML, the meaning of the USL-text will be the syntagmatic rhizome studded with the constellation of paradigmatic stars that automatically correspond to it. If a text in language A is translated (whatever the means of translation) into IEML, we would thus automatically obtain the meaning of this text in the form of a semantic circuit that is readable in all languages, a circuit transformable by calculable functions of all kinds.

10.4.2. *Correspondences between chains of signifiers and circuits of signifieds: the natural semantic machine*

A text is an arrangement of signifiers. In the case of natural languages, the arrangement is generally that of a chain (a linear sequence) of sounds or characters, but the arrangements can be more complex for other symbolic systems such as architecture, music and choreography. In the case of IEML, the basic text (the arrangement of signifiers) is the USL. A meaning, or a concept, is a circuit of signifieds that explicates the paradigmatic and syntagmatic relationships of these signifieds. The signifieds are necessarily encoded in some kind of symbolism and are therefore represented in turn by arrangements of signifiers[15]. These definitions can be generalized to most symbolic systems. Thus a symbolic system in general is a set of rules that establish a correspondence between signifying arrangements and graphs of signifieds, between texts and semantic circuits. In more teleological terms, a symbolic system is a tool for representing and manipulating semantic circuits (of meaning or concepts) by manipulating and representing chains of signifiers (text). It is possible that the basic "textuality" of symbolic cognition assumed by authors such as Derrida refers ultimately to the innate human capacity to "decode" texts, i.e. to transform them into semantic circuits[16].

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13 See section 9.2.2.

14 Actually, the same text in natural language could, because of its polysemy, lead to the construction of many semantic circuits. This definition of meaning is entirely theoretical.

15 On this point, see the analysis of the concept in section 9.2.

16 On this point, see section 3.3.

From a theoretical point of view, this implies that the basis of symbolic cognition can be represented by an abstract semantic machine, as shown in Figure 10.2, which links three machines (that are equally abstract). The first machine, which I have called the textual machine, produces and manipulates signifiers. The second, the conceptual machine, produces and transforms signifieds, or related concepts. The third, the linguistic engine, interprets the products of one in terms of the other. I would like to point out that the interpretative work of this third machine (in the middle in Figure 10.2) includes both the processes of reading (from text to meaning) and those of writing (from meaning to text).

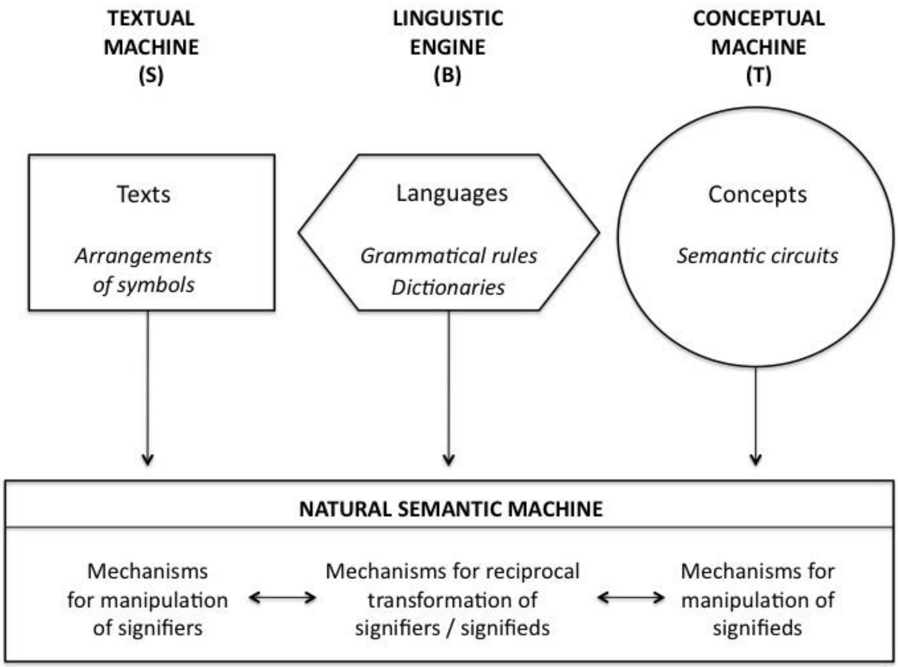

Figure 10.2. *Natural semantic computation*

Let us keep in mind that a symbol is a social convention that connects a signifier and a signified. The foundation of symbolic cognition does not so much concern the local relationship between a particular signifier and a particular signified as it does the system of relationships between textual machine (which manipulates signifiers) and conceptual machine (which manipulates signifieds), a system of relationships that is controlled by languages (see Figure 10.2). As we will see in the next chapter, the IEML model is capable of modeling symbolic cognition computationally because it activates a linguistic engine that automatically connects a textual machine and a conceptual machine. Symbolic cognition cannot be reduced to the IEML semantic machine that reciprocally transforms symbols into conceptual categories and manipulates both. It also includes the hermeneutic functions that produce and interconnect ideas. The IEML semantic machine manipulates the concepts used to classify ideas, however, so it is the necessary condition for the hermeneutic functions and for symbolic cognition as a whole.

10.4.3. *The independence of the textual and conceptual machines*

If in the sentence, “the sky is blue”, I can quite naturally replace “blue” with “gray”, it is because the signifieds “gray” and “blue” are both colors, and are also sky colors. If in the same sentence I replace “blue” with “unconstitutional”, however, the result of the substitution seems less natural, probably because the signifieds of the words “unconstitutional” and “blue” do not belong to the same domain of variations of colors of the sky. Signifieds are organized in systems of differences, or paradigms: colors, virtues, sciences, plants, prohibitions and obligations, etc. These domains of variation constitute classes, which are themselves linked through relationships (between objects and colors, between sciences and virtues, etc.) and form domains of variations of classes. Classes of signifieds are structured in complex hierarchies combined in sets and subsets. The universe of possible signifieds, or concepts, extends without predetermined limits, and the relationships that organize this semantic universe can be as subtle and interlinked as we wish. Through its capacity to structure signifieds, the conceptual machine generates a potentially infinite variety of ways of organizing the practical world and thought.

The textual machine organizes signifiers, i.e. it structures the reflexive representation of signifieds in the phenomenal world according to the rules of a certain symbolic system. In the functioning of a given cognitive system, whenever one of the two machines is activated, the symbolically complementary operation of the other is triggered. One cannot work without the other. But in most processes of natural symbolic cognition, the structures that organize the two machines are autonomous.

Thinking of symbolic encoding–decoding as a “clutch” or interface between two distinct machines is not without consequences. It expresses the inherent autonomy of conceptual operations (which organize signifieds) and textual operations (which organize signifiers). This thesis is obviously in keeping with the widely accepted idea that most systems of symbols are arbitrary, or conventional. To illustrate the autonomy of the order of the signified (or signifier, depending on the starting point chosen), let us return to the example of colors from the beginning of this section. In many natural languages, nothing in the signifier of a color category indicates a color signified. In English, color adjectives are not distinguished by any specific structure or phoneme. Color can be indicated by a noun ("I like red"), an adjective ("the red house") or a verb ("to redden"). So there is a class of signifieds that has no correspondence with any one phonetic or grammatical category, i.e. a class that cannot be distinguished by signifying (textual) criteria. The category of color terms is determined only by conceptual criteria, although it has a symbolic projection toward a set of signifying terms, or else it would be impossible to distinguish it.

The fact that the two machines are autonomous does not merely mean that another sound could be used to designate the same meaning, because in this case we are speaking only of the relationship between a signifier unit and a signified unit. As I pointed out above, it is not only the individual forms that have no natural or automatic relationship on the other side of the symbolic fold between conceptual operations and signifying phenomena, but also the classes of forms and the mechanisms of manipulation of forms[17]. This independence in principle between the determinations of a conceptual machine and a textual machine connected by an engine of linguistic inference has important practical implications.

First, it provides the basis for the possibility of translation. If complex programs of manipulation and organization of concepts could not be projected – using various functions of linguistic inference – in different mechanisms for the organization of signifiers, communication would be limited to people sharing exactly the same systems of signifiers (the same textual machines). However, notwithstanding certain extremist postmodern currents, translations, adaptations and cultural transpositions of all kinds have been carried out all over the world for millennia[18].

Second, this autonomy explains the variability of interpretations and concepts that are based on the same system of signifiers. It is well known that different, and even opposing, philosophical or political points of view can be formulated in the

17 The philosopher Gilles Deleuze put particular emphasis on the disagreements of cognitive faculties in *Difference and Repetition* [DEL 1994].

18 For an inventory of the borrowing and circulation of concepts among disciplines, see Isabelle Stengers (ed.), *Les Concepts Nomades* [STE 1987]. On the problems of translation in philosophy, see "De l'intraduisible en philosophie", *Rue Descartes*, no. 14 (1995), and more recently Barbara Cassin (ed.), *Vocabulaire Européen des Philosophies* [CAS 2004]. Like the famous paradox of Zeno of Elea on the impossibility of motion, the notion of the impossibility of translation is obviously paradoxical, since it denies in theory what is done in practice every day. It would be better to talk about the problems or risks of translation.

same culture and the same language[19]. We also know that a text can be interpreted in different ways by speakers of the same language.

Third, the respective autonomy of the conceptual and textual machines opens a space for aesthetic and poetic creativity, in which no form is necessarily required to represent a specific meaning in an arrangement of signifiers.

10.4.4. *The interdependence of textual and conceptual machines*

After declaring the *de jure* independence between the determinations of the two machines, it must be added that they are almost never, *de facto*, absolutely independent. It is because the two machines are in principle independent that translation is possible, but it is because their structures weigh – sometimes heavily – on one other that translations are difficult, problematic or provisional. The textual and conceptual machines influence each other and can even have a relationship of iconicity – in the sense that the structuring of signifiers can imitate the intellectual operations it symbolizes. The textual machine is capable of providing an analogy with the conceptual circuits it is intended to represent[20]. This is why many grammatical categories also correspond to semantic categories[21]. An obvious example, already cited above, is that verbs generally represent processes and nouns generally entities, their representations being produced by different cognitive mechanisms. Moreover, discourse functions like little plays in which each sentence iconizes the "scene" it is intended to represent. To express the same thing, we can choose words (use of passive or active verbs, use of nouns to designate processes)

19 This simple observation obviously runs counter to the Sapir-Whorf hypothesis (which, in its most simplistic form, perhaps belongs more to certain commentators on those authors than to Sapir and Whorf themselves) that natural languages absolutely determine the categories and thought processes of their speakers. See Edward Sapir, *Language: An Introduction to the Study of Speech* [SAP 1921] and Benjamin Lee Whorf, *Language, Thought, and Reality* [WHO 1956].

20 An extensive exploration of the theme of iconization of meaning can be found in my book *L'Idéographie Dynamique, vers une Imagination Artificielle* [LÉV 1991].

21 This has been clearly shown by studies in cognitive grammar and by psychologists who have studied the relationships between cognition and categorization. See George Lakoff, *Women, Fire and Dangerous Things: What Categories Reveal About the Mind* [LAK 1987], Ronald Langacker, *Foundations of Cognitive Grammar* [LAN 1987] and Lakoff and Johnson, *Metaphors We Live By* [LAK 1980].

and arrangements of words that produce different mental models[22]. Distinct intellectual perspectives on the same fact can be expressed by different texts.

Many linguistic and anthropological studies have shown that the grammar and vocabulary of natural languages correspond to unique ways of dividing up and organizing the world. In one famous study, Émile Benveniste highlighted the structural homology between the (supposedly universal) categories of Aristotle and the grammatical categories of Ancient Greek[23]. In this case, the textual machine of Greek is said to inform Aristotle's conceptual machine. Conversely, one of the great contributions of critical thought, of "deconstruction" and contemporary cultural studies has been to show how conceptual machines are reified or naturalized in textual machines.

Finally (and this is the closest interdependence between the two machines), there are deliberately constructed symbolic systems such as those of the divinatory arts, games, scientific and musical notations, economic transactions, etc., where the structuring of the signifiers is used explicitly to serve a certain organization of the signifieds. The textual forms are thus aligned as far as possible with the conceptual operations. It is probably in the development of systems of mathematical notation that this effort to align the textual machine with the conceptual machine (and vice versa) is the most striking. It is also here that it easiest to understand how much symbolic cognition can benefit from the support provided by an effective signifying organization (a textual machine). Textual and conceptual machines never cooperate so closely as in systematic ideographies, whether they are logical, mathematical, chemical, cartographic, musical or other. These ideographies organize a deterministic one-to-one correspondence between textual structures and conceptual structures. IEML is precisely in the lineage of those ideographies deliberately constructed to organize the correspondence of a textual machine with a conceptual machine. In the case of IEML, this correspondence is both deterministic and open to play, since it is programmable.

We will see in the next chapter that the functioning of the IEML semantic machine is analogous to that of the natural semantic machine. The text units it manipulates are organized in layers, classes and roles. It has mechanisms for transformations between concepts and texts, which are implemented by a linguistic engine that includes a dictionary (controlling paradigmatic networks) and rules for the grammatical interpretation of texts (controlling syntagmatic networks). Once the

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22 This point was made by Langacker [LAN 1987]. On the concept of mental model, I refer to the classic work by Philip Johnson-Laird, *Mental Models* [JOH 1983].

23 See "Categories of thought and language" [BEN 1958], reprinted in *Problems in General Linguistics*, Vol. 1, pp. 55-64 [BEN 1971]. See also the Sapir-Whorf hypothesis, mentioned above.

meaning of the IEML texts is represented in the form of paradigmatic and syntagmatic circuits, it can be transformed mechanically. The main difference between IEML and natural languages is that the transformations of its texts and its semantic circuits are automatable. As this metalanguage has the same structure as natural languages, at least one calculable metalanguage exists that is capable of encoding the universe of concepts so as to produce a model that is usable in scientific practice. At least theoretically there is now nothing preventing the realization of Leibniz’s dream.

Chapter 11

The IEML Semantic Machine

Having described the general properties of the IEML semantic sphere in Chapter 9 and the linguistic properties of IEML in Chapter 10, I will now describe the IEML semantic machine, which automatically constructs the mega-network of the semantic sphere and translates its nodes and links into natural languages. As shown in Figure 11.1, the semantic machine is the fundamental core of the IEML model of the mind. In order to clearly understand its role, it will be useful to review the different types of functions involved in modeling symbolic cognition.

11.1. Overview of the functions involved in symbolic cognition

11.1.1. *Arithmetic and logical functions*

According to the working hypothesis of the cognitive sciences, which I have fully made my own, it must be possible to model cognitive functions as arithmetic and logical functions. I will not insult readers by reminding them what arithmetic operations are. I will simply summarize the main operations of logical functions:

– Logical functions make it possible to manipulate sets of elements using union, intersection and symmetric difference operations. It is these set operations executed by logical automata that make it possible to automatically deduce, for example, that if all the elements of A possess property P and X is an element of A, therefore X possesses the property P.

– Logical functions also make it possible to correctly transfer truth between propositions. For example, if proposition X is true and proposition Z is false, then “X OR Z” is true, but “X AND Z” is false.

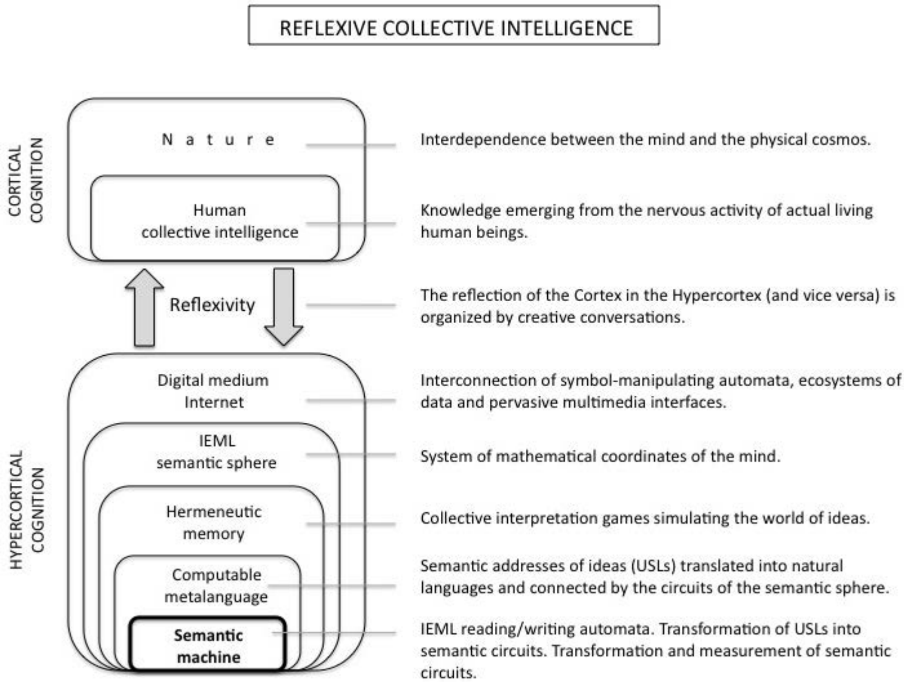

Figure 11.1. *Position of Chapter 11 on the conceptual map*

Since the mid-20th Century we have had programmable electronic automata capable of executing arithmetic and logical functions; for short, I will call them *logical automata*. They are increasingly miniaturized, distributed, interconnected and accessible in our everyday material environment.

The "great automaton" of the digital medium operates on a series of layers of encoding and protocols, the main ones of which are the following:

– *digital encoding* (0 and 1) allows logical automata to perform operations on numbers, characters, images, sounds and data in general;

– the *operating systems* of particular logical automata assign physical addresses to bits of information (0 and 1) in their local memory;

– the *Internet protocol* assigns universal physical addresses to logical automata, making it possible to operate networks or societies of automata practically independently of their geographic locations; and

– the *Web protocol* (HTTP, URLs, etc.) assigns universal physical addresses to data, which opens the way to the automatic, coordinated execution of arithmetic and logical functions on data distributed in the digital medium.

11.1.2. *Hermeneutic functions*

As we saw above, in the IEML model, ideas make up the contents of the mind, and hermeneutic functions (which categorize and evaluate percepts) are responsible for their assembly. The categorization function links a concept (formalized as a USL) and a percept (formalized as a URL), while the evaluation function determines the affect of the idea (which is formalized as a semantic current).

Now what about the calculable formalization of hermeneutic functions, i.e. their execution by logical automata? Since the affective dimension of ideas is modeled as a semantic current, whose value at a given time is indicated by an intensity and a polarity, i.e. by numbers, then it is calculable without major problems. With respect to the categorization of data by concepts, there are already all kinds of algorithms for this purpose in use today, which could be used or perfected in the Hypercortex. Categorization is therefore calculable. As for the multimedia content of URLs, it is already provided by the activity of Internet users, or produced and transformed automatically through such activity, for example, in massively multiplayer online games.

The main obstacle to the calculable modeling of the mind today lies in the absence of interoperable functions for generating and transforming concepts. The problem thus consists of formalizing the natural semantic functions represented in Figure 11.2 in a calculable way (to be executed by logical automata).

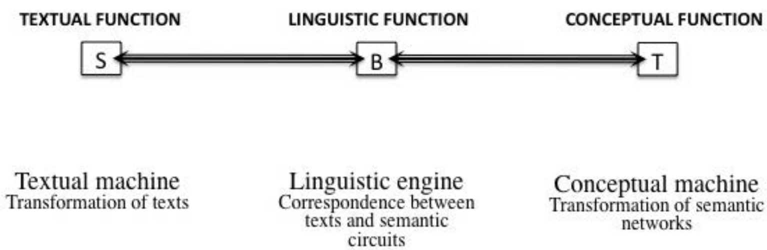

Figure 11.2. *Natural semantic functions*

11.1.3. *Natural semantic functions*

We know that logical functions infer the truth or falsehood of propositions from the truth or falsehood of other propositions. But what do semantic functions do? They produce, recognize and manipulate concepts. The following are examples of semantic operations: (i) distinguish between the subject and object of a sentence; (ii) transform a verb in the past into a verb in the future; (iii) identify differences and similarities between the meanings of two complex discourses. More generally, semantic functions process the content or meaning of propositions, while logical functions process their truth value. I will first briefly discuss (since we have already analyzed them in the previous chapter) the natural semantic functions that the IEML semantic machine formalizes. The rest of the chapter will then be devoted to the description of the IEML semantic machine itself.

First, concepts, considered as categories or signifieds, are represented by texts, which are sequences of symbols or signifiers. But concepts *are not* the texts that represent them. We have no direct access to concepts except through the symbols that stand for them. A text represents a concept – and thus can categorize a percept in an idea – only because it belongs to a symbolic system or language that makes it possible to go from the text to its meaning. A concept is something abstract (a system of relationships) that can only be manipulated through a symbolic system.

Second, we cannot think about or know the identity (the meaning, the category) of a concept independently of the relationships of this concept with other concepts. There are no isolated concepts, no concepts that have no relationships of inclusion, intersection, participation, complementarity, opposition, derivation, etc., with other concepts. Thus concepts are by definition nodes or junctions in networks of concepts. In short, a concept is a semantic circuit.

In order to manipulate concepts or semantic networks (which is the role of the conceptual function as such), we must therefore be able to manipulate the texts that represent the concepts (which is the role of the textual function) and translate these texts into semantic networks (which is the role of the linguistic function). In short, there are three distinct but interdependent semantic functions: the textual function, the linguistic function and the conceptual function. Let us examine these functions one by one with the help of the diagram in Figure 11.2.

11.1.3.1. *The textual function*

The textual function (S) produces and transforms texts according to syntactically ordered arrangements, so that the texts that result from its operations can be decoded according to the norms of a language. This corresponds to Chomsky’s universal grammar, the theory that human beings have an innate capacity to manipulate symbols according to complex syntactic rules.

11.1.3.2. *The linguistic function*

To "understand" a text, i.e. to infer a network of concepts from it, the mind must possess (consciously or unconsciously) the grammatical rules and lexicon (dictionary) of the language in which the text is formulated:

– The dictionary makes it possible to identify the lexical units and situate them in a network of semantic relationships with lexical units that do not belong to the text (but that belong to the dictionary). It is only in this way that the lexical units can "acquire meaning". The semantic network that situates the text units in a linguistic circuit external to the text is the paradigmatic network.

– The grammatical rules make it possible to link the lexical units internal to the text according to relationships such as verb–subject, noun–modifier, etc. Thus from the linearity of the text the mind constructs a network of grammatical relationships among lexical units that form sentences, and a network of relationships among sentences that form more complex propositions, and so on to the level of the text. This semantic network internal to the text is the syntagmatic network.

Typically, the linguistic function (B) starts with a text – a sequence of symbols – and arrives at a complex semantic circuit – a network of concepts – in which a paradigmatic circuit and a syntagmatic circuit are intertwined.

11.1.3.3. *The conceptual function*

The mind can in principle manipulate signifieds or categories – i.e. networks of concepts – abstractly, and thus relatively independently of the symbols through which the concepts are expressed. The fact that we are capable of recognizing that two different expressions designate the same concept is proof of this. The capacity to manipulate abstract categories, the conceptual function as such (T), corresponds broadly to the symbolic faculty at its least figurative: the capacity to reason, whether deductively, inductively, abductively, analogically, metaphorically, analytically, synthetically, etc.

11.1.3.4. *The interdependence of semantic functions*

Since the mind is capable of semantic computation, we can assume that it incorporates a natural semantic machine combining three sub-mechanisms:

– a textual machine that manipulates sequences of signifying symbols;

– a linguistic engine that transforms texts into semantic networks and vice versa;

– a conceptual machine that manipulates networks of signifieds or semantic circuits.

The distinction between the three types of mechanisms (textual machine, linguistic engine and conceptual machine) is itself a conceptual distinction: in the reality of human cognitive activity, the semantic machine gives rise simultaneously to the semantic functions, which can only function together[1]. One of the main conclusions that come out of this discussion is that it is impossible to formally represent the manipulation of concepts without at the same time formally representing the semantic machine (which combines the textual, linguistic and conceptual functions) in its entirety.

I wanted to describe the mind scientifically, so I had to construct a calculable formal model of natural semantic computation, the structure of which I have just outlined. In the reality of the nature of the mind, as evidenced by human history, the semantic machine is sufficiently general and universal to be adapted to a wide variety of different languages and symbolic systems. To model this machine, I had to choose one particular symbolic system. As I stated above, most "natural" symbolic systems have emerged in the course of cultural evolution and do not lend themselves to automatic semantic calculation. History has seen the invention of a numerical notation system that can easily be used for automatic calculation (the positional notation system with zero, of which binary notation is only one specific instance) and notation systems that permit the automation of logical reasoning (starting with Boolean algebra). In the same vein, I was obliged to invent a notation system for concepts – i.e. a symbolic system – that would make it possible to automate the operations of natural semantic computation. This was the origin of the invention of IEML.

11.2. Requirements for the construction of the IEML semantic machine

The encoding and manipulation of concepts in the IEML model of the mind meets four main requirements.

11.2.1. *Concepts must be encoded in IEML as semantic networks*

First, the nature of concepts is such that they cannot be encoded adequately as numbers or points in ordinary geometric space. It is agreed that everything that is processed by means of automatic calculations in the digital medium must somehow be represented by binary numbers. Furthermore, it is always possible to design

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1 The nature of the mind does not carry out computation that is purely syntactic, i.e. limited to the textual machine. The fact that natural cognition always encompasses conceptual (therefore semantic) computation is clearly shown by Brian Cantwell Smith in his *Age of Significance* [SMI 2010].

interfaces representing the universe of concepts in two- or three-dimensional space. I only want to point out here that concepts expressed by languages do not have the same structure as numbers or points in geometric space. That is why the IEML model represents concepts using paradigmatic and syntagmatic networks, i.e. as semantic circuits.

11.2.2. *The conceptual, textual and linguistic functions of the IEML semantic machine must be inseparable*

Second, as I pointed out above, since concepts are necessarily represented by signifiers belonging to a symbolic system, they cannot be formalized without formalizing the symbolic system they belong to and the semantic functions that manipulate all aspects of that symbolic system. In other words, in order to automatically manipulate the semantic circuits representing concepts, a semantic machine must be designed that also automatically manipulates texts and reciprocally converts texts and semantic circuits.

11.2.3. *Concepts encoded in IEML must be variables of a transformation group*

Third, one of my main goals is to describe the modifications of concepts and their relationships using coherent calculable functions, and to thus be able to identify symmetries and invariances. This is why the semantic circuits that represent concepts have to be variables of a transformation group[2]. Only a transformation group on encoded concepts permits us to attain a semantic interoperability worthy of the name. It is clear that there are already a great many algorithms that perform semantic functions, but they do it today according to *ad hoc* methods that differ depending on the language, the area of application, etc. The issue in the current discussion is the automation of semantic functions by means of a general method, using interoperable algorithms and working with a universal semantic code. Hypothetically, these interoperable semantic algorithms belong to the class of logical automata, i.e. they can be effectively implemented in the digital medium.

11.2.4. *Concepts encoded in IEML must be automatically translated into natural languages*

The fourth and last condition, which arises from a practical requirement that needs no comment, is that the addresses of the system of semantic coordinates – that

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2 See the discussion of symmetry in section 9.4.

identify and represent concepts – must automatically be translated into natural languages.

I constructed the IEML semantic machine, a diagram of which is shown in Figure 11.3, in order to have a calculable mathematical model of the natural semantic machine (see Figures 10.2 and 11.2) that would meet the four requirements stated above. We will see that this abstract machine is also consistent with the properties of the semantic sphere described in Chapter 9 and the metalinguistic properties described in Chapter 10.

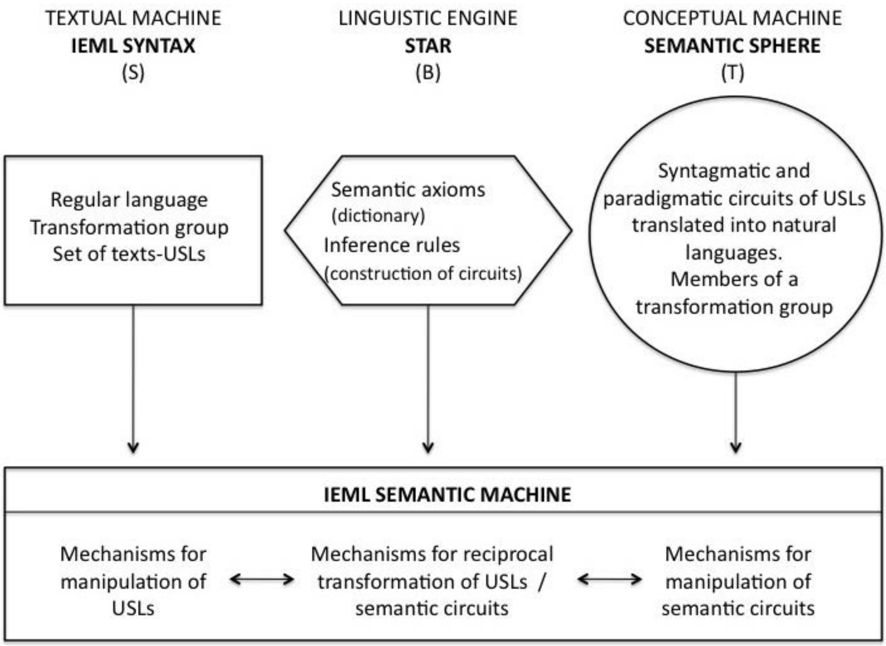

Figure 11.3. *A computable model of semantic processing based on the IEML encoding*

The goal of my undertaking was the semantic sphere, i.e. a scientific system of coordinates of the mind. I pursued this goal over many years, patiently manipulating ideograms and formalizing these manipulations mathematically or algorithmically, constantly going back and forth between empirical bricolage and theoretical formalization. I only "found" this semantic sphere by creating it, following a perilous path of constructions and deconstructions that led me to increasingly simple and powerful, and yet more complex, structures. I finally reached my goal only by modeling an abstract machine capable of automatically generating and manipulating the semantic sphere. This semantic machine can be broken down into three submachines: (i) the textual machine, (ii) the STAR linguistic engine and (iii) the conceptual machine that manipulates the semantic sphere.

As shown in Figure 11.3, the semantic machine is made up of three types of mechanisms (inside the rectangle at the bottom):

– the textual machine includes finite automata that manipulate USLs. These textual automata correspond to the traditional operators of regular languages;

– the STAR linguistic engine includes a set of finite automata that symmetrically transform USLs into semantic circuits translated into natural languages;

– the nodes and links of the semantic sphere are labeled with USLs. The conceptual machine includes finite automata that perform transformations, trace paths, measure distances and calculate similarities on the circuits of the semantic sphere.

In terms of mathematical structure:

– the set of USLs is a transformation group on which all operations on regular languages can be carried out;

– the set of circuits of the semantic sphere belongs to a transformation group on which all operations on graphs can be carried out; and

– the STAR linguistic engine is a morphism – a function – that goes symmetrically between the group of USLs and the group of circuits (there is one, and only one, semantic circuit corresponding to each USL).

11.3. The IEML textual machine (S)

11.3.1. *Introduction to the textual machine*

Let us first look at the textual machine (on the left in Figure 11.3). The textual function acts as the interface between the logical and the semantic functions. It ensures that the signifying texts that are used by the IEML semantic machine as the medium for signified concepts can be transformed by logical automata.

We know that symbolic cognition, by definition, involves the use of symbolic systems. Furthermore, a symbolic system is necessarily based on a signifying code. In order to be manipulated automatically, this signifying code has to work transparently with logical functions, which is why IEML is a regular language. It must also work with specifically semantic functions, which is why IEML is homologous to the structure of natural languages.

The textual machine, i.e. the syntax of IEML, can be compared to a system of phonology, writing or typography: it automatically produces and recognizes sets of sequences of six primitive symbols. These sequences are marked by recursive triplication: sequences of three symbols, sequences of three sequences of three symbols, sequences of three sequences of three sequences of three symbols, etc. The IEML texts (sets of sequences) are totally manipulable by finite automata because of their formal syntax, but they have no meaning prior to their linguistic interpretation.

11.3.2. *The mathematical properties of IEML*

Texts in IEML, i.e. syntactically valid expressions in IEML, are called USLs. IEML is a regular language[3], which means it is optimally suited for all kinds of automatic manipulations. IEML texts (USLs) are sets of sequences of symbols. That is why the set operations symmetric difference and intersection define a transformation group on the USLs. The key point is that IEML encoding provides the interface between arithmetic and logical computation on binary data and semantic computation on concepts and ideas.

The fundamental structure of the IEML language can be described quite simply by the following five propositions:

– All valid IEML expressions are constructed from a basic alphabet of six primitives (T, B, S, A, U and E).

– A triplication operation (concatenation of three sequences) recursively constructs seven layers (from 0 to 6) of sequences of primitives. The sequences in layer 0 contain only one symbol.

For example, T belongs to layer 0, USE to layer 1, USEABEEEE to layer 2, etc.

– Categories are sets of sequences in the same layer (i.e. of the same length).

For example {USE, ABE, EEE, TTE} is a category in layer 1.

– Catsets are sets of categories in the same layer.

For example {{USE}, {ABE, EEE}, {TTE, TBE}} is a catset in layer 1.

– USLs combine from 1 to 7 catsets from different layers.

3 In Chomsky's sense. See [CHO 1963].

For example,

{

{{T,S},{E,A},{B}}

{{USE},{ABE,EEE},{TTE,TBE}}

{{USEABEEEE,ASEABEEEE},{TSEABEEEE}}

}

is a USL containing three catsets from layers 0, 1 and 2.

From this structure certain mathematical results follow that will be demonstrated in the chapter entitled “Semantic topology”, in Volume Two. The following six points summarize the main results, which guarantee that IEML can serve as the basis for the construction of a semantic machine:

– IEML is a finite regular language, which means – I repeat – that it is suitable for transparent automatic manipulation.

– A symmetric transformation group on the “textual variables” that are the IEML expressions can be defined. Operations of union, symmetric difference and intersection can be carried out on categories in the same layer and USLs in general.

– Semantic relationships between categories or between USLs can be represented by graphs called semantic circuits.

– Operations useful for the definition of semantic relationships – and therefore for the construction of semantic circuits – are automatable.

– The set of semantic circuits (the vertices and edges of which are identified by USLs) form a transformation group.

– There are formal calculable methods for measuring the distance between two vertices of a semantic circuit (including the distance weighted by the intensity of the semantic current) and for measuring similarities between circuits (using spectral graph theory).

What is the semantic relevance of the structure of IEML and the mathematical results that follow from it? It is clear, first of all, that it is possible to automate all kinds of algebraic functions in order to manipulate both USLs (texts) and semantic circuits (which explicate the meaning of texts). Beyond that, one of the main advantages of the IEML semantic machine is the possibility of automatically transforming USLs into circuits, i.e. automatically translating IEML texts into semantic graphs expressed in natural languages.

11.4. The STAR (Semantic Tool for Augmented Reasoning) linguistic engine (B)

11.4.1. *Introduction to the linguistic function*

Let us now look at the linguistic engine (in the center in Figure 11.3). The linguistic interpretation of IEML texts (USLs) is ensured by the grammatical rules and dictionary of the STAR linguistic engine. It has been demonstrated that this engine can be broken down into a finite set of finite automata. Providing a linguistic interpretation of any IEML text means transforming the IEML text (a punctuated sequence of signifiers) into a hypertext network – paradigmatic and syntagmatic – of signifieds that are readable in natural languages. The linguistic function automatically goes from a transformation group of texts (which are sets of sequences) to a transformation group of signified concepts (which are graphs of texts interpreted in natural languages). This is how the STAR engine automatically produces a semantic sphere common to users of the Hypercortex: the interoperable set of the hypertexts signified by the IEML texts.

11.4.2. *Metalanguage*

As we know, human cognition usually manipulates concepts using various symbolic systems, first and foremost natural languages. Due to their irregularities, however, natural languages cannot easily be processed automatically. It was to remedy this problem that IEML was designed as a regular language. In order to usefully play its role of semantic addressing, this regular language keeps the main structures that permit natural languages to represent concepts: layers of increasing complexity (morphemes, words, sentences, etc.), grammatical functions (subject, object, etc.) and grammatical classes (noun, verb, markers of case, gender, number, tense, etc.).

The linguistic engine of the IEML semantic machine can be broken down into two parts. It includes, first, a set of rules for automatically transforming IEML texts (USLs) into semantic circuits – paradigmatic and syntagmatic networks – translated into natural languages. Second, it includes a dictionary, i.e. a set of correspondences between IEML terms and concepts expressed in natural languages. The dictionary itself is a formal semantic circuit among terms.

The STAR linguistic engine may be compared to a theory, the axioms of which are contained in the dictionary and the inference rules of which make it possible – on the basis of the axioms – to interpret any IEML text as a semantic circuit translated into natural languages. I call the calculable linguistic function of going automatically from an IEML text to the semantic circuit that represents its meaning in natural languages *semantic inference*, and call the mechanism that performs this function *linguistic engine*. The automation of the linguistic function will be dealt with more extensively in Volume Two, but I will now present the general principles.

11.4.3. *Rules for the construction of circuits*

The rules of semantic inference can be divided into rules for the construction of syntagmatic circuits and rules for the construction of paradigmatic circuits.

The syntagmatic circuit corresponds to grammatical relationships internal to the USL. It will thus explicate, in the form of a graph, relationships among propositions (which correspond to the distinct categories[4] of the USL), among the sentences of a proposition, among the words of a sentence and among the morphemes of a word.

The paradigmatic circuit corresponds to the interdefinitional semantic relationships that connect terms in a dictionary. In IEML, these can be stated as various kinds of relationships: etymological, taxonomic, symmetrical (relationships of possible substitution) and serial (graduation of words or expressions on linear semantic scales, such as concrete to abstract). The paradigmatic circuit of a USL will therefore connect the terms of the USL with the terms of the dictionary that define their meaning.

11.4.4. *The dictionary*

The rules for the construction of circuits can be compared to the rules of logical inference. As long as no proposition is declared true, it is impossible to deduce anything. That is why any logical theory is based not only on inference rules (how to go from one true proposition to another in general) but also on an initial series of true propositions (axioms), from which other true propositions (theorems) are inferred[5]. Similarly, in order for the IEML semantic engine to be able to infer the semantic circuit translated into natural language corresponding to a given USL, it is necessary to first define the meanings of certain terms and their networks of paradigmatic relationships. In order to start operating, a semantic inference engine thus needs to be provided with a dictionary that specifies the semantic relationships among its terms and their translations into natural language. The dictionary may be considered an "axiomatic" paradigmatic circuit.

4 The word *category* is used here in the technical sense it has in IEML: "set of sequences of the same length (or in the same layer)"; see section 11.3.

5 On this point, see Robert Blanché on axiomatics and the history of logic [BLA 1955, BLA 1970].

11.4.5. *The STAR dialect*

The structure of IEML and its resulting mathematical properties make the construction of a large number of distinct linguistic engines possible. All these engines must meet the same requirement: that of automatically projecting a semantic sphere interpreted in natural language based on the regular IEML language. A specific linguistic engine may be considered a dialect of the IEML metalanguage, a dialect that necessarily incorporates choices with respect to the architecture of the semantic sphere. In reality, there is currently only one IEML dialect (in 2011), which is called STAR. From the point of view of its origin, IEML can be considered a generalization of STAR. As I had a practical objective, I first created a dictionary and rules for the construction of circuits. Only then did I define the abstract mathematical structure of the IEML syntax, which will eventually make it possible to construct other dialects. Neither the semantic inference rules of STAR nor the paradigmatic circuits predefined in its dictionary are absolute or objective: they are conventional principles for the interpretation of USLs. This convention aims to be universal, like many useful conventions[6], but it is a strictly linguistic one that necessitates no particular interpretation of the data. To apply a metaphor I used in Chapter 7, the syntax of IEML may be seen as a machine and its semantics (STAR) as the linguistic operating system of this machine. In other words, the STAR linguistic engine establishes a particular interpretation in IEML, but it leaves users entirely free to categorize their data as they wish.

11.4.6. *From USL to semantic circuit*

After this general explanation of the functioning of the linguistic engine, I will now describe how the IEML model links ideas and concepts. Each valid IEML text (a USL) is a set of sequences of signifying symbols. The USL is transformed into a concept determined by the STAR engine. This transformation can be broken down into two logical steps. First, the USL is transformed into a network of USLs in the semantic sphere: the graph of USLs shown in Figure 11.4. Second, this network of USLs is translated into natural languages. The result, a network of USLs translated into natural languages, is a semantic circuit. Technically, then, in the IEML model, a concept is one-to-one correspondence between a USL and a semantic circuit. The concepts of the semantic sphere projected by STAR can then play their role as semantic addresses of ideas.

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6 See the discussion of this point in section 5.3.3.

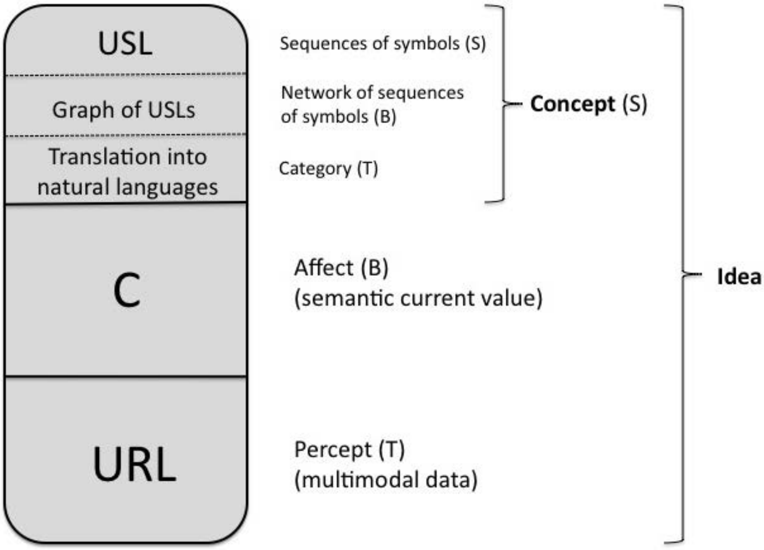

Figure 11.4. *IEML model of ideas*

I make no claim to having completed the mapping of meaning with the STAR dialect in its current form (in 2011). The task will likely never be completed, and progress in the research program based on IEML will require cross-disciplinary and cross-cultural collaboration by many teams. All I have done is verify that it is possible to construct a system of semantic coordinates that can unify the nature of the mind within the computational framework of a transformation group.

11.5. The conceptual machine (T)

Once the semantic sphere is produced by the STAR linguistic engine, there is a finite set of finite automata (the conceptual machine: on the right in Figure 11.3) that transform the semantic circuits and trace pathways in them. The semantic circuits will be able to be used by collective interpretation games to produce, recognize and compare ideas and networks of ideas and to channel the circulation of semantic current.

11.5.1. *The transformation of semantic circuits*

Starting from the USLs that are provided as input, the STAR linguistic engine produces a coherent set of semantic circuits. The nodes of these circuits are USLs translated into natural languages, and their connections are explicit semantic (syntagmatic and paradigmatic) relationships among the USLs. I want to stress the fact that the circuits of the semantic sphere – representing concepts – are constructed regularly and automatically by the STAR engine from the IEML codes, the USLs. As a result, any transformation of a USL is reflected in a regular way in a transformation of the semantic circuit corresponding to that USL. Since there is a parallelism between the transformation of the USLs and that of the corresponding semantic circuits, it becomes possible to automatically manipulate concepts through the manipulation of texts encoded in IEML. In addition, the semantic circuits are variables of a transformation group[7]. The semantic sphere is thus not only a topological structure – a mega-network of concepts – it is also an abstract machine whose operations generate, transform and measure all the aspects of this structure. Of course, it is only because they are encoded in IEML – and because a STAR linguistic engine also exists – that concepts and their semantic relationships can be formalized as a transformation group. In short, the IEML semantic sphere makes it possible to address concepts by meeting all the scientific requirements for a system of coordinates of the mind.

11.5.2. *The openness and complexity of the circuits of the semantic sphere*

The IEML semantic sphere permits an intellectual openness and an unrestricted freedom of inter-conceptual movement. This is because the topology of the huge system of coordinates of the mind meets three requirements for semantic circuits: the first concerns their number, the second, their variety, and the third, their complexity.

The circuits of the semantic sphere permit a practically unlimited number of paths between two USLs. This means that for symbolic cognition, there is in principle no insurmountable divide, boundary or separation between two signifieds taken at random. Two concepts, whatever they are, can always be connected by a number of continuous series of semantic transformations, with these transformations modeling intellectual operations on concepts. The topology of the semantic sphere forms a single whole, and it makes universal communication among concepts, without which there is no free thought, possible.

Links (i.e. transformations) among the USLs of the semantic sphere can be created through an infinitely open variety of different functions. In particular, all the circuits that can be traced automatically in the semantic sphere are not (or not only) simple hierarchies of classes and subclasses. The same USL can be either the operand or the result for several different functions. This means that, from the point

7 See the demonstration in Volume 2.

of view of pathways in the semantic circuits, each USL functions as a junction from which it is possible to choose not only the next node – the next destination – but also the next type of semantic transformation. In Volume Two, I will go into detail on certain functions of the construction of circuits.

Far from being limited to linear sequences, the paths of semantic current can branch out into graphs of indeterminate complexity. At the smallest scale of cognitive activity, that of the oscillatory rhythms of the central nervous system, it is likely impossible to consider more than one "idea" at a time[8]. However, our everyday experience creates movements of thought and relationships of meaning that do not necessarily occur sequentially. At least subjectively, we are capable of following several discursive threads simultaneously and performing certain activities in "multitask mode". This is even more obvious for the collective intelligence of a community as it may be manifested in the dynamics of the use and collaborative transformation of its computerized system of knowledge management. In this case, if there is a common conceptual network – in the form, for example, of a thesaurus or ontology[9] structuring a database – it is clear that, starting from a given concept, many conceptual paths can be followed simultaneously by the collective intelligence of the community. In general, for a living intelligence, the actualization of relationships among concepts – modeled as current flows in the IEML semantic circuits – takes the form of complex branching, even fractal rhizomes[10]. Effective intellectual circulation among concepts probably resembles the pulsations of asymmetrical lightning illuminating thick clouds of phenomenal data more than well-behaved hierarchies on an administrative organizational chart. Still, it must be possible to inscribe even the meaningful tempests of a brainstorming session or a lovers' quarrel in the functional topology of the semantic sphere.

In short, the coherent set of circuits of the semantic sphere opens up practically an infinity of intellectual paths among an open variety of distinct concepts, according to an unlimited diversity of transformations along indefinitely complex

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8 Discursive thought, like speech, is sequential. As Varela *et al.* point out, it is as if the structure of lived time is not continuous, but rather is a sequence of functional quanta. Francisco J. Varela, Eleanor Rosch and Evan Thompson, *The Embodied Mind: Cognitive Science and Human Experience* [VAR 1991].

9 The term *ontology* is used here as in computer science, meaning "a formalized network of concepts used as the basis of logical calculations by programs" and not in the metaphysical sense of the general study of being.

10 I recall here that the concept of rhizome was developed philosophically by Gilles Deleuze and Félix Guattari in the introduction to *A Thousand Plateaus* [DEL 1987b]. The rhizome provides an image of thought characterized by active a-centric multiplicities and reticular dynamics that cut across hierarchical organization and classificatory tree structures.

sequential or parallel paths[11]. In the model of symbolic cognition based on the semantic sphere, the movements of the mind can go in an infinity of different intellectual directions from a given concept, represented by a USL. Against this backdrop of limitless virtualities, however, nothing prevents us from deliberately inscribing semantic paths of limited number, variety and complexity in order to model specific cultural structures or intellectual operations. Freedom of thought is thus ensured. In addition, each step along a path, each link, remains precisely identifiable by the semantic coordinates of its starting point, the semantic coordinates of its end point and the automatable transformation that leads from one to the other. The scientific requirement of calculability is thus respected.

11.6. Conclusion

11.6.1. *The unit of semantic information*

The IEML semantic machine can be seen as the "missing link" of cognitive modeling. The first consequence of the formal existence of the IEML semantic machine is that there is no longer any theoretical obstacle to the calculable modeling of the mind in the digital medium, and thus to its reflexive scientific observation. Indeed, this machine ensures the calculability and interoperability of the hermeneutic and semantic functions. Since the circuits of the semantic sphere are variables of a transformation group, we have a universal system of coordinates that can contain the world of ideas. In the model of the mind that uses the semantic sphere as its system of coordinates, an idea is represented by a unit of semantic information (see Figure 11.5). A concept is encoded as a USL, which is automatically converted into a circuit of the semantic sphere and translated into natural languages. An affect is encoded as a semantic current (polarity, intensity) flowing in this circuit. Finally, a percept – multimodal data – is addressed as a URL.

The adoption of the unit represented in Figure 11.5 as the standard for the semantic information economy would make the digital medium the supporting structure of a Hypercortex, i.e. a universal cognitive calculator or a mirror of collective intelligence. The Hypercortex would be fuelled by public data on the Web and would be "programmed" by creative conversations through a wide variety of collective interpretation games.

11 A glimpse of this model can be found at the beginning of Michel Serres, *Hermès I, La Communication* [SER 1969].

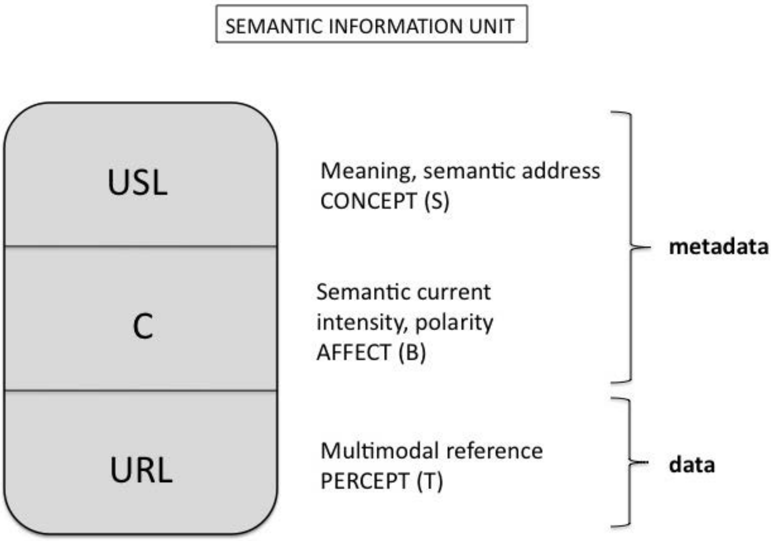

Figure 11.5. *Formal model of an idea in the IEML framework*

11.6.2. *The two faces of the semantic sphere*

The IEML semantic sphere can be seen as having two faces. The first one expresses all the relationships of meaning among the texts (the USLs) of a calculable metalanguage. These texts can be manipulated according to semantic criteria and translated automatically into the natural languages supported by its dictionary. On this metalinguistic face, IEML presents a system of semantic notation capable of precise correspondence with natural languages, and thus with data. This aspect was discussed in Chapter 10.

The semantic sphere also has another face: that of a monadology of concepts. The USLs are the encoded addresses of the nodes of a hypercomplex semantic topology. Although huge and fractally intricate, the hypertext network of concepts is nevertheless a symmetrical system of algebraic transformations that can be manipulated automatically. This aspect was studied in Chapter 9 in Part 2, with more detail here in Chapter 11. The IEML semantic machine really does meet the requirements for scientific knowledge of the mind. Indeed, the semantic sphere constructed and surveyed by this machine provides symbolic cognition with an addressing system that is unifying, symmetrical, coherent and meaningful, while allowing for inexhaustible complexity.

As language and calculable topology, linguistic system for categorizing data and system of algebraic transformations, the IEML semantic sphere is the cornerstone of the Hypercortex: it makes it possible to go from logical calculation to semantic calculation and it opens the way to computational modeling of symbolic cognition. The semantic sphere emerges from the operations of a machine that formalizes human semantic functions and it organizes a perspectivist hermeneutic memory driven by an unlimited variety of collective interpretation games. Symbolic cognition then appears as an infinite but coherent nature, a cosmos that is indefinitely explorable by scientific means.

11.6.3. *Directions of development*

It is very difficult at this point to foresee all the applications of the Hypercortex based on the semantic machine. I can nevertheless indicate four probable directions of development.

First, we already have a common addressing system for data (URLs), but the organization of metadata is still opaque and fragmented. The Hypercortex will make it possible to augment all the processes of semantic collaboration. It will, first of all, enable us to overcome the compartmentalization that still exists in 2011, caused by natural languages, ontologies, social media platforms, search engines and in general by the big corporations of the Web that use cloud computing. Next, it will significantly augment the power and interoperability of calculations on metadata, since USLs and the semantic current are variables of transformation groups. The Hypercortex will therefore make it possible to more effectively practice: (i) collaborative semantic tagging; (ii) collaborative semantic filtering of data and individuals; and (iii) collaborative semantic search.

The second direction of development is semantic knowledge management, whether personal or collective. The Hypercortex based on IEML provides a perspectivist organization of accumulated knowledge that is suited to the multimedia digital memory and calculating power we now have available. We have to think simultaneously about hermeneutic freedom – the capacity to develop large numbers of functions for categorizing and evaluating data, functions that vary according to the traditions, interests and points of view of creative conversations – and about the capacity for interoperability, comparison and open exchange through a common system of semantic coordinates.

The third direction of development is simulation and modeling of individual and collective cognitive systems in the human sciences, of course, but also management, design, marketing, the design of collaborative games, networked art, digital storytelling, etc. Again, the key point is that cognitive models produced within the frame of reference of the Hypercortex, as varied as they may be, are generative, evolving and interoperable and can exchange units of information, data and functions.

Ultimately, we can imagine new types of interfaces, as yet unknown methods of navigation in data – and even in knowledge – that will likely take the form of massively multiplayer collective interpretation games and will be based on augmented reality technologies using pervasive computing and wireless devices.

In short, the Hypercortex will contain a new generation of socio-semantic automata that support the creation, exchange and appropriation of knowledge. The IEML semantic sphere will serve as technical support for a decentralization of computing, with each collective interpretation game using the common system of coordinates and the calculating power available in the "clouds" in its own way. Beyond technical advances, the Hypercortex will improve the productivity of a knowledge-based economy and will make it possible to refine collaborative strategies for human development adapted to a multitude of situations and contexts.

Chapter 12

The Hypercortex

Having recalled the essential role played by media and symbolic systems in human cognition, I will now paint a general portrait of the contemporary digital medium and its likely evolution. I will elaborate on the idea I mentioned in preceding chapters, that the IEML semantic machine paves the way for the emergence of a Hypercortex capable of reflecting human collective intelligence by using the storage and calculation power of the digital medium. As shown in Figure 12.1, this chapter gives an overview of the hypercortical cognition that will be contained in the digital medium.

12.1. The role of media and symbolic systems in cognition

There is no doubt that human cognition is based on biologically determined cerebral organization and neural activity[1]. Nevertheless, recent decades have seen the publication of an impressive quantity of research on intellectual technologies and symbolic tools[2]. The main idea that unifies this interdisciplinary area of research is that mechanisms of memory, communication media and symbolic systems – all of

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1 See *Neuronal Man,* by Jean-Pierre Changeux [CHA 1985], or *Neural Darwinism*, by Gerald Edelman [EDE 1987]. It should be noted that I am not saying that human cognition is *determined by* neural activity, but that it is *based on* neural activity.

2 I am referring to the work of Goody, Ong, Havelock, Logan, Jaynes, etc. See the bibliography: [BOT 1987, GOO 1977, GOO 1987, HAV 1988, JAY 1976, LOG 2007, ONG 1982]. On the way in which intellectual disciplines such as rhetoric (including its spatial and iconic dimensions) have influenced cognitive activities, see Yates and Carruthers [CAR 2000, YAT 1974].

which are cultural – play an essential role in shaping cognitive skills, both individually and collectively[3].

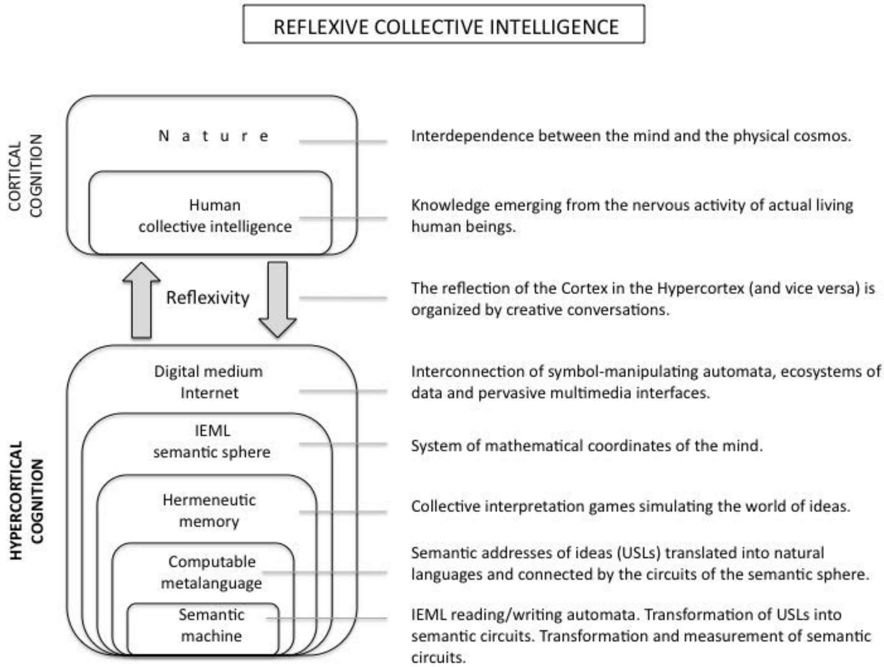

Figure 12.1. *Position of Chapter 12 on the conceptual map*

The invention of writing permitted the development of systematically organized knowledge (lists, tables, archives, accounting and complex hermeneutic procedures) that went beyond the practical wisdom of oral cultures, which were organized around myths, stories and rituals[4]. The invention of the alphabet, i.e. a system of phonetic writing based on about 30 signs (as opposed to writing systems requiring thousands of ideographic signs or mixed systems), led to the social extension of writing and reading abilities and fostered the development of abstract thought[5]. The invention of the Indo-Arabic numerals, including the positional notation system and zero, made arithmetic simpler and easier, mainly by allowing the use of uniform

3 See Edwin Hutchins, *Cognition in the Wild* [HUT 1995].

4 See [GOO 1977, GOO 1987, HAV 1988, ONG 1982].

5 See Innis, McLuhan and, more recently, Robert Logan: [INN 1950, LOG 2004, MAC 1964].

algorithms[6]. Just try multiplying Roman numerals and you will understand the importance of symbolic systems in the execution of cognitive tasks. As well as being an unprecedented vehicle for the dissemination of information and knowledge, printing led indirectly to the development of many systems of scientific notation, including accurate maps based on the geometric projection of parallels and meridians, systems of biological classification and systems of mathematical and chemical notation[7]. Printing also favored the development and formalization of linguistic studies[8] and the creation of systems of metadata for libraries and archives[9]. It should be noted that the development of new symbolic systems did not take place immediately after the invention of printing: it took several generations to assimilate and exploit the cognitive possibilities of this new medium. In general, cultural evolution follows technological evolution. By analogy, we can predict without too much risk that the full symbolic exploitation of the new environment of communication and processing provided by computer networks, i.e. the digital medium, is still to come.

These historical remarks suggest that many major advances in the evolution of human cognition are linked to the invention of media and symbolic systems.

12.2. The digital medium

12.2.1. *General definition*

The digital medium is an environment of ubiquitous interactive global multimedia communication that is open to growing numbers of communities of users. Its main characteristic is that it is driven by massively distributed symbol-manipulating automata. The growth of the digital medium is essentially the result of the convergence of three processes:

– First, the constant increase in calculating power: computer hardware and software are increasingly efficiently automating symbol manipulation.

– Second, the continuing expansion of the volume of digital data: human cultural memory – both short- and long-term – is gradually being digitized and put online. This creates the conditions for a unification of local memories in a shared ubiquitous

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6 On this point, see Robert Kaplan, *The Nothing That Is: A Natural History of Zero* [KAP 1999], and Georges Ifrah, *Universal History of Numbers: From Prehistory to the Invention of the Computer* [IFR 1998].

7 The reference on this subject is Elisabeth Eisenstein's book [EIS 1983].

8 See Sylvain Auroux [AUR 1994].

9 See Elaine Svenonius [SVE 2000].

virtual space, while digitization makes it possible to automate the processing of these data on a huge scale.

– Third, the continuous growth of the numbers of people making direct use of the digital medium: close to a third of the world population in 2011[10] versus less than 1% in 1995. We can safely predict that at least 50% of humanity will be connected to high-speed Internet long before the middle of the 21st Century.

12.2.2. *The automation of symbol manipulation*

Automation first occurred in agriculture, transportation, energy production and manufacturing. We now have technologies that can not only record, duplicate and instantaneously transmit symbols, but can also manipulate them automatically at electronic, and soon optical, speeds. Programmable symbol-manipulating automata (logical automata) have been available in a few political and industrial centers for half a century. They have been in the hands of the public in the richest countries for only about the last 30 years: scarcely more than a generation has passed since the introduction of the personal computer and the development of the Internet. Finally, less than a generation separates us, in 2011, from the emergence of the global hypertext mediasphere, the World Wide Web, in the mid-1990s.

Symbol-manipulating automata are practically capable of carrying out all formally definable operations on any type of information, as long as that information has been digitally encoded. According to the often-cited Moore's law, which has held true for more than 20 years, the processing power of computers doubles every 18 months. We commonly use logical automata to write, publish and read texts; to produce and view images; to produce and listen to music; to manage our money, our economy and our administrations; and increasingly, to structure our learning and our organizational knowledge in an integrated way. Their capacity to help us make decisions, to produce and modify documents, and to provide interactive support for virtual environments is barely beginning to be explored.

12.2.3. *The digitization of memory*

The second process that is contributing to the growth of the digital medium is the digitization of cultural memory. By this I mean both long-term memory (archives, encyclopedias, libraries, museums, company records, etc.) and short-term memory (media, blogs, forums, correspondence, games, etc.). The digitization of memory is accelerating, whatever the subject (scientific, artistic, historical, economic, etc.) and whatever the original form of the information (texts, images, sounds or programs).

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10 See *Internet World Stats:* http://www.internetworldstats.com.

This digitization fuels the activity of logical automata, which can only work with data encoded in 0 or 1. It enables a quantitative power of processing and a refinement of automatic transformation and analysis on a scale unimaginable half a century ago[11]. Most of the symbolic production of humanity is thus in the process of being represented in digital documents that are available online. As a result, constraints related to the physical location and material inscription of collective memories are vanishing[12]. Contemporary technology makes ubiquitous universal access possible and reduces the reproduction and copying costs to practically zero. Thus, as soon as information is somewhere on the network, it is potentially everywhere.

Digitized documents are virtually part of a dynamic universal hyperdocument that is fed, read and processed by all institutions and individuals participating in the digital medium. While the institutions traditionally responsible for memory and communication struggle to adapt to these new conditions, new forms of collective memory that have appeared in recent years give us a glimpse of the future. *Wikipedia* was launched in 2001, and by 2010 it had close to three million articles in 200 languages, more than 300,000 volunteer collaborators and millions of users every day, which makes it the most complete and most consulted encyclopedia in the world. Web sites permit hundreds of millions of Internet users to share and comment collectively on videos (YouTube) or photographs (Flickr). Sites such as Diigo allow Internet users to share their bookmarks and to index or tag sites they want to bring to the attention of others, using their own keywords. In this case, users take over the documentalist's role of classification. The result is that the resources of the Web are organized as democratic "folksonomies" rather than taxonomies imposed by experts.

The latest example of these changes in collective memory is peer-to-peer (P2P) file exchange systems such as Kazaa, eMule, BitTorrent or GNUnet, which allow Internet users to share documents on their dispersed hard drives as if they were all connected to a shared memory combining their individual memories. These are the main channels for the large-scale exchange of "pirated" games, films and music, much to the chagrin of publishers, producers and recording companies threatened with bankruptcy. P2P file exchanges are thought to consume most of the bandwidth of the Internet.

These new forms of collective memory have at least four features in common:

– from the user's point of view they are immediately global, dissociated from any territorial anchor point, even though they obviously rely on technical

11 I am writing this in 2010.

12 On this point, see section 4.3.3.

infrastructure (networks, huge computing centers) located on the surface of the Earth. This is known as *cloud computing*;

– they are egalitarian, non-hierarchical and inclusive, in the sense that authors/creators, readers/viewers, critics/curators and documentalists/organizers can exchange roles[13];

– they are open, in the sense that they allow real-time interaction and direct access and manipulation;

– they have laid the foundations for a form (albeit still limited) of participatory collective intelligence through creative conversation, which I outlined in Chapter 4.

If the capacity for automatic manipulation by software agents is combined with the pervasiveness and interconnectedness of digital memory, we get the potential power of the collective intelligence of online communities. This power is still only potential, because there are major obstacles that prevent creative conversations from taking full advantage of the technical potential of the digital medium. These obstacles can be divided into three interdependent groups: (i) the compartmentalization of symbolic systems; (ii) the non-computable – or not readily computable – nature of these systems; and (iii) the opacity maintained by the big oligopolistic corporations that actually control access to shared memory.

12.2.4. *The compartmentalization of symbolic systems*

The first obstacle concerns the multiplicity of symbolic systems and their compartmentalization. In this regard, we need to distinguish between data and metadata. The term *data* designates archived documents (texts, images, sounds, programs, magazines, books, recordings and films, digitized or not) while *metadata* designates annotations added to the documents in order to organize, find and filter them (abstracts, key words, subjects, evaluations, etc.). With respect to data, to begin with there are huge numbers of natural languages and there are still no systems of automatic translation that are both general enough and reliable enough. With respect to metadata, there is the additional problem of the multiplicity of storage systems. During the 19th and 20th Centuries, many systems of indexing and cataloguing were developed by librarians and documentalists. Earlier in this book I mentioned Dewey's hierarchical decimal system, Ranganathan's faceted classification and Otlet's pioneering attempt at hypertextual classification[14]. In their times, all these systems were essentially designed to manage collections of material

13 In reality, of course, certain actors produce more or are more influential than others. I am speaking here of the general organization of the communication mechanism, which gives no privilege or monopoly in principle to certain professions or certain institutions.

14 See section 4.3.2.

documents in physical buildings. As long as the collections of libraries and documentation centers were separated by large geographic (and cultural) distances, the diversity of classification systems did not pose too many practical problems. In an era of online convergence of geographically dispersed memories, however, the absence of harmonization makes itself painfully felt. In addition to the many documentary languages used by administrators of important collections, each culture, intellectual tradition, discipline or theory has its own terminology and its own classification of concepts. The way "subjects" or concepts are organized is, like language itself, an essential dimension of thought. There is thus no question of imposing some uniform classification on anyone in order to facilitate online research, and even less of imposing English as the sole language. That is why I am hypothesizing that the solution can only come from a metalanguage capable of encoding the diversity of languages or, if you will, from a universal system of semantic coordinates through which as many different classifications as desired can be projected.

12.2.5. *The non-computability of symbolic systems*

The second group of obstacles concerns the difficulties encountered by computer engineering in expressing the meaning of documents, using general methods. It is well known that there is enormous grammatical variation in the actual use of natural languages (this is part of the normal life of languages), that words have many senses and that different expressions can mean practically the same thing, not to mention differences of interpretation depending on context. For this reason, the main methods of automatically analyzing texts in natural languages are based essentially on statistics, which means that algebraic or topological processing of meaning – which is more reliable – is currently largely unattainable.

In comparison, the positional number notation system (whether base 10, base 2 or other) permits a universal one-to-one interpretation of the meaning of every digit according to the place it occupies in an expression. The concept corresponding to the sequence of digits (the number) can therefore be deduced automatically from that sequence. In contrast, the alphabetical notation of words in natural languages results in arbitrary codes – chains of characters – that it is still possible to compare or connect with other chains of characters (other words that have the same meaning, for example), but without the characters or their arrangements being *directly* interpretable semantically. In fact, the elementary symbols here represent sounds, not elements of meaning. In short, for symbol-manipulating automata, numbers noted in Indo-Arabic ideography are directly accessible (or transparent), while expressions of concepts in natural languages, noted in alphabetical characters, are semantically opaque. The compartmentalization and non-computability of symbolic systems constitute a formidable obstacle to the ideal of *semantic interoperability*, as computer engineers call it. But the opacity of the Web is also caused by factors that are not technoscientific in nature.

12.2.6. *The opacity of the Web*

There is no question here of denying that commercial search engines provide a service to Internet users. I would simply like to point out the limitations of these services. I note, to begin with, that Google, Bing or Yahoo only index approximately 25% of the mass of documents on the Web. The rest is called the "deep Web" by experts in information research. In addition, commercial search engines base their searches on chains of characters, not on concepts[15]. For example, when a user enters a request for "dog", this word is processed as the sequence of characters "d, o, g" and not as a concept translatable into many languages (*chien*, *kelb*, *perro*, *cane*, etc.), belonging to a subclass of mammals and domestic animals, and constituting a superclass that includes bulldogs, poodles, etc.

Not only do the major commercial engines not permit searches for concepts (instead of words in natural languages), but they are also incapable of adapting to atypical perspectives[16], sorting results according to criteria chosen by the user, assigning a value to the information, etc. Their search algorithms are uniform and static. On top of all this, they are notoriously lacking in transparency, since their search algorithms are commercial secrets. Their main aim is to bring in maximum advertising revenues from Internet users' clicks. All this explains why it is much easier to obtain a relevant result when you know what you are looking for than when you want to freely explore the mass of information available. Moreover, the big corporations of the Web Consortium (Google, Yahoo, Microsoft, AOL, etc.) and the leaders in social media (Facebook, Twitter, MySpace, etc.) exercise a powerful control over search services through their huge distributed databases. This control gives them the power to censor certain data or bias search results. Finally, the centralized services of search engines, messaging and social networks allow a small

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15 I remind the readers that RDF means Resource Description Framework and that OWL means Ontology Web Language. Both are standard file formats recommended by the WWW consortium. The fact that many major search engines recently began to take metadata into account using the RDFa standard only solves this problem very partially, as we will see. Moreover, "semantic" search engines (Powerset, Hakia, etc.) using algorithms for processing natural languages usually process English only, and very imperfectly at that. The purchase of Metaweb (which organizes the Freebase database with the tools of the web of data, RDF and OWL) by Google seems to be a sign of a "semantic" change in direction for Google, but within the limited paradigm of traditional artificial intelligence; see my (constructive) criticism of artificial intelligence in Chapter 8.

16 The search and "page ranking" algorithms are not customizable.

group of oligopolistic corporations to market the huge quantities of information produced by Internet users during their activities. In other words, contemporary Internet users are dispossessed of the information they collectively produce, which they could use to benefit their collective intelligence and human development in general.

12.2.7. *An unfinished matrix*

Information and its automatic processing agents are becoming materially unified in a virtual memory common to all of humanity, but because the barriers, compartmentalization and semantic incompatibilities have as yet only been very partially removed, the growth of collective intelligence, though remarkable, has fallen far short of what it could be. Should we be surprised by this? The vast majority of systems for encoding meaning that are available today were invented and refined long before the existence of the digital medium. This medium itself has existed for the global public for less than a generation. Techno-symbolic support for the new cultural matrix is unfinished. Promoters of the use of shared memory to serve creative conversations and human development are therefore confronting the problem of inventing, adapting and perfecting a new generation of symbolic systems that will be in keeping with the unity of memory and the processing power now available. In order to place my solution to this problem in context, I will now describe the progress that has been made in the construction of the digital medium, where the techno-symbolic matrix of the knowledge society and its information economy is gradually being created.

The basic structure of the contemporary online collective memory can be analyzed as a nested series of layers of addressing. These different layers of the digital medium were developed successively over time and each one needs the existence of the preceding ones in order to function. The first layer (the operating systems of computers) addresses the elementary bits of information at the physical level of the circuits and hardware of the symbol-manipulating automata. The second layer (the Internet) addresses the automata that receive, manipulate and transmit digitized information in the communication network of cyberspace. The third layer (the Web) addresses the pages of documents and, soon, the data of which those pages are composed. The addressing system of the Web makes it possible to create hypertext links among data. As readers already know, I feel that it has now become necessary to implement a fourth layer of addressing: a system of coordinates for mathematically mapping out a universal and practically infinite semantic space. This fourth layer of addressing will make it possible to address, manipulate and evaluate data automatically, based on the semantic metadata that represent them, while paving the way for a multitude of semantic perspectives and games of the information economy (or collective interpretation games). For purposes of demonstration, the approach proposed here emphasizes the logical and symbolic dimensions of the digital medium more than its hardware.

12.3. The evolution of the layers of addressing in the digital medium

12.3.1. *The era of big computers (addressing of bits)*

The entire structure of the digital medium is based on mathematical logic and binary encoding of information, which became standardized in the mid-20th Century. Conceptually, the two main components of a computer are its memory and its processor. The processor reads, writes and deletes information in the memory. Thus the memory's addressing system is essential to the functioning of logical automata. It is usually the operating systems of computers that manage the physical addresses in the memory.

From 1950 to 1970, computers were still only operated by experts. Human–machine communication took place, logically and symbolically, through complex programming languages, and physically through perforated cards or tapes and rudimentary printing systems. They were used mainly by big corporations and public administrations in rich countries, for scientific calculation, statistics and accounting. Computer technology in this era was centralized, centralizing and dominated by the major hardware manufacturers (IBM).

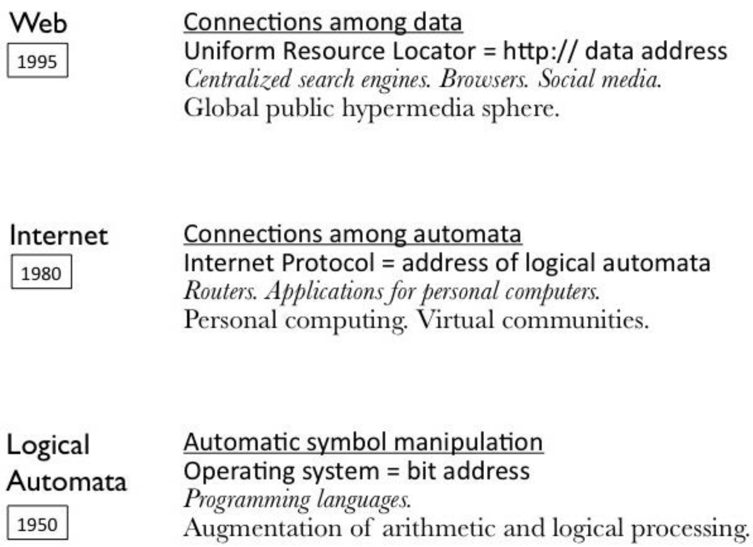

Figure 12.2. *The first three addressing layers of the digital medium*

The development of computer technology starting in the 1950s created the technical conditions for a remarkable increase in the arithmetic and logical processing of information. The layer of addressing of bits of information on the hardware, an inheritance from the early days, is still present today and is the basis of the digital medium. At the level of the machines that make up the nodes of the big network, this addressing is managed in a decentralized way by various computer operating systems (such as Unix, Windows, MacOS, etc.) and is used by software applications.

12.3.2. *The age of personal computers and the Internet (addressing of automata)*

With the mass production and falling prices of microprocessors, the 1980s and early 1990s saw profound changes in the world of automatic calculation. Thanks to new communication interfaces (icons, mice, multiple windows, etc.) between machines and users and the marketing of applications adapted to users' needs, non-experts were beginning to operate machines and manipulate data without programming. The PC increasingly became the essential tool for calculating a budget or creating and publishing texts, images and music, and there was a proliferation of recreational and educational applications. This period of decentralization in information technology was dominated by companies that designed the interactive experience of users (Microsoft, Apple). Scientists, professionals, urban youth and office employees in rich countries took possession of the power of computers. At the same time, personal computers and information servers were starting to be interconnected in many networks, which would later be linked in the Internet. Computers became a medium for communication and collaboration, and increasing numbers of virtual communities began to develop. A powerful drive to digitize information led to a convergence of the previously separate fields of telecommunications, media and computer science.

During this period, a new layer of universal addressing was adopted. In order to be able to exchange information with other computers, every information server now had an address assigned according to the universal protocol of the Internet. IP (Internet Protocol) addresses are used by the information routing – or switching – system that makes the interconnected networks function. In the 1980s, the main uses of the Internet were electronic mail, discussion forums, file transfers and remote calculations: the Web did not yet exist.

12.3.3. *The era of the Web (addressing of data)*

The small team assembled around Tim Berners-Lee at the CERN in the early 1990s succeeded in giving technical expression to the long-cherished dream of visionaries such as Vannevar Bush, Douglas Engelbart and Ted Nelson, who had foreseen the interconnection of digital documents, whatever their physical location, through hypertext links.

The secret of this technical exploit, which was simple in principle, was once again a universal addressing system. After the addressing of bits in the memories of individual computers and the addressing of servers in the network that makes the Internet work, the third layer of the digital medium, the World Wide Web, addresses the pages of documents or other information resources. The address of a page is called a URL (Uniform Resource Locator) and the links between documents are processed according to the HTTP (Hypertext Transfer Protocol) standard. Browsers and search engines would obviously be incapable of processing hypertext links in a standard way if their source pages and target pages were not addressed according to a universal protocol. Note that the HTML (Hypertext Markup Language) standard permits the graphic display of pages independently of the many operating systems and browsers employed by Internet users.

The spread of the Web beginning in 1995 led to the opening up of the global multimedia public sphere we see developing in the early 21st Century. Based on high-speed communication, wireless technologies and portable devices of all kinds, this new public sphere has given rise to an explosion of electronic commerce, the growth of online social networks, the development of virtual massively multi-player gaming environments and the spread of collaborative knowledge management technologies in education and business.

After the decentralization of the era of PCs and the Internet, the era of the Web marks a new phase of centralization. Information search services (Google, Microsoft’s Bing, Yahoo), personal contact services (wireless telephone, major social media such as Facebook or Twitter) and sales services (Ebay, Amazon) are concentrated in the hands of a few big corporations that operate huge data centers. These veritable information factories – the new hardware of cloud computing – assemble hundreds of thousands of interconnected computers in buildings under tight security, consuming the amount of energy produced by a small electrical plant. In practice, then, the constantly expanding global online memory is being used by “central computers” of a new kind. Scattered around the world to be closer to demand, these data centers are directly connected to the main channels of the Internet and are capable of processing staggering amounts of information.

The third layer of the digital medium is further enriched by a set of technologies its promoters – mainly Tim Berners-Lee and his collaborators in the World Wide Web consortium – were calling the “semantic Web” a few years ago and now call the "web of data"[17]. In a recent article, I discussed the web of data, its formats (XML (Extensible Mark-up Language), RDF) and its OWL[18]. Suffice it to say here that from my perspective – and as Tim Berners-Lee himself says – the web of data is an improvement of the World Wide Web or completes it. It is not a new basic layer of the digital medium. Indeed, the fundamental addressing system of the web of data is still the familiar URLs[19]. These are opaque because of the way they are constructed[20]. They function like physical addresses in a telecommunications network or access codes to information in a distributed database, and not as coherent semantic variables of a transformation group. The very axiomatics of the Web require the absence of an essential relationship between Web address and meaning.

12.3.4. *The era of the semantic sphere (addressing of ideas)*

With respect to the digital medium, the only thing that is certain is that the story is just beginning. There is no reason to believe that the technological basis of the new cultural matrix, the major features of which I outlined in the previous sections, has reached its final state. Digital encoding, while it is certainly fundamental, is only the first layer of a gigantic pyramid of superimposed codes, norms, languages and interfaces that link electronic circuits (and soon optical or bioelectronic circuits) to human users. This multilayered structure of transcoding is likely very far from finished. Paradoxically, just when the growth and diversification of the uses of the digital medium are strongest, software engineering (which today excels in the design of interfaces and applications) is having difficulty renewing its fundamental concepts. Problems involving the complexity of meaning and its interpretation – which are among the classic themes of the human sciences – can no longer be circumvented by the builders of the new global communication space. It may be that the initiative for the construction of the digital medium will, at least in part, lie with intellectuals trained in the human and social sciences. After all, the logic incorporated into computer programs and electronic circuits was first formalized by philosophers, starting with Aristotle. We have seen that semantic refinements (which are even more subtle than those of logic) can also be formalized mathematically. Who better than human sciences researchers (with the help of computer scientists) to tackle the task of creating a scientific mapping of socio-semantic phenomena?

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17 Or "linked data".

18 See [LÉV 2010a].

19 I will not go into the subtle distinction between URLs and URIs in this book (more information can be found by consulting experts on the web of data or WC3 documents, such as: http://www.w3.org/TR/uri-clarification/) and I will still talk about URLs.

20 See the basic WWW Consortium document on this subject: http://www.w3.org/DesignIssues/Axioms.html#opaque.

To supplement the Web's opaque data addressing system, I am therefore proposing the construction of a transparent addressing system for metadata based on the grid provided by the STAR-IEML semantic sphere. As shown in Figure 12.3, the USLs of the semantic sphere are the counterparts of the URLs of the Web. It is thus not a matter of replacing the Web, since it will still be indispensable for addressing data in the digital medium, but of adding a new layer of addressing – a public, transparent protocol – that will permit us to interpret and use the data of the Web much better than we do today.

Coordinated by the semantic sphere, all the symbol-manipulating automata interconnected by the Internet and all the data interconnected by the Web would enter into a form of higher synergy, qualitatively different from that existing today. The addition of this fourth layer of addressing would enable the digital medium to cross a threshold and begin to reflect our collective intelligence scientifically. With the Hypercortex addressed by IEML, the digital medium will reach maturity.

Semantic Sphere 2015	Connections between ideas Uniform Semantic Locator = *concept addresses** in IEML *Personal knowledge management systems.* *Collective interpretation games* Global perspectivist hermeneutical memory.
Web 1995	Connections between data Uniform Resource Locator = http:// data addresses. *Centralized search engines. Browsers. Social Media* Global hypermedia public sphere.
Internet 1980	Connections between automata Internet Protocol = automata addresses. *Routeurs. Applications for PC* Personal computing. Virtual communities.
Logical Automata 1950	Automatic symbol manipulation Operating Systems= bits addresses. *Programming Languages* Augmentation of arithmetical and logical processing.

Figure 12.3. *Addressing layers of the Hypercortex*

12.4. Between the Cortex and the Hypercortex

12.4.1. *Parallels between the Cortex and the Hypercortex*

To put the anthropological function of the Hypercortex that will soon emerge from cultural evolution into perspective, I will compare it to the human cortex that emerged from biological evolution.

As we have seen in Part 1, human cognition combines sensory-motor experience of the phenomenal world (which is common to all animals with nervous systems) with discursive thought based on symbol manipulation. We can consider phenomenal experience as an implicit, or opaque, kind of knowledge, and its creative translation into the terms of symbolic systems as an explicit, transparent kind of knowledge. Insofar as it is symbolized (explicated), knowledge can be shared and transformed more easily than the (opaque) knowledge that is part of phenomenal experience. Supported by the human Cortex that has emerged from biological evolution, the dialectic between phenomenal experience and discursive symbolization expresses the original form of our intelligence. It is because of this engine of reciprocal transformation between implicit perception and explicit language that we are able to socially coordinate our cognitive processes more effectively than other social animals and share a cultural memory. The symbolic representation of the categories that organize our experience opens up for us a dimension of reflexivity unknown to other animals: we are able to represent our own cognitive processes to ourselves, recognize the gaps in our knowledge and ask questions. We can also envision the cognitive processes of others, imagine their subjectivity, negotiate the meaning of shared situations and agree on norms for reasoning and interpretation. We are capable of dialog. Finally, our narrative capacities permit us to produce and receive complex space–time models of phenomena, stories in which actors (grammatical subjects) bring about various changes (verbs) in objects in a complex intertwining of causal sequences and cascading citations. We all produce different narratives of our lives and the environments in which they unfold, but the narrative capacity is universal in the human species.

Now let us draw a parallel between the huge mass of interconnected multimedia digital data that oscillates and fluctuates on the Web and the phenomenal experience or implicit knowledge contained in the vast techno-cultural Hypercortex. The Web is certainly a hypertext, but it is an opaque hypertext, fragmented among languages, classifications, ontologies and commercial platforms, a hypertext whose nodes are ultimately only physical addresses. If we want to use the Web to coordinate our collective intelligence and share our cultural memories on a new scale; if we want to more clearly represent our processes of social cognition to ourselves, identify blind spots in our knowledge and augment our capacities for critical questioning; if we want to progress toward better intercultural understanding and cultivate the effectiveness of our creative conversations; if we want, finally, to increase our capacity to construct and interpret digital narratives by using the calculating power available, then we will have to complete the digital medium with a new layer of addressing and semantic calculation. This new layer will creatively translate the real but implicit (its interconnection is opaque) knowledge content of today's Web into a knowledge content whose explicit meaning is transparent to automatic symbol manipulation (the transparent hypertext of USLs, as shown in Figure 12.4, coordinated by the IEML semantic sphere). Symbolic manipulation based on the explication of categories is a "trick", an inherent capacity, of the human species. Here this means simply using the same old trick on another level – the meta-level of automatic processing of semantic information in a universal, ubiquitous memory.

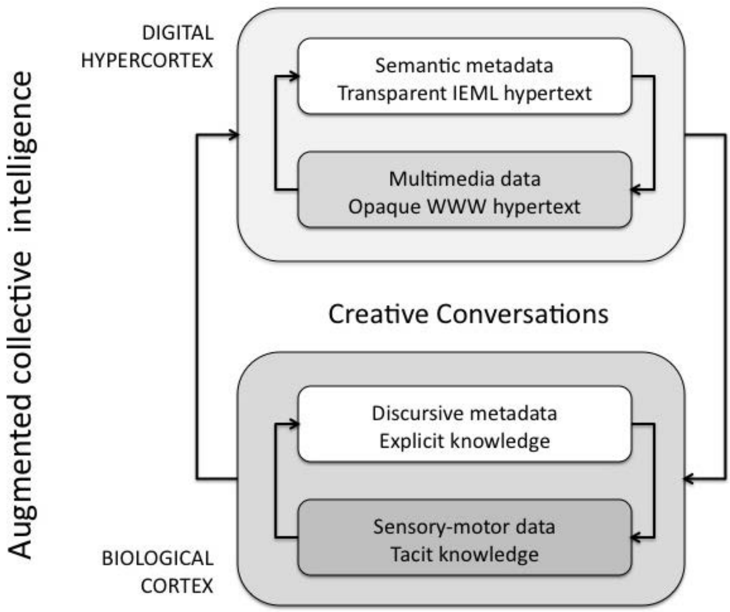

Figure 12.4. *Augmentation of the cortex by the Hypercortex*

Just as the secret of the human biological cortex lies in a dialectic between phenomenal experience and discursive thought, the secret of the digital Hypercortex may be found in a reciprocal correspondence between opaque networks of multimedia data and transparent circuits of semantic metadata. Since discursive thought can only be expressed in phenomenal form (the signifiers of the symbols are classes of sounds, images, etc.), the process of calculation on the semantic metadata will necessarily have to take the form of calculations on data: once again, the addressing system of the Web as it exists today will still be necessary as the "physical" medium for the semantic mechanism. Going from one layer of addressing to the next, the semantic sphere is based on the Web, which is based on the Internet, which itself interconnects physical automata whose operating systems address bits[21].

How autonomous will the new Hypercortex be? I am well aware that science fiction stories and the prospect of a "singularity" as discussed by Kurzweil often evoke the threat of machine intelligences becoming autonomous. I have elaborated on this point already[22], but I must mention here that in the early decades of the development of computers, all journalists and most scientists talked about nothing but artificial intelligence and autonomous machines. Only a few rare visionaries (such as Douglas Engelbart and Joseph Licklider) were working – amid general indifference – toward the augmented intelligence and collaboration that would follow. In fact, the actual development of the digital medium gave rise to a new universe of communication and cultural creation rather than to artificial intelligence (unless we call any symbol-manipulating automaton artificial intelligence). The coming Hypercortex is techno-cultural and socio-semantic. It has no existence outside its link to the biological Cortex. Of course, the production and interpretation of data will be augmented by symbol-manipulating automata, programs themselves supported by physical machines. It will always be living human beings – driven by their phenomenal experience and discursive thought steeped in emotion – who will read, write and program, who will express themselves and interpret the messages of their peers, who will interweave the virtual multimedia universes of culture and the space–time territories of nature. What is more, the addition of semantic metadata to the data of the Web, like the translation of these metadata into multimedia images, will involve interpretation. This interpretation will be able to be automated, but this could be done in any imaginable way, depending on the needs, desires and orientations of widely varied communities. It is the processes of creative conversation that will organize the relationship between the biological Cortex of an individual and the digital Hypercortex of the species. It is creative conversations that will link the (opaque) network of the data of the Web and the (transparent) circuits of the metadata of the semantic sphere.

12.5. Toward an observatory of collective intelligence

As shown in Figure 12.3, the Hypercortex develops over time, emerging from the superimposition of successive layers of addressing. In Figure 12.4, the emphasis is on the structural symmetry between cortical cognition and hypercortical cognition, and on the central role of creative conversations in controlling the

21 See Figure 12.2.

22 See section 8.2.

relationship between the Cortex and the Hypercortex. I would now like to present a third perspective on the Hypercortex: that of the conditions required for the construction of a mirror of collective intelligence, as shown in Figure 12.5.

The Hypercortex is represented here as an observatory or mirror of cortical cognition. The mirror as a whole may be seen as two linked spheres: the logical sphere (the Internet) and the IEML semantic sphere. Materially, the existence of the Internet is obviously necessary for the functioning of the semantic sphere. The semantic circuits are simulated by electronic circuits coordinated by the Internet. The units of semantic information (IEML models of ideas) connect URLs to USLs and, finally, Web applications implement collective interpretation games of the hermeneutic memory.

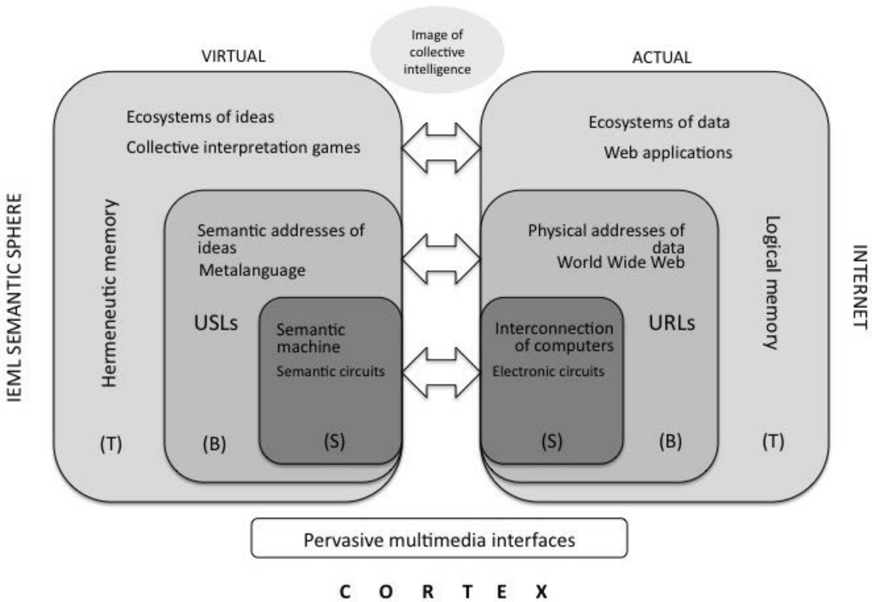

Figure 12.5. *Model of the Hypercortex*

12.5.1. *Sensory-motor interfaces*

The contemporary (2011) digital medium corresponds roughly to what could be called the logical sphere. This sphere is based on digital encoding, the availability of logical automata for operating on binary encoded data, universal communication of these automata through the Internet and, finally, universal addressing of data by the Web. I defined this universal logical sphere in terms of a few basic characteristic properties, which I recall here. First, it permits automatic manipulation of symbols and, consequently, of multimedia digital data of all kinds. Next, it should be noted that these data can be interconnected, compiled and differentiated at will. Finally, both the interconnected multimedia data and the calculating power are now available ubiquitously by means of all kinds of non-invasive interfaces (pervasive computing, various wireless devices and augmented reality). There is thus no doubt that the digital medium has the technical capacity to reflect back to creative conversations and the individuals participating in them personalized images, calculated in real time, of the subjects or processes that interest them. It is through the logical sphere of the Internet and its sensory-motor interfaces that the Hypercortex will be linked to human bodies, and thus to the Cortex.

12.5.2. *The IEML semantic machine*

The semantic sphere corresponds to what I have called the fourth layer of encoding of the digital medium. The semantic sphere is itself generated by the IEML semantic machine. This machine may be visualized as an abstract mechanical spider navigating and weaving the semantic sphere. As we saw above, this machine may be broken down into: (i) a textual machine based on IEML; (ii) a linguistic engine based on the STAR dialect; and, finally, (iii) a conceptual machine that traces and measures circuits in the semantic sphere. Let us consider the nodes of the semantic sphere (the USLs translated into natural languages) and their relationships as the variables of an algebraic system of symmetric transformations. The conceptual machine can then be defined as the interoperable set of automata manipulating these variables. No one will be surprised to find that the heart of this mechanism of reflection is a machine implementing a system of symmetrical operations.

12.5.3. *The semantic sphere*

The semantic machine models the heart of the human symbolic faculty: the semantic functions, which permit the manipulation of explicit concepts. Woven by the semantic machine, the semantic sphere coordinates the universe of concepts. The mathematical demonstration that the semantic machine can actually be implemented also proves that the semantic sphere can be simulated.

Let us imagine a huge fractaloid circuit in which the junctions (the USLs) and the channels (the semantic relationships) are translated into natural languages. This hypertext, which is transparent to calculation, places the world of ideas in a unique system of semantic coordinates. Symbolic cognition then belongs to a practically infinite nature that is coherent and describable in calculable functions that combine – as much as possible – the operations of transformation groups. It thus becomes scientifically knowable.

The USLs translated into natural languages are the densely interconnected nodes of a conceptual monadology. Each USL represents a concept that is formally defined by its relationships or semantic links with other concepts. The set of semantic links among the USLs forms the topology of a consistent cosmos. The semantic sphere encodes a huge number (beyond the recording capacities of the physical universe) of distinct concepts and semantic relationships among these concepts. Both the USLs (representing concepts) and the semantic circuits among the USLs belong to a single system of algebraic transformations and thus form the variables of an unlimited diversity of functions that are calculable by the semantic machine. The transformations and paths in the universe of concepts modeled in this way represent the movements of discursive thought.

12.5.4. *The IEML metalanguage: the key to semantic interoperability*

The Web is gradually encompassing all of human memory, and its public content is increasingly becoming the corpus of the human sciences. The new scope of this memory confronts us with a unique problem of coordination, which has two facets: semantic interoperability is a serious problem for engineering, and knowledge management is a serious problem for the human sciences[23]. The existence of a calculable, interoperable scientific language for encoding concepts solves both the problem of semantic engineering and that of the human sciences by providing a system of semantic coordinates that has until now been lacking. The nucleus of this language exists. All it needs to become fully operational is to be developed lexically and instrumentally.

The STAR dictionary contains 3,000 terms in 2011. This is obviously not enough, but it nevertheless proves that the construction of a dictionary is possible. Since its scientific (mathematical and linguistic) foundations are solid, a team of engineers and researchers in the human sciences could work with full confidence on the development of the STAR dictionary and computer applications for using the metalanguage. With the STAR linguistic engine, each valid IEML expression will be translated automatically into a multitude of natural languages. IEML could thus be used as a bridge language, which means that the solution to the problem of semantic interoperability is in sight. For the human sciences, the availability of a scientific metalanguage will lead to new methods of knowledge management. IEML will improve collaboration among research teams working with different hypotheses, theories or organizing narratives. In fact, the same metalanguage makes it possible to say a thing and its opposite, to categorize the same data differently and to categorize different data the same way. Rival schools of thought will thus be able to use the same language of semantic metadata exactly the way enemy armies use

23 See Chapters 4 and 5.

the same system of geographic coordinates. If we want a Hypercortex that serves the needs of knowledge management and competitive cooperation in the human sciences (whose basic corpus is now none other than the Web itself, i.e. logical memory), then this Hypercortex must reflect collective human intelligence from all possible points of view while ensuring the interoperability and comparability of these points of view.

12.5.5. *Ecosystems of ideas: introduction to hermeneutic memory*

The Hypercortex will reflect collective human intelligence not only in terms acceptable to the human sciences, but also in a manner that will improve their tools, methods and modes of collaboration, without imposing any kind of epistemological, theoretical or cultural bias[24]. I express this condition by saying that the Hypercortex will contain a hermeneutic memory. As we know, hermeneutics is the art of interpretation of texts or signs in general. I have chosen the adjective *hermeneutic* to describe the memory of the Hypercortex in order to clearly indicate its perspectivist dimension[25]. The memory of the Hypercortex will accommodate open hermeneutic activity without imposing any particular method of interpretation.

There can be no intelligence without memory. Human collective intelligence is a mechanism of memory: cultural *traditions* (i.e. trans-generational memories) are organized by *symbolic systems* such as languages, sciences, religions, laws, esthetic rules and genres, and political structures. This means that a memory that contributes to the *reflection of collective intelligence* cannot just be a simple accumulation of data. It must *also* represent the divergent points of views from a multitude of cultural traditions and symbolic systems. This requirement implies complete freedom of interpretation of data. That is why the hermeneutic memory will allow the conception of all kinds of functions of categorization and evaluation of data (functions of perception) and of production and association of ideas (functions of thought), as well as the composition of a multitude of collective interpretation games combining these functions. To represent the value or weight of the symbolic energy that is distributed and exchanged in ecosystems of ideas, the collective interpretation games will model dynamics of current in the circuits of the semantic sphere. The hermeneutic memory of the Hypercortex will thus contain an open semantic information economy, in the sense defined in Chapter 6.

The openness of the hermeneutic memory accommodates the need to explore new points of view on the shared corpus and allow competition among different methods of categorization, evaluation and semantic interconnection of data, i.e.

24 See Chapter 5 on the epistemological transformation of the human sciences.

25 *Perspectivism* is used here in the philosophical sense, as in Leibniz or Nietzsche.

different ways of knowing and interpreting. This point is as essential for the vitality of the human sciences as for freedom of thought in general. The semantic addressing, evaluation and theoretical or narrative presentation of data are hermeneutic constructions (i.e. interpretations) that are free and plural, and as such deconstructable. All schools of thought will be able to model their own universes of discourse and their collective interpretation games in the Hypercortex. It will be impossible to impose a collective interpretation game on a creative conversation that wants a different one. At the same time, on a broader scale, the rivalry of schools of thought will serve cognitive cooperation. Indeed, since the different collective interpretation games organizing the memory will use the same metalanguage, the same semantic playing field, it will become possible to compare meanings, knowledge and practical orientation effects produced by competing universes of discourse, narratives and games.

12.6. Conclusion: the computability and interoperability of semantic and hermeneutic functions

As shown in Figure 12.5, the logical sphere (the Internet) and the semantic sphere (IEML) cooperate to make the Hypercortex work.

The logical sphere performs the functions of data storage and arithmetic and logical calculation. It makes a multitude of ubiquitous sensory-motor interfaces available to users.

The semantic sphere ensures the computability and interoperability of semantic functions (production, connection and transformation of concepts) and hermeneutic functions (production, connection and transformation of ideas). It is based on an artificial language that generates a “semantic topology”, i.e. a universal system of calculable semantic coordinates. This system of coordinates permits the collaborative categorization and evaluation of data by means of a multitude of collective interpretation games.

The Hypercortex reflecting collective human intelligence responds to a “transcendental deduction” of the conditions of possibility of a scientific modeling of the mind[26]. The most fundamental condition for the possibility of the Hypercortex is a semantic machine capable of working with a universe of concepts. Since this machine is abstract, or formal, in nature, its existence depends on its mathematical definition and proof of the calculability of its operations. Since I have formally defined this machine and demonstrated the calculability of its operations, it therefore

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26 On the concepts the *transcendental* and *conditions of possibility of knowledge* in general, see *The Critique of Pure Reason*, by Immanuel Kant [KAN 1787].

exists (formally)[27]. The virtual existence of this machine ensures that scientific modeling of the world of ideas is possible. The beginnings of a multilingual STAR-IEML dictionary show that it is also possible to weave the semantic sphere of USLs and translate its great hypertext network into natural languages[28]. Therefore it seems to me that it has been established that IEML can effectively play the role of a system of semantic coordinates for a multitude of collective interpretation games driving a huge ecosystem of ideas. I deduce from this that it is practically feasible to organize the data of the Web (which are currently rather opaque) in a perspectivist and transparent hermeneutic memory. Finally, it is obvious that if this hermeneutic memory were to take form, the ubiquitous multimedia digital medium could reflect back to creative conversations and their participants the synthetic, personalized, interoperable images of their collective interpretation games.

Once again, it is difficult to predict the pace of these developments and all their scientific and cultural implications. The technical and organizational effort required will certainly be considerable. Since the conditions of possibility of a Hypercortex containing a hermeneutic memory already exist formally, and since the network of creative conversations that will decide whether to take this path to cognitive augmentation will gain some advantage from it in terms of human development, I predict that the digital medium will sooner or later become the scientific mirror of collective intelligence.

27 See the chapter on semantic topology in Volume 2 and, meanwhile, [LÉV 2010b].

28 On the work under way in building the dictionary, see [LÉV 2010c].

Chapter 13

Hermeneutic Memory

13.1. Toward a semantic organization of memory

The Hypercortex can be seen as a memory, since it contains and organizes data. It functions as a *hermeneutic memory* that allows the application of multiple interpretation strategies. As we will see in this chapter, this memory is perspectivist – it integrates many distinct points of view – and is structured in layers of increasing complexity (data, information, knowledge). Different creative conversations can generate automatable functions in it as they see fit. Some of these functions will categorize and evaluate data, thus producing semantic information units, which are formal representations of ideas. Other functions will situate these information units in encompassing theoretical or narrative contexts that will specify or transform their meaning. The combinations of these hermeneutic functions form a multitude of collective interpretation games. It is thanks to the existence of a common metalanguage for computable semantics (IEML), which, as we have seen, provides a system of coordinates for the world of ideas, that all these games can converse and exchange their cognitive resources in the same general semantic information economy. The Hypercortex will thus function as a collaborative tool for enhancing individual and social knowledge management[1].

Figure 13.1 shows the location of Chapter 13 in the discussion of the general structure of reflexive collective intelligence. Neither the semantic machine nor the IEML metalanguage is a goal in itself. The main goal of the techno-symbolic system based on the IEML semantic sphere is the modeling or simulation of the world of

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1 As we will see, this chapter deals with the same subject as Chapter 6 and contributes to solving the problems raised in Chapters 4 and 5.

ideas that reflects collective intelligence. It is precisely this monadological model of the world of ideas that will be described in this chapter on the hermeneutic memory of the Hypercortex.

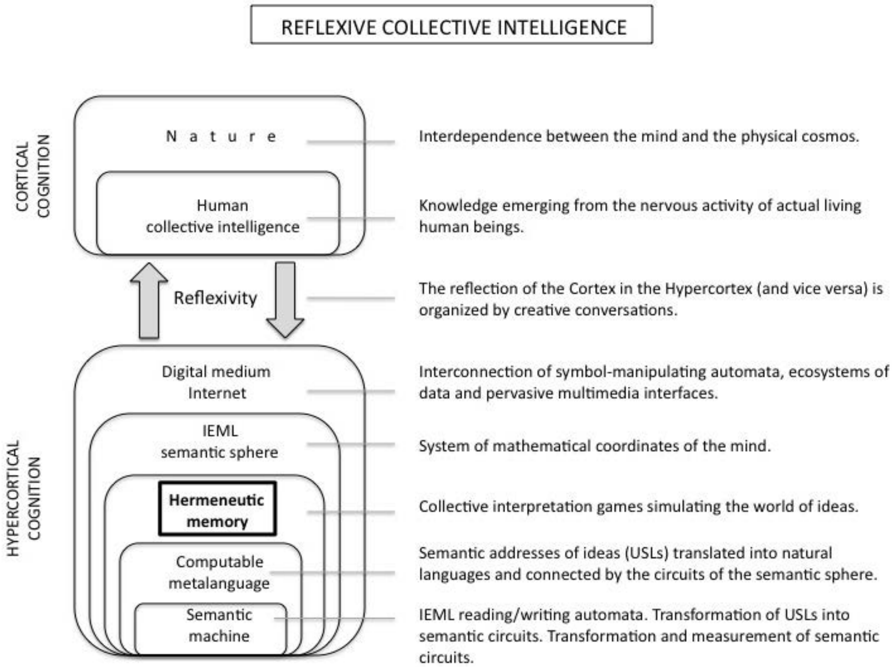

Figure 13.1. *Position of Chapter 13 on the conceptual map*

13.1.1. *Implications of collective processes of categorization in the digital medium*

For the first time in history, thanks to the digital medium, humanity is cultivating an interconnected shared memory in which ubiquitous data can be transformed at will by symbol-manipulating automata. The public has only had access to the Web since the mid-1990s, so the techno-cultural exploration of this shared memory has only just begun. Even before the appearance of the Web, a few intellectual technologies using computers had already emerged, such as spreadsheets, multimodal interactive simulations and hypermedia. My hypothesis, however, is that the major developments in the full symbolic and cognitive exploitation of a global digital memory are still to come. No generation before ours has been able to organize and use a practically inexhaustible flow of data of such cultural variety, produced by human communities present and past. To meet this challenge, we have to deal with the problem of augmenting our collective capacity to categorize and evaluate digital data.

Generally speaking, the activity of categorization is the key to cognitive processes, and this is particularly the case for human cognitive processes, which are organized in symbolic systems that are cultural in origin[2]. More specifically, recent work has shown that the design and management of databases – which are ultimately organized by systems of categorization – is becoming one of the main scientific activities[3] and perhaps the essence of digital art[4]. Social media such as Diigo, Facebook, Twitter, LinkedIn, Flickr and YouTube, as well as blogs, ask their users to actively participate in categorizing data. In the future, personal cloud management – managing personal data and services via the Internet[5] – and online personal knowledge management will become widespread and systematic. Here again, the implications of the methods of categorization are central and they have impacts on the collaborative management of the knowledge that is taking shape in public administrations, corporations and research networks[6].

The problems involved in categorizing data have become hypercomplex and gigantic in scale. The first efforts to solve these problems while respecting their complexity are beginning to see the light of day. I mention in particular research on improving processes of social tagging[7] online and the web of data based on the RDF standard and ontologies expressed in OWL[8].

13.1.2. *A renewed approach to the problem of categorization*

The reader who has reached this point is already familiar with my thesis: natural languages, like systems of notation invented before 2000, are not suitable for the nature and scale of the collective processes of categorization that will become

2 See *The Savage Mind* [LÉV 1966].

3 See the excellent book by Geoffrey Bowker, *Memory Practices in the Sciences* [BOW 2005].

4 See the classic book by Lev Manovich, *The Language of New Media* [MAN 2001].

5 On all these topics, see Nova Spivack's blog: http://www.novaspivack.com.

6 See Chapter 4 on creative conversation.

7 See the technical studies by Smith, *Tagging: People-powered Metadata for the Social Web* [SMI 2007], and Dichev *et al.*, "A study on community formation in collaborative tagging systems" [DIC 2008]. Also worth consulting is Michèle Drechsler's thesis, Le Socialbookmarking dans l'Éducation [DRE 2009].

8 OWL is the acronym for Ontology Web Language. See Feigenbaum *et al.*, "The semantic web in action", and Handler and Allemang, *Semantic Web for the Working Ontologist* [FEI 2007, HEN 2008].

current in the digital medium in the 21st century and beyond. Neither natural languages nor the traditional documentary languages (such as those used in libraries) were designed to exploit the new interconnected global memory and its calculating power. Natural languages are in harmony with the functioning of the human brain and are obviously not made to be processed automatically. The old systems of notation and writing were invented in times when methods of physical storage and retrieval of information were heavy, slow, manual and local, as opposed to the automatic, ubiquitous, ultra-rapid systems we have today.

Most search engines circumvent the problem of precise semantic representation of data and their free interpretation by users by carrying out statistical calculations on chains of characters – the primary purpose of which is to represent sounds (and not concepts) – or links – the primary purpose of which is to point to data (and not to categorize them).

Ontologies deal with the problem of categorizing data on the Web by constructing rigid logical relationships among chains of characters, most often URLs (which are semantically opaque). This is the heritage of expert systems and research on artificial intelligence (AI) that predate the Web, however, and these ontologies only formalize limited conceptual universes. That is why the web of data produces a large number of ontologies that are often disconnected from each other, while all digital data are potentially interconnected in the global memory.

In my view, trying to synchronize and optimize processes of categorization as varied and massive as those in the digital medium using natural languages and systems of categorization that pre-existed the Web is like trying to perfect algorithms for manipulating numbers encoded in Roman numerals instead of first seeking a better symbolic system for encoding numbers. We need a symbolic system for the notation and manipulation of concepts that is designed from the outset for massively distributed real-time social computing in an interconnected global memory. This is precisely what IEML is. In order for IEML to help each creative conversation to organize the digital memory for its own purposes while maintaining semantic interoperability with all the others, the use of the metalanguage must be based on a coherent philosophy of memory.

13.2. The layers of complexity of memory

We are familiar with the famous quotation from T.S. Eliot: “Where is the life we have lost in living? Where is the wisdom we have lost in knowledge? Where is the knowledge we have lost in information?”[9]. This poetic cascade of questions

9 [ELI 1934].

elegantly describes our situation in the practical world. It has been used in the world of corporate management for some 30 years[10] to describe the chain of successive abstractions – or the scale of growing value – linking data (which we do not find in the Eliot quotation), information, knowledge and wisdom. Usually when the data–information–knowledge–wisdom (DIKW) hierarchy is invoked, it is to prevent confusion between one link in the chain and the next. Data (numerical or quantitative) are rudimentary, while information (readable and interpretable) is categorized, evaluated and commented on.

Information is isolated, however, whereas knowledge links information in patterns and gives it meaning in a context. This knowledge (of experts?) may eventually be explicated and formalized in a communicable theory, while wisdom (of leaders?) implies both profound experience in human affairs, the humility that comes from self-knowledge, and direct intuition that is impossible to express in a formula. The DIKW chain also suggests a process of progressive refinement or transformation, going from raw material, represented by data, to the most valuable but probably the most volatile final product – wisdom. Although the DIKW chain or pyramid has been cited for decades and has appeared in thousands of PowerPoint presentations, its elements have rarely been precisely defined. We would search in vain in scientific journals for a functional formalization of the transformations from one to the next.

I will now use the structure provided by this commonplace chain to describe the four degrees of complexity of memory in the cognitive model of the Hypercortex[11]. I will propose my definition of each level of complexity as well as an operational approach to the transitions from one level to another.

I would like to begin by defining the hermeneutic approach to symbolic cognition, which will permit me to functionally formalize the DIKW pyramid.

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10 See, for example, [ACK 1989].

11 The four layers of addressing of the digital medium (see Figure 12.3) must not be confused with the four layers of complexity of memory, which I am discussing here (see Figure 13.2).

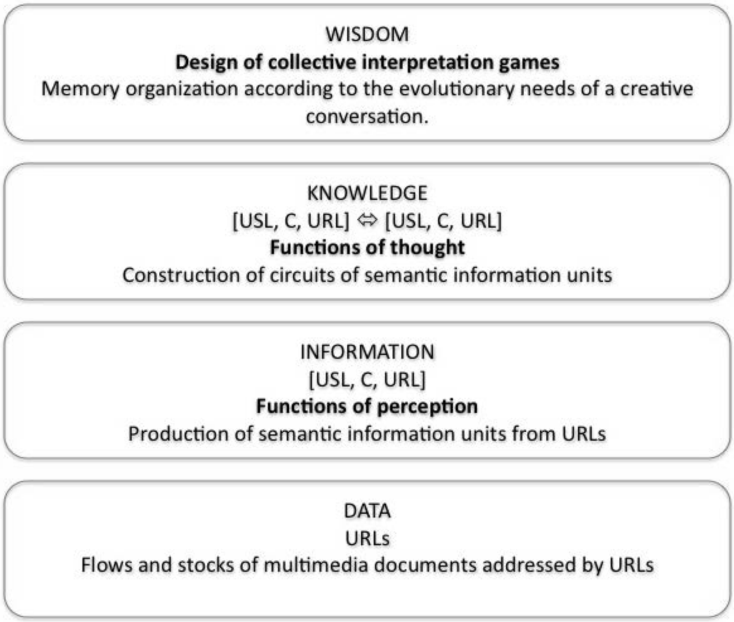

Figure 13.2. *Complexity layers in the hermeneutic memory of the Hypercortex*

13.3. Radical hermeneutics

13.3.1. *Introduction to the hermeneutic approach to cognition*

At its origin, hermeneutics was the art of interpretation of texts[12]. Interpreting a text essentially means reading it in a deep, systematic way in order to extract the meaning that is most interesting and useful from the point of view of the interpreter and the community to which he or she belongs. This work of reading consists, in practice, of writing texts (peritexts, epitexts, paratexts of all kinds) about the text being interpreted. Reading and writing involve the same basic hermeneutic operations, in which the creation of meaning is central.

The concept of text in contemporary hermeneutics is much broader than that of the written notation of speech. On this point, I am drawing on postmodern and deconstructionist (in the broad sense) perspectives pioneered by authors such as

12 See Georges Gusdorf, *Les Origines de l'Herméneutique* [GUS 1988].

Wittgenstein[13], Foucault[14], Derrida[15] and Lyotard[16], in which all types of symbolic arrangements can be considered texts, including those based on oral traditions or iconic, musical, ritual or other non-linguistic symbolic systems. In this approach, the processes of reading and writing texts involve an infinitely open multitude of language games, epistemes or functions of textual production and interpretation, no one of which is favored in principle. Ultimately, there is no objective, exterior or neutral meaning. Meaning is always produced by a particular mechanism of textual interpretation, and all hermeneutic (meaning-producing) machinery is necessarily dated and situated.

My conception of hermeneutics is also in keeping with the view popularized by Gadamer[17], Ricoeur[18], Gusdorf, Vattimo[19], Grondin[20], etc., that the hermeneutic process in the human sciences, rather than producing an "objective truth" through the application of formal methods to cultural artifacts, translates a truth of human experience that is always singular and is embedded in a particular history. This understanding of hermeneutic activity has obvious affinities with Nietzsche's perspectivism[21], which must be distinguished from the view that "everything is

13 See *Philosophical Investigations*, [WIT 1958]. Wittgenstein does not use the word *text*, but his approach to language games and their "grammars" could be translated into a general theory of textuality.

14 Michel Foucault, *The Archaeology of Knowledge* [FOU 1972]. In this book, Foucault develops the concept of *discursive formation* and extends the concept of *episteme*. Judgments of truth and interpretive statements are reduced to the sociohistorical conditions in which enunciating subjectivites (I would say: cognitive functions) are constructed. Although Foucault emphasizes the multiplicities, ruptures and differences that act on discursive formations, he is clearly drawing on Nietzschean perspectivism (therefore hermeneutics) and structuralism.

15 See *Of Grammatology* [DER 1976], which puts forward an abstract view of writing or text and sees it as prior to – and independent of – any system of characters, letters or notation of speech.

16 See Jean-François Lyotard, *The Postmodern Condition: A Report on Knowledge* [LYO 1984] and *The Differend: Phrases in Dispute* [LYO 1988].

17 Hans-Georg Gadamer, *Truth and Method* [GAD 1988].

18 Paul Ricoeur, *The Conflict of Interpretations: Essays in Hermeneutics I* and *From Text to Action: Essays in Hermeneutics II* [RIC 1974, RIC 1991].

19 See the remarkable *Etica dell'Interpretazione* [VAT 1989], in which Vattimo clearly distinguishes radical hermeneutics, which originates in a meditation on language, from plain and simple cultural relativism.

20 Jean Grondin, *L'Universalité de l'Herméneutique* [GRO 1993] and *L'Herméneutique* [GRO 2006].

21 It is useful here to remember that as a very young man, Nietzsche was a teacher of philology and that he had been trained in the interpretation of ancient texts [NIE 1900].

equally valid", which is typical of extreme relativism. With the freedom to interpret comes the responsibility to guide a community's symbolic cognition, which requires great prudence[22]. My approach to hermeneutics also owes a lot to the concept of radical imagination developed by Cornelius Castoriadis[23], for whom human creations of meaning cannot be entirely reduced to some mechanistic determinism but derive from an autonomous, irreducible creative power.

13.3.2. *The thesis of radical hermeneutics*

My hypercortical model of cognition is consistent with a thesis held today by many scholars in faculties of arts and social sciences, which may be called *radical hermeneutics*. This thesis can be articulated in two interdependent propositions: first, it is impossible to separate symbolic cognition from memory and, second, all organization of memory is interpretative in nature.

13.3.2.1. *It is impossible to separate cognition from memory*

The physical recording of data (like the material capacity to store, classify, sort and organize data) is certainly a condition of memory, but it cannot be identified with memory itself. Common sense tells us that an indefinite accumulation of data without any form of organization does not make a very useful memory. We can think of a random pile of books as opposed to a library, where the books are arranged on shelves according to call numbers and can be found by author, title and subject in a catalog. Storehouses of data become real memories only insofar as they permit operations of selection according to semantic criteria (categorization: what is the document about?) and criteria of importance or relevance (evaluation: what is the value of the document?), which depend ultimately on an emotional investment. In addition, we know that data only become meaningful when structured by theories, narratives or other organizing perspectives. Memory therefore implies most other cognitive operations, in particular affective investment, categorization and discursive organization.

Similarly, it is difficult to conceive of any cognitive operation (perception, learning, problem solving, symbolic manipulation in general) that does not call upon short-term or long-term memory. How, for example, could a person understand an utterance if he or she only remembered the end of it and not the beginning (short-term memory) or had no knowledge of the context shared with the speaker (long-term memory)? The same is true of music: without memory, we could not perceive rhythm or melody, and music itself can bring back memories. For these reasons we

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22 I am speaking of prudence in Aristotle's sense, i.e. as practical wisdom that comes from moral strength, a courageous prudence that has nothing to do with fear or timidity.

23 Cornelius Castoriadis, *The Imaginary Institution of Society* [CAS 1998].

must not think of memory as something that can be separated from cognition, but as its temporal dimension, and it is impossible to remove cognition from time. This is true not only for personal cognition but also for social cognition: institutions, like cultures, necessarily function on the basis of a memory: archives, narratives, rituals, transmission of memories or traditions, landscapes shaped by humans.

13.3.2.2. *All organization of memory is interpretative in nature*

As we have seen, memory implies categorization, evaluation and some kind of narrative or theoretical ordering. All these operations result from interpretative choices – they are hermeneutic operations – because there are always other possible ways in which to organize data. Since all symbolic cognition implies the participation of memory and all memory results from interpretative choices, symbolic cognition is intrinsically hermeneutic in nature. In other words, according to the thesis of radical hermeneutics I am defending here, a cognitive system is an interpretive machine. This thesis can give rise to certain misunderstandings, which I would like to dissipate immediately.

13.3.3. *Radical hermeneutics beyond the misunderstandings*

First, interpretation is not necessarily a vague, "purely subjective" process. It is clearly possible to establish very strict rules of interpretation, as is done, for example, in linguistics, philology, law, theology, etc. The modern natural sciences are based on rigorous interpretation procedures. Scientific research does not preclude interpretation; it simply advocates methods of interpretation that are explicit, shared and unambiguous, that lead to observable predictions, etc. It is a commonplace in the epistemology of science that observable data have meaning only according to a theory, i.e. theory truly plays the role of a system of interpretation of data. There is therefore no contradiction in principle between the hermeneutic approach to cognition and the scientific imperative of functional modeling of cognitive mechanisms.

Second, affirming the hermeneutic nature of symbolic cognition does not mean accepting that there can be no communication among people or that cultures are incommensurable, on the pretext that "everything is a matter of interpretation". It is understood that certain messages are produced with the intention of being interpreted in a certain way and not any other way. The thesis of the hermeneutic nature of cognition in no way precludes interlocutors from different cultures from sharing common interpretation procedures. This is precisely the case with mathematics and the exact sciences, whose statements and practices can circulate among different cultures. In music, dance and other art forms, the expressive force also seems to transcend the barriers of cultural codes. Finally, international trade, in spite of its risks and inequities, is further evidence of cross-cultural agreements that work.

Third, as I stated above, radical hermeneutics does not necessarily imply extreme relativistic indifference. It is clear that certain methods of interpretation, because of their practical consequences, are not viable in the long term, while others tend instead to benefit the communities or institutions that use them.

Now that possible misunderstandings have been dissipated, I can say that radical hermeneutics states simply that symbolic cognition (whether individual or social) involves processes of creative interpretation rather than representations of a pre-given reality. There is no categorization, evaluation, narration or theorizing that is absolutely true: all these operations interpret the given, i.e. they give it meaning. In addition, in human cognition the production of meaning is necessarily based on cultural apparatuses. It is indissociable from social memory, in which meaning emerges from the collective manipulation of symbolic systems (the classic examples of which are languages and writing systems) working on corpora of shared data.

I conceived the cognitive model of the Hypercortex so that it would be in keeping with the hermeneutic approach to cognition I have described. In this model, IEML plays the role of language for data interpretation, or metalanguage. The metalanguage is shared, but the statements (the acts of categorization) and the texts in IEML (the USLs) are unique and are the responsibility of their authors. Categorization is not all that is involved. It is also necessary to consider evaluation. In fact, as I pointed out above, the production of meaning does not occur without a certain intensity of emotion or force of intention. Could there be any distinctly human meaning without circulations of affects and desires infusing their energy into the games of symbolic structures? That is why the semantic machine at the core of the Hypercortex automatically transforms IEML texts (USLs) into circuits in which evaluations will produce semantic currents. These semantic flows represent the affective dimension of the production of meaning.

13.4. The hermeneutics of information

13.4.1. *Data*

The base of our pyramid of the complexity of memory is occupied by data. From the point of view of cognitive modeling in the Hypercortex, data are not defined by their content but by their addressing system. Data can therefore be rudimentary or elaborate, quantitative or textual, audio or video, light or massive: they will be considered data only because they are addressed by URLs. It should be noted that the URL is in no way a unique description of unique content. The same content can be found in many different URLs and the same URL can address a flow of data rather than a fixed content, as is commonly seen in blogs and newsfeeds of social media. The URL is opaque and simply provides an access route to the electronic container, but it says nothing about the content of this container.

13.4.2. *Perception*

Ideally, creative conversations should be able to collaboratively categorize, evaluate and filter the storehouse of data of the Web according to their own criteria. In addition, if data are organized in different ways, so that creative conversations are separated by walls, the potential usefulness of a global memory is not optimized. Let us recall the well-known silos created by the incompatible formats of the "clouds" controlled by the big companies of the Web or the "semantic silos" of ontologies. The problem is going from data (identified by the addresses of their electronic containers) to semantic information units, i.e. data freely categorized and evaluated but meeting the requirements of semantic interoperability. The function of perception is implemented by a mechanism that adds a metadatum (a semantic current in the semantic circuit corresponding to a USL) to a datum. When the datum that is the URL is categorized and evaluated, everything works as if it was "perceived" by the cognitive system of a creative conversation.

13.4.2.1. *Categorization*

In the model of hermeneutic memory, a datum is defined solely by its Web address (a URL). To obtain a semantic information unit, this datum must first be categorized, i.e. given a semantic address, a USL, with which the STAR-IEML linguistic engine automatically associates a semantic circuit. Assigning USLs to data can be done by any method imaginable, from the most spontaneous, artisanal and "manual" to the most regular, industrial and automated[24]. There is no question here of any kind of regulation.

13.4.2.2. *The semantic current*

The strength of the link between a multimedia datum (formalized by as a URL) and the semantic address that categorizes it (formalized as a USL) is represented by a semantic current *C*[25]. The semantic current is a symbolic energy insofar as it joins

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24 All kinds of methods of statistical analysis of data or software for automatic processing of natural language can be used for categorization in IEML. See, for example, Yair Neuman and Ophir Nave's interesting method for extracting meaning from documents based on the analysis of metaphors [NEU 2009].

25 On the concept of semantic current and its justification from the point of view of the human sciences, see section 6.3.

together the two parts (category and datum) of a symbolic unit. It is the energy that, in connecting the semantic sphere to the web of data, creates the information unit. The production of this current can itself be broken down into two components: the production of polarity and the production of intensity.

13.4.2.3. *The production of polarity*

After categorization ("What is it? What is it about?"), the second major function of assimilation of data in symbolic cognition is thus its evaluation, which can be broken down into the evaluation of quality (typically, good or bad) and of quantity (typically, little or a lot). The quality, or polarity, of the current ("What is it worth?") is represented by an ordinal number[26]. The function of evaluation of polarity corresponds roughly to the affective dimension of animal cognition: attraction or repulsion, pleasure or pain. Polarity can be determined by a price or by a vote, by manual or automatic procedures, etc. All games of evaluation are possible. The word *polarity* designates nothing absolute here. It is a degree on a scale based on certain evaluation criteria. The value of polarity can indicate truth (for example, on a scale from completely false to completely true), importance, suitability, danger, humor, beauty, effectiveness, etc., as the case may be. Polarity thus has an assignable meaning only if the method and criteria of evaluation used to determine it are explicit. Like the functions of categorization, the functions of evaluation of polarity should be absolutely free. They can meet a large number of distinct criteria, even a whole range of combinations of criteria.

13.4.2.4. *The production of intensity*

A clear distinction needs to be made between the qualitative evaluation of polarity and the quantitative evaluation of intensity. This is not always obvious because we tend to believe that everything that has a numerical form is quantitative. When a teacher gives a student a mark, for example, it does not really represent a quantity, although it is a number. It is simply a convenient way to place the student on a scale of quality or value in comparison to other students in the same class or in relation to a criterion of excellence established by the academic institution. It is clear, for example, that the question of whether a document is of high or low quality is distinct from that of whether the document contains little or a lot of text, measured in bytes (quantity). The intensity of semantic current measures quantity and is formalized by as a cardinal number. It may indicate the number of downloads or clicks, the volume of a data flow or frequency of use, but also, depending on the way a creative conversation creates its information units, a volume of production or

26 An ordinal number designates a "rank" or numerical order. It gives the position of an item in an ordered series, while a cardinal number is used to define the size of a set. On the importance of ordinal numbers to express priorities or preferences, see [SLO 2009].

consumption, a debit or a credit, etc. Like the evaluation of quality, the production of the intensity of semantic current should follow an explicit procedure.

13.4.2.5. *The result of perception: the phenomenal information unit*

The operation of perception combines two hermeneutic operations: categorization, which determines the semantic circuit associated with a datum, and production of semantic current in the circuit. The production of the current can itself be divided into the production of intensity and the production of polarity[27]. The result of perception is a *phenomenal information unit*, or a *phenomenal idea*.

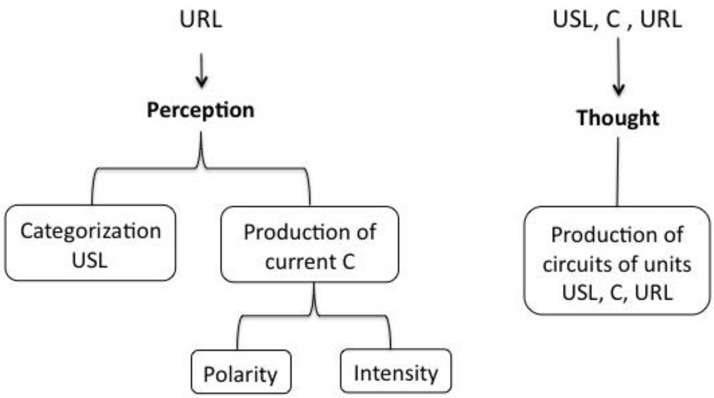

Figure 13.3. *Hermeneutic functions of a collective interpretation game*

13.4.3. *The semantic information unit*

As shown in Figure 11.5, the semantic information unit is represented by a triad (URL, C, USL). First, the semantic information unit so defined represents a datum that is actually categorized, quantified and evaluated. This is precisely what we were looking for. Second, each creative conversation can adopt its own rules of perception. The functions of categorization and production of current on the data of the Web are entirely free, and are thus in keeping with our hermeneutic approach to cognition. Third, all semantic information units are interoperable, since they are expressed in interoperable terms. Indeed, (i) URLs are universal; (ii) USLs and numbers, also universal, are variables of calculable transformation groups; and, finally, (iii) USLs are translated automatically into semantic circuits that are readable in all languages. Our model of ideas – semantic information units – is thus

27 See Figure 13.3.

in keeping with the epistemological requirements of full explication and calculability of the exact sciences.

13.5. The hermeneutics of knowledge

13.5.1. *Thought*

The data categorized and evaluated by creative conversations can be considered their perceptions or phenomenal ideas. Once these phenomenal ideas are produced, the problem of creative conversations is to put them to use in order to understand their environment and orient their actions. This is where the functions of thought come in.

Unlike what happens with the functions of perception, the input variables of the functions of thought are not data (URLs), but semantic information units (USL, C, URL), which are produced either by functions of perception or by functions of thought.

The output variables of the functions of thought are circuits of semantic current among information units: narratives, sequence of statements, activation of networks of ideas, simulations, etc. I call these circuits *noumenal circuits*, and the information units that make them up *noumenal information units* or *noumenal ideas*. Semantic circuits, which are graphs of USLs, should not be confused with noumenal circuits, which are graphs of semantic information units (USL, C, URL). Moreover, noumenal ideas have exactly the same composition (USL, C, URL) as phenomenal ideas; they are just produced by different functions.

The functions of thought interpret the information units that emerge from the perception of data or from other functions of thought. When I say that the functions of thought interpret the phenomenal ideas resulting from perception, I do not mean to imply that these ideas are neutral and are not themselves results of interpretative processes. Quite the contrary! Phenomenal ideas are indeed products of hermeneutic functions, and functions of thought in turn interpret these products. One of the roles of functions of thought is to situate phenomenal ideas in (supposed or imagined) patterns of emergence, transformation and disappearance of phenomena. In short, they place information in relationships.

Noumenal circuits (in the vocabulary of the IEML model) can be considered to formalize knowledge (in the vocabulary of information management). Unlike the rather vague descriptions of the DIKW theory, the term *noumenal circuit* here has a very precise technical meaning: it is a network of relationships among semantic information units, a network that is produced by an explicit function of thought.

Once again, the essential point is that the USLs and the semantic current C that make up information units (USL, C, URL) are variables of transformation groups. Functions of thought can thus automatically generate oriented graphs of USLs and transformations of the semantic current in these graphs.

13.5.2. *The semantic information unit as a tool for cognitive modeling*

The above overview of hermeneutic functions has provided a general idea of the production, use and placement of information units in circuits by IEML collective interpretation games:

– These information units are produced from data (URLs) by functions of perception, and from other information units (USL, C, URL) by functions of thought.

– They are used (as input variables) and interconnected in noumenal circuits by functions of thought.

I will now translate the formal model of the semantic information unit into the cognitive registers of ideation, enunciation and memory.

13.5.2.1. *The information unit as an idea*

The semantic information units (URL, C, USL) model the phenomenal and noumenal ideas of hypercortical cognition. A comparison of Figure 9.2 and Figure 11.5 shows that the formal structure of the semantic information unit is also the structure of an idea: (T) multimedia data (URLs) represent sensory data, or percepts; (S) USLs represent concepts that categorize data; and (B) the semantic current C represents the value (attraction or repulsion) of the categorized percept, namely the affect.

It should be noted that this objective unit of hypercortical cognition is not subject to any limitation of scale. An abundant source of data (represented by a URL) categorized as a semantic circuit (since the USL represents a circuit) as broad and complex as desired, in which the distribution of the current is transformed according to the variation of the data, can be conceived as a single variable idea. The data flow can come from a traditional site, an object, a sensor or a news originator. Here, the semantic information unit indicates the meaning and relevance of the data flow identified by its URL. This approach is particularly suitable for the “web of flows” or “real-time web”.

13.5.2.2. *The information unit as an utterance*

The semantic information unit can also be considered the model of a referenced utterance. According to this perspective, the discourse or utterance is supplied by the USL, the reference by the URL, and the pragmatic force of the utterance by the semantic current C that links the URL and the USL through a function of explicit evaluation. In this approach, hermeneutic functions can be considered functions of enunciation, since they produce referenced utterances driven by a pragmatic force. When an information unit is dated and signed, it becomes a completely explicit "unit of enunciation". The player, user, person, community or creative conversation that takes responsibility for the enunciation can be considered the author of the utterance.

13.5.2.3. *The information unit as a meme*

Finally, semantic information units can also be considered units of memory, or memes. It should be noted, however, that these memes are much more elaborate than those of Dawkins's memetics, which is based on a biological model that is inadequate for the complexity of cultural processes. The hermeneutic memory of the Hypercortex, seen as a holistic cognitive faculty, simultaneously represents the potential for both memory and forgetting. Each creative conversation decides what it retains and what it disregards, according to its own criteria of perception and thought.

In the foreground of its cognitive mirror, the creative conversation conducts a dance of urgent, important information: its "here and now".

In the middle ground, it displays the familiar information units and knowledge it has to be able to recall quickly in order to understand its present.

In the background is the rest of the information, structured according to its own hermeneutic functions, which must be accessible in one way or another because it may be useful or interesting.

Finally, in the shadowy depths of its unconscious is the opaque ocean of unperceived, unthought-of data or data interpreted according to criteria too different from its own to be useful to it.

The creative conversation thus projects its own cognitive map on the semantic sphere, a map arranged in concentric strata, from well-lit foregrounds to shadowy backgrounds and, further, to the gradual darkness of forgetting. For each creative conversation, the landscapes of memory and forgetting are different, the gradations of reflexive consciousness and total unconsciousness are folded according to other folds. These conversations can dialogue, learn from each other and even merge, intersect or differentiate their memories at will, however, because they share the same semantic sphere, the same transformation group. Woven of fractal circuits among information units, subjected to intense currents and emotional storms, the whole semantic sphere turns and reorganizes itself around creative conversations, obeying their collective interpretation games.

13.5.3. *The noumenal circuit as a tool for cognitive modeling*

Having examined semantic information units, I would now like to consider the use that may be made of the noumenal circuits of hermeneutic memory for cognitive modeling. I cannot prejudge all that the collective intelligence of creative conversations will invent in the area of functions of thought, so I will just mention a few possible uses and suggest some directions for development.

13.5.3.1. *The noumenal circuit as a theory*

A piece of knowledge (a noumenal circuit) functions as the context that explicates the information units it links. Since this context has been constructed by a freely chosen function, there is obviously nothing "natural" about it; it is an interpretation. From an epistemological perspective, the function of thought can be compared to a theory that produces knowledge based on phenomenal ideas. Thus not only can a single multimedia datum enter into the fabrication of many different phenomena, but the same phenomenon can also be explicated by many different theories, i.e. by many ways of relating phenomena to each other. Theory simulates relationships among phenomena (among phenomenal ideas). That is why functions of thought can be considered tools of cognitive simulation, capable of producing useful knowledge for creative conversations.

13.5.3.2. *The noumenal circuit as narrative*

Cognitive psychology long ago taught us that one of the best ways in which to retain information is to organize it in narratives. While semantic information units are produced by acts of enunciation, noumenal circuits (i.e. knowledge in ordinary terms) become circuits of enunciations, which can be seen as complex narratives. According to this approach, a function of thought can be processed as a narrative function that arranges relationships among acts of enunciation. Once again, the authors of these narrative functions are free to place – i.e. interpret – the same enunciation in narratives that may be completely different.

13.5.3.3. *Cognitive simulation*

Perception[28] of data can be compared to the "sensory excitation" of a set of USLs by a semantic current. However, this excitation of USLs represents only the initial

28 Perception, i.e. categorization plus the measurement of value and intensity.

input of the cognitive functioning of the Hypercortex. The current received as input by the USLs that act as semantic sensors can be processed by all kinds of algorithms. Noumenal circuits can channel the transformations of the semantic current received by the sensors. The sensory input of the Hypercortex can then be transferred and processed along the noumenal circuits to which the receptor USLs are connected. The current can be amplified, blocked, summoned or freed according to thresholds. It can propagate through resonance and simulate cognitive processes that can be as complex as you wish. Massively parallel distributed calculations (of the "neural network" type) can be constructed by supplying USLs assembled in circuits with automata for processing semantic current[29]. All types of functions of thought are imaginable, not only those based on neural networks: fluid dynamics, heat propagation, genetic algorithms and artificial life programs, functions simulating emergent cognition in certain animal societies (swarm intelligence), classic economic games, logic rules of all kinds, not to mention functions drawing on the arts, humanities and social sciences to describe, invent or simulate original forms of collective cognition and dynamics of actor networks as closely as possible[30].

Finally, the noumenal calculations of the Hypercortex, as they are freely determined by creative conversations, can result in output information units, which can be considered "effecter excitations": robot control, production of multimedia data for users, syntheses, predictions, etc.

In short, the functions of thought on semantic information units model the ecosystems of ideas discussed in Chapter 6.

13.5.4. *Hierarchy of the functions of symbolic cognition*

I will now review the different cognitive functions that can be formalized and automated by the IEML Hypercortex.

13.5.4.1. *Semantic functions*

Textual functions produce and transform USLs (texts in IEML).

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29 The forerunner of this type of calculation was Warren McCulloch [LÉV 1986a, MAC 1965]. Subsequently, von Foerster and his team at the Biological Computer Laboratory [FOE 1981, LÉV 1986b] developed McCulloch's ideas. Massively parallel calculation based on neural networks has become a well-established sub-discipline of artificial intelligence; see McClelland and Rumelhart, *Parallel Distributed Processing: Explorations in the Microstructure of Cognition* [MAC 1986].

30 On the dynamics of actor networks and the modeling of technical, cultural and social phenomena using graphs, see my comments on Figure 5.1.

Linguistic functions transform USLs into semantic circuits that are readable in natural languages, and vice versa. They can also translate a semantic circuit that is readable in natural language *x* into a semantic circuit that is readable in natural language *y*.

Conceptual functions produce, transform and measure semantic circuits readable in natural languages.

13.5.4.2. *Hermeneutic functions*

Functions of perception create semantic information units (USL, C, URL) from data (URLs).

Functions of thought create noumenal circuits among semantic information units, using semantic information units.

The automation of semantic functions is the basis for the automation of hermeneutic functions, those that create semantic information units (URL, C, USL) and those that produce knowledge (noumenal circuits). There can be no Hypercortex, no universal digital memory serving collective intelligence, without automatic and conventional transformation between USLs and semantic circuits interpreted in natural languages. Indeed, the availability of USLs that have meaning is an essential condition for the automatic creation of semantic information units and their circuits. The existence of the IEML semantic machine is therefore the basis of the possibility of implementing a hermeneutic memory. USLs, semantic circuits, semantic information units and noumenal circuits are automatable constructions. While automatable, however, they are no less free, transparent and are hypothetical. As such, like all hypotheses, they can be deconstructed.

13.6. Wisdom

Nothing will ever rule out the categorization of data or the placement of information units in context “by hand”. All my effort to describe the cognitive model of the Hypercortex is to show that these operations are automatable and that this automation can augment the collective intelligence of online creative conversations. The programming of the functions of perception or thought, however, is not itself automatable. It depends on the free decisions of the communities concerned and, more generally, on a practical wisdom that Aristotle called *phronesis*, which is often translated as prudence[31]. By explicating – and thus

31 See Aristotle, *Nicomachean Ethics*, in particular Book VI. See also Pierre Aubenque, *La Prudence chez Aristote* [AUB 1963]. Practical prudence (*phronesis*) is contrasted with theoretical wisdom (*sophia*).

augmenting – the processes of collective cognition, this wisdom pursues a goal that is concrete rather than contemplative: it is in keeping with the actual needs of a community. Its good (or its striving toward improvement) is to be found in a middle course between excesses and deficiencies. It confronts problems of degree and balance: how can we measure, evaluate, categorize or generalize without putting too much importance on minor data, without disregarding “weak signals” and without missing the essential? How can we place information in context, but without getting submerged in generalities? This wisdom of the middle way does not involve blindly following the majority or submitting to a statistical average. On the contrary, it demands firmness, courage and independent judgment, not to mention the capacity to criticize your own decisions in light of their results. While such practical wisdom can and should produce deterministic rules – those of the collective interpretation games – its private operation cannot itself be based on deterministic rules. It will, at most, call upon heuristics, methods of stimulating invention and openness to situations. If knowledge is the organization of memory, wisdom is the organizer. At the top of the DIKW hierarchy, wisdom must confront the problem of the arrangement of a memory. How can functions of perception and thought (which will determine methods of filtering and searching) best suited to the needs and desires of a creative conversation be created? How can we construct information units from data, and knowledge from information? What are the organizing narratives that give meaning to ideas?

Information is an interpretation of data, and knowledge is an interpretation of information. That is why the wisdom that governs the cognitive operations of memory cannot come out of any absolute precept or supposedly objective science. It is a hermeneutic wisdom, and thus eminently free and open, which proposes conventions to particular communities rather than offering transcendent, universal truths. The historical experience of humanity shows that hermeneutic wisdom is constructed patiently along paths interwoven with traditions of interpretations of secular corpora[32]. This wisdom requires a long memory, because it is responsible for thinking about the long-term effects of the way our creative conversations create their information units and extract knowledge from them. The ultimate purpose of hermeneutic wisdom is to improve the cognitive functions of communities that are organized around a shared memory, and to do so within a sustainable horizon of learning and discovery.

13.7. Collective interpretation games

Before closing this chapter on the hermeneutic memory of the Hypercortex, I would like show how collective interpretation games can become social tools. The

32 *Corpora* is the Latin plural of *corpus*.

design of these games can indeed be considered an art or, if you prefer, a wisdom that serves the lasting augmentation of the cognitive power of communities of players.

Collective interpretation games cause interaction between automatic functions and human perceptions, actions and reactions in self-organizing loops. The automatic functions can be divided into two major classes: hermeneutic functions, which we have already studied in this chapter; and multimedia navigation functions, which make it possible to explore the universe of information organized by the Hypercortex in an interactive, polysensory way. The game is based on the process of continuous feedback from the players, who produce new data and new metadata and progressively develop their hermeneutic functions and navigation systems. A collective interpretation game should be considered the hypercortical avatar of a creative conversation.

13.7.1. *Reading/writing*

We can imagine iconic or musical translations of USLs in addition to their translation into natural languages. Instead of starting from writing a text using a keyboard, the construction of semantic circuits could be controlled by manipulations of symbolic objects in augmented reality, using digital capture of movements. Reading could also be augmented by sensory-motor exploration of hypertext circuits whose nodes were represented by figurative objects (instead of texts in IEML or natural languages).

13.7.2. *Exploration*

To access the cognitive processes simulated in the Hypercortex, all multimedia interfaces are possible. The various phases of automated hermeneutic processing of data, as well as their results, can be communicated to the players by means of interactive and immersive representations using virtual or augmented reality. Drawing on certain video games, it would be possible to project processes modeled in the semantic sphere into an immersive 3D space. Semantic browsers should facilitate collaborative exploration of the semantic sphere and make players aware of regularities and singularities of hypercortical processes.

13.7.3. *Feedback*

Once they are aware of the cognitive processes that are modeled by the Hypercortex and represent the state of the collective interpretation game in which they are participating, users are capable of producing data and/or IEML metadata in order to respond to the situation. A collective interpretation game therefore lives along a communication loop. This loop begins with the distributed production of data. It continues with the production (also distributed) of metadata: categorization, evaluation and quantitative measurement of the data. The metadata are projected in the semantic sphere, which causes associative or contextual automatic processing: semantic currents flow through the noumenal circuits of the semantic sphere and transform the moving landscape of meaning of the Hypercortex. The results of the processing are then sent back to the players on their mobile devices or through an immersive multimedia environment in augmented reality. The signals from the semantic sphere synthesize the dynamics of shared memory resulting from the actions of all the players. On the basis of their interpretations of these signals, the players can then produce data – symbolic physical actions, movements or expressions – that will steer or stabilize the collective interpretation games in the direction desired.

In an environment enriched with ubiquitous computing and robots, players can at any time consult the current representations of their favorite games. They use these games to coordinate their activities, improve their information searching and filtering, optimize their learning activities to meet their needs, organize and synthesize huge masses of information quickly, manage their social networks, navigate in urban landscapes, orient themselves in geographic space and, finally, make decisions that will be reflected in shifts of data flows or the evolution of hermeneutic functions. In performing all these tasks, players benefit from information and data from the interaction of all the other players, whatever their languages or home institutions, and do so transparently, regardless of the material platforms (computers, mobile devices or cloud services) they use.

13.7.4. *Coordination of the games*

The collective interpretation games based on the IEML semantic sphere function as mechanisms for the internal organization of creative conversations thanks to a ubiquitous distributed memory with symbolic processing capacities using the full computational power of the digital medium. A collective interpretation game thus serves as an instrument of both observation and steering of creative conversations: a virtual vessel exploring the semantic sphere in its own way. We need only look out of the porthole to see a swarm of other vessels with which its explorations can be coordinated. The different games can form relationships since they share the same semantic sphere. Beyond knowledge management and cognitive augmentation, the machinery of the Hypercortex can and should be used for all kinds of scientific modeling and simulation of cognitive processes, at the level of both individual cognition and that of communities and cultures.

The information economy (which gives its name to the IEML language) coordinates all the collective interpretation games that drive the Hypercortex. All the games are in competitive cooperation in a general economy of information in which data, semantic information units (categorized and evaluated data), semantic circuits, noumenal circuits and functional modules of cognitive models are exchanged. It is this semantic information economy – an economy whose hermeneutic functions are transparent and freely chosen – that now makes the scientific exploration of the human cognitive ecosystem as it is expressed in the digital medium possible.

Chapter 14

The Perspective of the Humanities: Toward Explicit Knowledge

The spread of the digital medium is already giving rise to a profound change in the public sphere. This is a change in the scale of civilization, and it will be thought out over several generations, as was the case for the invention of writing, the alphabet and printing. Just as previous changes in communication led to or brought about (without mechanically determining them) transformations in the forms of knowledge, the changes under way will likely lead to a scientific revolution. The exact contours of such a revolution are still difficult to predict, but the IEML model suggests certain intellectual and methodological horizons. In this chapter, I will explore how the Hypercortex could contribute to the renewal of the human sciences. As shown in the conceptual map in Figure 14.1, I will look at the culture studied by the humanities and social sciences, that is, human collective intelligence. If this intelligence can be reflected in the mirror of the Hypercortex, how will the landscape of the human sciences be changed?

14.1. Context

Chapter 5 outlined the general context of the transformation of the human sciences, in particular the stakes involved and the weaknesses and strengths of the contemporary human sciences. As regards the stakes, the question of human development is becoming increasingly important. It is clear that societies that fund public research and education in the human sciences expect "results" in terms of security, economic prosperity, public health, well-being, innovation, cultural productivity, transmission of heritage, etc. As regards the weaknesses, I noted the disciplinary and theoretical fragmentation and the rarity of calculable models of the social production of meaning. Finally, regarding the strengths we can already see the growth of new forms of collaboration and observation (availability of data) made possible by the digital medium.

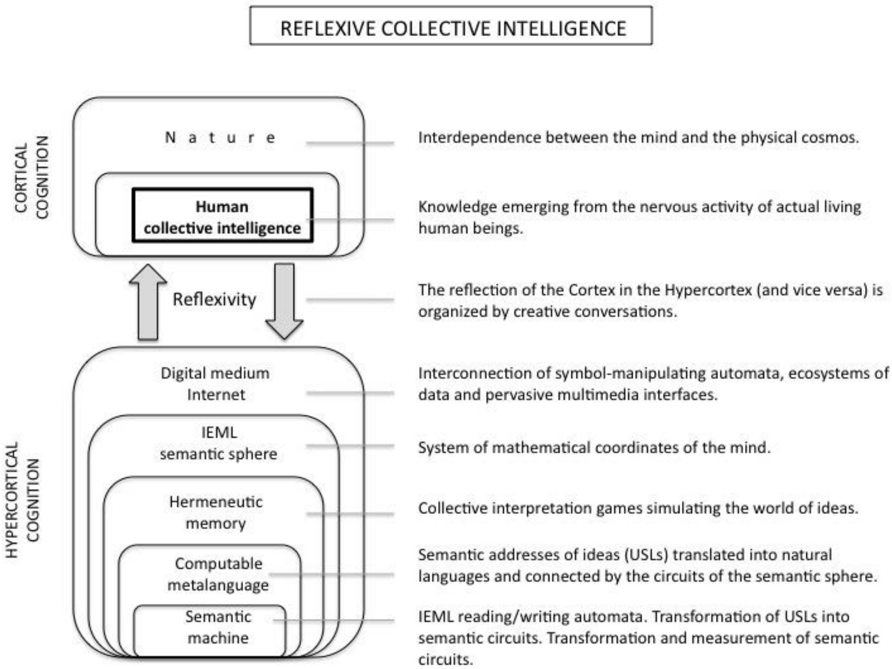

Figure 14.1. *Position of Chapter 14 on the conceptual map*

14.1.1. *The increasingly transnational, transdisciplinary and democratic nature of the human sciences*

I would now like to add a few elements to this description of the context. The material natural sciences are universal in the sense that they share the same scientific metalanguage (system of coordinates, units of measurement, atomic elements, molecules, etc.). It is clear that the human sciences have not yet reached this level of maturity. Nevertheless, there is a trend toward open universality, as indicated by three parallel thrusts that can be clearly felt in contemporary universities: transnational globalization, transdisciplinary collaboration and democratization. These three developments are already being, and will continue to be, accelerated by the expansion of the digital medium, a medium that is inherently global and hypertextual, in which everyone can be author, reader, documentalist, interpreter, curator, publisher, etc.

Globalization is evident in student exchanges, mobility of professors, increased numbers of international conferences, the domination of international journals, support and grants for cooperative projects and well-known international researchers, etc. Although there are still traditions and references that are purely national or are linked to a particular language, the general trend is toward internationalization of references and theoretical currents.

The past three or four centuries were marked by disciplinary differentiation in the human sciences, starting with the liberal arts, philosophy and theology. Today we are seeing the reverse trend, favoring efforts toward multidisciplinary, interdisciplinary and transdisciplinary convergence. This is obviously only a trend rather than an irreversible abolition of disciplinary compartmentalization. We nevertheless observe that many universities are encouraging students to take transdisciplinary learning paths. In addition, there is a strong demand in programs in communications, education and management, which are transdisciplinary by nature.

The strongest trend is undoubtedly the democratization of the human sciences. This democratization is first of all demographic, since in every country an increasing proportion of each generation goes on to higher education, many of them in the human sciences. Democratization also involves gender, since in most rich countries the female student population now outnumbers, or is on its way to outnumbering, the male student population. Finally, the democratization of the human sciences, and of university in general, affects disadvantaged classes, "lower" castes, formerly colonized nations, oppressed "races", and in general all ethnic, sexual, linguistic, religious and other minorities. Along with all these forms of *de facto* democratization, there is a theoretical or ideological democratization that promotes the memory and discourse of the oppressed, the conquered, first nations, and generally all subjectivities purported to have been suppressed by some orthodoxy or power.

Consequently, the basic corpus of the human sciences is no longer limited to the carefully selected classical works traditional elites have used to construct, reflect and refine their individual and collective subjectivities. This corpus is now expanding to encompass all the cultural productions of humanity. The new virtual corpus includes symbolic productions excluded from the list of objects worthy of study by universities (created by the Catholic Church in the late 12th Century) and by the sociocultural groups that for a long time dominated the legitimate production of knowledge about humanity. I note, finally, that the expansion of the corpus and the multiplication of points of view not only affects universities in the Roman Catholic tradition, it is also having an impact on all scholarly traditions, including the Chinese, Indian, Arabic-Islamic, etc.

14.1.2. *Agendas and the stakes of power*

The path of collective intelligence that I am proposing here for the human sciences recognizes the globalization that is currently under way in the community of students and researchers, the growing need for transdisciplinarity and the opening up of the corpus and perspectives. In the wake of this ideological democratization, I take for granted that any discourse in the human sciences can be interpreted as endorsing a conceptual, theoretical, emotional, subjective, identity-based, economical, social, political or other agenda. It is clear that the performative nature of discourse does not stop at the university gate: power is at stake in all symbolic production. Researchers and teachers, like their counterparts in the media, economics and government, can thus legitimately be subjected to this type of interpretation, whatever their ideological (in the broad sense) or political orientations. What distinguishes the human sciences is not their objective neutrality (what symbolic production could ever make such a claim?), but the explicit, systematic, modeled, reflexive, documented, conversational nature (citations, openness to debate) of their approaches and discourses.

Symbolic cognition is a totally interpretative process. This is the point the human sciences have now reached, and there is no longer any need for demonstration. The problem now for these sciences is to find the way to a reflexive interdiscursivity (a civilized dialog) among traditions or schools of interpretation and to ensure that this dialog, this open collective intelligence, serves human development[1]. The IEML model of symbolic cognition offers a solution to this problem: it presents the human mind as a universal, symmetrical, free nature of inexhaustible complexity.

This chapter has two parts. As we will see in section 14.2, when the digital humanities adopt IEML it will become the methodological vehicle of the coming scientific revolution. Section 14.3 offers a philosophical meditation on my main thesis with regard to this revolution, namely that the augmentation of the collective intelligence (and thus the potential) of human communities will come about mainly through explicit self-knowledge.

1 On the concept of human development, see section 5.1.

14.2. Methodology: the digital humanities

14.2.1. *The science of collective intelligence and the collective intelligence of the human sciences*

Before the IEML model, there was no serious unit of measurement or rigorous scientific method for studying collective intelligence. The few efforts that had been made in this area[2] were usually limited to selecting a set of indicators and measuring quantities (a "collective intelligence quotient"), while what was needed was to describe the dynamics of systems, patterns of evolution, and models of transformations of forces and values in a universe of ideas in ecological interaction. It is precisely this lack of a scientific method developed to process the semantic dimension of collective intelligence that is remedied by the IEML model.

Most contemporary approaches maintain the traditional distinction between the object studied and the subject studying it, but the aim of the IEML model is reflexive knowledge of collective intelligences *by themselves*. If we reject the reflexivity of collective intelligence, there is no guarantee that the object being studied (a human group) has not developed cognitive dimensions that completely elude those who call themselves experts in measuring or evaluating it. In contrast, the IEML model incorporates an approach that is radically open, dialog-based and symmetrical (or reciprocal: the object and the subject exchange roles). Indeed, creative conversations are themselves the ultimate source of the functions of categorization, evaluation and association that govern their collective interpretation games[3]. The image presented to the observer is reflexive. A creative conversation "sees itself" by observing its collective interpretation games in the mirror of the Hypercortex. The different disciplines, hermeneutic traditions and schools of thought of the human sciences can be considered creative conversations organizing and exploiting the digitized data on the Web. Each of these schools, each of these disciplines has an original point of view that is processed symmetrically (without "favoritism") by the IEML semantic machine. Thus a reflexive, perspectivist, collaborative science of collective intelligence necessarily calls for a collective intelligence of the human sciences.

Before I discuss its methodological vehicle, I will review the epistemological framework and theoretical orientation of the collective intelligence project that IEML offers for the human sciences.

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2 See the work of the Center for Collective Intelligence at MIT: http://cci.mit.edu/.

3 On the concept of reciprocal anthropology, developed by Alain Le Pichon, see the *Transcultura* journal: http://transcultura.jura.uni-sb.de/english/index.html.

Epistemological foundation. The path of collective intelligence in the human sciences is laid out in a universal nature of the mind that is free and inexhaustibly complex. From the perspective of the IEML semantic machine that simulates collective interpretation games as flows of current in circuits, i.e. as symmetric operational variables, all games are equivalent, each one "equally distant" from the abstract center where the machine is located. Within this perspectivist nature, each cognitive system is in a position to reflect the others from its own perspective. If the IEML semantic sphere is seen as the political constitution of a state, and the cognitive systems as citizens simultaneously exercising their cognitive power in this state, we would have a democracy organized according to the strict principle of separation of powers. With respect to the individual freedom of the citizens, the only power authorized to intervene in the organization of a cognitive system (a method of interpretation or a school of thought) would be the cognitive system itself. With respect to deliberative dialog and collective intelligence, each citizen would have virtual jurisdiction over all the others through the capacity to reflect – and thus interpret – them in his or her own way. The computational power of the IEML semantic sphere makes the large-scale mechanization of this reciprocal interpretation possible.

Theoretical orientation. Once the environment in which the journey takes place has been established, what is the direction of the path the human sciences are being invited to take? I would first of all like to make clear that this is not a linear path from a point A to a point B, but rather the assembling and omnidirectional growth of a self-reflective cognitive state. We start from a situation in which reifying essentialisms fragment the nature of collective intelligence and struggle to interpret (transform into useful knowledge) the oceanic flows of data. Our aim is the expansion of an open public space energized by powerful schools of thought, or scientific creative conversations. These distinct – and even competitive – schools will be able to collaborate in interpreting data thanks to the calculable cognitive perspectivism offered by the IEML semantic sphere. The multitude of creative conversations will build a living hermeneutic memory on the topological framework of the semantic sphere, like the growth of a coral reef illuminating the ocean of data through its myriad intellectual perspectives.

Methodological vehicle. In order to advance this project of civilization, we need technology capable for automating – interoperably – the transformation of data into reflexive knowledge: production and transformation of semantic circuits, categorization of multimedia data, production of semantic currents, production and transformation of noumenal circuits, etc. The interoperability of the semantic automata will be ensured by the common metalanguage of IEML. The specific role of the digital humanities, and in particular of the IEML semantic engineering, will be to provide tools for the creative conversations, schools of thought and cognitive systems in their work of creating knowledge from data.

14.2.2. *What are the digital humanities today?*

The digital humanities combine computer engineering and the human sciences. They are concerned with methods of structuring and using digitized corpora for the humanities and social sciences[4]. These methods include encoding, applying metadata, data mining and representing data (for example, visually), as well as all forms of collaborative annotation that make it possible to maintain a kind of permanent virtual seminar around a given corpus. The digital humanities also reflect on the impact of their own methods on the cultural legacy and institutions for the conservation of memory, such as archives, museums and libraries. Finally, they study digital culture in general, i.e. the new social and symbolic environment that is developing in the digital medium. Researchers working in the digital humanities are particularly interested in exploring and analyzing the new forms of publishing and reading (for example, hypertext) made possible by the digital medium, including their consequences for research and teaching. It is easy to predict that in a generation – or less – the vast majority of research activities in the human sciences will be computerized, so much so that the expression *digital humanities* will be redundant.

14.2.3. *A new writing that serves the human sciences*

Until now, the digital humanities mainly just used or modified the tools provided by engineers to analyze, format and annotate corpora of texts assembled using static writing techniques. Some of the most advanced work in the digital humanities involves the transformation of the genres of book and article into fluid, interconnected, ubiquitous processes of collaborative reading/writing in social media suited to researchers' needs. This is only the beginning of a process of cultural change that shows no signs of stopping. Indeed, as the digital medium evolves, we can envisage new writing systems that are much more powerful than the static writing inherited from tradition.

IEML is to my knowledge the first example of a new kind of writing (or encoding of meaning) expressly designed to exploit all the memory and calculation resources of the digital medium for the benefit of research in the human sciences. The explicit premise of the research program based on IEML is that the new corpus of the human sciences is nothing other than all the flows and stocks of data on the Web. Thus, IEML can serve as a metalanguage for the categorization of data, the automatic hypertextualization of the data categorized, the arrangement of information in semantic circuits and the automatic calculation of paths and distances among items of information. I recall here that IEML texts are called USLs (Uniform Semantic Locators) and that each USL is a variable of a transformation group the

4 See, for example, [SIE 2004].

algebraic operations of which correspond to semantic operations. Writing in IEML thus means creating semantic circuits for channeling information flows or constructing data filters or even data mining tools. Reading in IEML means carrying out automated comparative analyses of semantic structures and extracting information on the flows channeled by these structures. In the new intellectual environment established by the IEML semantic sphere, collaboration in research will take the form of organizing collective interpretation games, games whose rules automate the categorization, evaluation and contextualization of data.

14.2.4. *The encoding and semantic use of data*

From the point of view of the humanities, most great civilizations – or intellectual traditions – are based on (i) a writing system, (ii) an open corpus of "classics" written using that system and (iii) a set of intellectual disciplines that allow the maximum relevant meaning to be extracted from the corpus. As I have already said, the Web is becoming the new corpus of the human sciences. But the Web expresses its data using a multitude of "natural" symbolic systems (languages, static writing techniques, video, music, interactive games, programs, etc.). We have seen that these symbolic systems are disparate, their automatic translation is problematic and their physical addressing (URLs) is semantically opaque. In addition, few of the systems of notation or representation in use today, because of their irregularities, can be processed except by using statistical methods. The main purpose of IEML is the semantic re-encoding of the data of the Web using semantically transparent USLs. This encoding needs to be done freely, openly and collaboratively. Coordinated by the IEML semantic sphere, the Hypercortex builds the operational unity of the new corpus of the human sciences. Far from being standardizing, it is a perspectivist unity, creating symmetrical relationships among a multitude of distinct points of view. IEML is a regular language, the syntax and semantics of which are calculable, which is automatically translatable into natural languages and opens up practically infinite possibilities for the notation of meaning. This symbolic tool should now be used to unify the new corpus of the human sciences (the content of the Web) and increase the possibilities for interrogating and interpreting data.

Logic and statistics are not enough. We will only be able to automate the creation and use of semantic information by drawing on the very ancient hermeneutic legacy of the human sciences[5]. Then, and only then, will humanity acquire some mastery of the symbol-processing potential of computers. Researchers in the digital humanities are thus invited to participate in the development of a new intellectual tradition. The tools and methods of this tradition could be much more

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5 On this point, see Chapter 13.

powerful than those of previous traditions, because they are based on: (i) the calculating power and memory of the digital medium; (ii) the "social" capacities of human communication and collaboration opened up by this medium; and (iii) the combination – through IEML – of a universal system of notation of meaning and a hypertextual topology structured as a calculable transformation group. For the physical/biological sciences "the great book of nature is written in the language of mathematics". Geometry is used as a method of decoding the natural phenomenal text. Similarly, for the human sciences progressing toward reflexive collective intelligence, the great opaque hypertext of the Web will be decoded into the transparent hypertext of the IEML semantic topology.

The reader can now glimpse the development of a new intellectual tradition. IEML will be the scholarly writing of that tradition. This intrinsically multilingual and calculable writing automatically weaves semantic relationships among its texts. The public data of the Web constitute the valuable corpus of classics of the new tradition. Finally, creative conversations will act as associated free hermeneuts extracting the maximum relevant meaning from the corpus. The ultimate goal of the new intellectual tradition is to domesticate the calculating power now available so that it serves the reflexivity of human collective intelligence, and thus to pave the way for the civilization of the future.

14.3. Epistemology: explicating symbolic cognition

14.3.1. *Reflexive knowledge and non-reflexive knowledge*

The civilization of the future that I spoke of above will be universal, but not in the sense of an authoritarian imposition of a doctrine or orthodoxy at the expense of other doctrines. This is an open, not a totalizing, universalism: all the ways of creating meaning belong to the same infinite virtual sphere of the thinkable generated by human symbolic cognition[6].

This open universalism represents a path of cognitive fecundity that contrasts with two sterile attitudes: a standardizing monism and a divisive pluralism. A totalizing, excluding or imperial monism would "homogenize" the human mind and claim to deduce from the unity of the playing field (symbolic cognition) the exclusive legitimacy of a single rule of the game (a single way of knowing). At the other extreme, a divisive pluralism "essentializes" historical, cultural or existential differences, whether racial, religious, sexual, national, political, theoretical or other.

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6 See my book *Cyberculture* [LÉV 1997], in which I develop the concept of *universal without totality*.

By compartmentalizing humanity, this rigid pluralism excludes certain points of view and impedes reflexive dialog and reciprocal interpretation.

The open universalism supported by the IEML model of the mind is intended to be reflexive, i.e. each step, each operation of the cognitive process can be described explicitly, shared and recognized for what it is: a choice, a freely acknowledged decision among a multitude of other possible choices. Reflexive knowledge corresponds to a perspectivist attitude. In contrast, non-reflexive knowledge, instead of considering the singularity of its own cognitive functioning, projects that functioning on the object of its cognition and declares: “this is the essence of this object”. Non-reflexive knowledge is manifested as essentialist belief. Non-reflection implies a hardening, an ossification of cognition that limits its flexibility, its power, its capacity for adaptation, evolution, learning, innovation and creation, and ultimately weakens or endangers the human group (or individual) that maintains the opacity and the essentialist illusion of its own cognitive processes. In addition, an essentialist attitude increases the number of obstacles to interdisciplinary and transdisciplinary dialog, which everyone agrees the sciences of the mind urgently need in order to solve the problems of human development.

14.3.2. *The cognitive process*

The truth of a representation consists in the conformity of that representation with reality. We have seen that what characterizes symbolic cognition (at least in the IEML model) is that it creates its reality, particularly the meaning of that reality, on the basis of selection of data and interpretation programs. Within the framework outlined above, a hermeneutic school, creative conversation or collective interpretation game thus cannot claim to hold “The Truth” or even aim for an asymptotic approach to truth understood as conformity with reality. I am not speaking here of the accuracy of data (truth with a small *t*), which is obviously a key concern of researchers. I am talking about truth of meaning or interpretation, which necessarily involves conceptual, axiological, narrative and practical decisions. If objective truth cannot be used as a criterion of science, what remains? Are we condemned to sterile relativism? Is there no difference, then, between knowledge and ignorance?

In the new orientation I am proposing here for the human sciences, it is in fact possible to distinguish between scientific knowledge and ordinary knowledge, and even to improve scientific knowledge asymptotically. All that is needed is to adopt reflexivity – instead of truth – as a criterion of knowledge. The IEML model of symbolic cognition makes it possible to break down the cognitive process into steps and examine the degree of reflexivity of each step. In what follows, I will analyze the steps of the cognitive process as logical phases and not as a chronological succession. If I were to adopt a chronological point of view, I would have to describe a looped self-organizing process in which it would be impossible to assign an absolute priority either to the movement of virtualization or to the movement of actualization (see Figure 14.2).

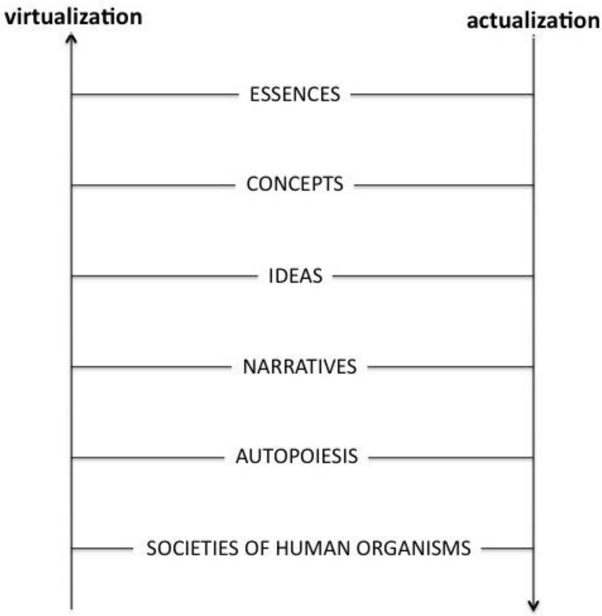

Figure 14.2. *The degrees of the cognitive process*

14.3.3. *Essences: the power of symbolic cognition*

Let us first consider the pure and simple capacity to identify symbols or symbolic arrangements. Suppose that for each distinct symbolic arrangement perceived by the senses, the mind conceives a corresponding distinct "essence". Essences have no particular determination *a priori*; they are only distinct "places" in which forms or concepts can be distributed. They may be compared to points in a system of coordinates, markers in a symbolic memory or squares in a gigantic intellectual game. Essences are formalized in IEML as sets of sets of sequences of a handful of primitive symbols (USLs). At this stage, essences do not yet have meaning. They are only identification codes. They are, by nature, devoid of any particular interpretation. This is essential because otherwise the human mind would be unable to use a countless number of different symbolic systems or collective interpretation games. With the squares of this cosmic chessboard comes what is, in principle, an unlimited capacity for the interconnection and tracing of paths among their addresses, as well as a programmable mechanism for manipulating the contents of the squares. The gigantic chessboard of essences and the mechanisms associated with it represent a source of inexhaustible but computable complexity. Each essence may be seen as an intellectual micro-mirror that can reflect any concept, and the basic playing field of the mind as a macro-mirror that can reflect or project any system of relationships among essences. Essences are in a sense the pixels of a huge intellectual retina. It is thanks to this retina that symbolic cognition is possible.

14.3.4. *Concepts: intellectual cognition*

In the second logical phase of cognition, the empty, reflecting squares of the heaven of essences are "occupied" by concepts and are interconnected in a determined way. As we have seen above, no specific concept has meaning in isolation, outside its interdependence with other concepts, whether this interdependence is paradigmatic or syntagmatic. A concept shines like a constellation in the night of essences. In the IEML model, the interdependence of concepts is shown in graphs of explicit relationships or semantic circuits. As soon as essences (cognitive pixels) are semantically defined and interconnected, they reflect concepts. Generally, it is linguistic or other symbolic systems that determine concepts and organize their relationships. The display of meanings determined by the cognitive process results from a conceptual projection against the reflective background of essences. This initial projection establishes the conceptual calendar of a cognitive system: fractal networks and cycles of constellations of meaning. In fact, the determination of the intellectual agenda of cognition often results from a synthetic or syncretic combination of many symbolic systems.

At the level of intellectual cognition, cognitive reflexivity consists in explicitly recognizing the structure of the symbolic system that organizes relationships among meanings. In contrast, non-reflexive knowledge does not recognize its own act of conceptual cognition. The most opaque non-reflexive knowledge imagines that each concept has a meaning separately, independently of its relationships with other concepts, outside the intellectual constellations that define it. Concepts are "essentialized". Non-reflexive knowledge that is a little less opaque recognizes that the meanings of concepts are interdependent but does not take responsibility for choosing the symbolic system that conditions this interdependence. In this latter case, it is the symbolic system as a whole (for example, a language) that is essentialized, i.e. considered "true", "objective", "normal", etc. In all cases, non-reflexive knowledge consists of imagining that essences spontaneously express determined concepts instead of realizing that they simply reflect the activity of some cognitive system. Each symbolic system – each distinct language – projects different intellectual figures on the retina of essences.

In the IEML model, intellectual cognition is fully explicated by the semantic machine. In particular, the STAR dialect makes it possible to reflect the projection of concepts in natural languages on essences (USLs) with maximum explication, since the process is automated. Thanks to this semantic computability, the conceptual constellations here take the form of a hypercomplex fractaloid – but symmetrical and formally determined – graph: the semantic sphere.

14.3.5. *Ideas: affective cognition*

Concepts projected by essences in the phase of intellectual cognition are projected in turn on sensory or multimedia data, which I have named with the very general term *percepts*. This second phase necessarily involves an affective force that functions as binding energy (repulsion, attraction or neutral) between a concept and a percept. It should be recalled that affective force is represented in the IEML model by a current in the circuits of the semantic sphere.

The affective stage of cognition corresponds to a highly complex process that comprises: (i) the production or selection of the percept that gives the idea its sensory content; (ii) the selection of the concept that gives the idea its semantic address; and (iii) the determination of the affective energy that connects the percept and the concept. These three sub-processes are logically simultaneous. The result of this second logical phase of symbolic cognition – an idea – is thus the combination of a percept and a concept under the effect of an affective force.

Some readers will perhaps raise doubts about my modeling of affects using numbers, based on the intuition, which is quite justified, that what is usually called an emotion may be manifested in infinitely subtle or nuanced ways and could thus elude numerical modeling. This doubt originates in the fact that what, in my technical vocabulary, I have called *idea* is in ordinary, non-technical vocabulary called *affect* or *emotion*. In fact, it is impossible for the human mind to feel a "pure" emotion, without any perceptual or conceptual aspect[7]. When we want to emphasize its affective force, we tend to call an idea an "emotion" although it also includes conceptual and sensory aspects. It is the concept and percept of the idea that confer on this "emotion" the 1,000 qualitative and existential nuances that are not contained in the intensity and polarity of the affect. In my technical vocabulary, the affect only designates the force, or semantic energy, of an idea. I recall that the idea is designated in the IEML model by a semantic information unit (see Figure 11.5).

7 Just as it is impossible to experience a "pure" concept or percept. Only ideas exist in the mind.

The existential meaning of an idea comes from the affective activity that generates it; an activity in which, according to the IEML model, several distinct hermeneutic functions converge (see Figures 13.3, 9.3 and 7.5). Just as a concept cannot be known independently of the symbolic system that determines it and connects it to other concepts, an idea has no autonomous existence. It gets its reality from the affective cognition that selects, categorizes and evaluates percepts. In the IEML model, affective cognition is described as hermeneutic functions. These functions establish the norms for the categorization and evaluation through which ideas are produced.

At the level of affective cognition, reflexivity consists of explicitly recognizing the functions of perception and thought[8] that generate ideas. In contrast, non-reflexive knowledge reifies acts of affective cognition. It imagines that things and events, including their meaning, sensory texture and affective value, "exist" in this way (and not differently) independently of the cognitive processes that construct them. In this regard, we could speak of an existential essentialism. Non-reflexive knowledge fails to recognize that essences – which are never anything but empty squares, simple cognitive pixels related symmetrically – reflect ideas dynamically produced by its own semantic and hermeneutic functions. By separating the existence of ideas from the process that brings them to life, non-reflexive affective cognition merges reified ideas with the essences that display them, creating an illusion.

14.3.6. *Stories: narrative cognition*

Until now I have only described the static aspect of cognition. As we have seen, intellectual cognition determines the conceptual contours of ideas, and affective cognition fills these ideas with sensory content and symbolic energy. In the phase of narrative cognition, ideas are in motion. This third phase corresponds to the functions of thought in Figures 13.3, 9.3 and 7.5. Here, the mind traces virtual journeys or paths of transformation among ideas. This is not movement in ordinary space, but virtual movement in the non-linear, rhizomatic time of memory[9]. Associative links among ideas are constructed by narrative or theoretical mechanisms[10], theory ultimately being only one particular narrative genre. By telling stories, narrative cognition creates a new layer of meaning, a dynamic meaning that could not emerge without an organizing narrative.

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8 Again, see Figure 13.3.

9 See [BER 1896].

10 Once again, these narrative mechanisms are formalized in the IEML Hypercortex as functions of thought; see section 13.5.

At the level of this third logical phase, the reflexivity of knowledge consists of recognizing that the virtual movements of narration – like the functions of thought that drive these movements – are created by the cognitive process itself. A story, in itself, has nothing "true" and has no independent existence outside the cognitive system in which it develops. Narration is a meaning-generating activity and not a neutral recording of "reality". This is precisely why we cannot do without it. The narrative perspectivism I am advocating here maintains that it is impossible for humans to live in a world without narrative, because only narratives[11] allow them to organize their memory, imagine their future as much as possible and orient their action. In contrast, non-reflexive cognition dreams that its narratives are "true" and "represent reality". Essentialism of narrative or theory results from the opacity of narrative cognition to itself. In this case, a cognitive system refuses to take explicit responsibility for the processes of thought that organize its memory, influence its predictions and push it to make specific practical decisions.

14.3.7. *Autopoietic cognition*

In the sequential order that starts from the most abstract virtuality and ends with the most embodied actuality, symbolic autopoiesis[12] is the last logical phase of cognition. In its autopoietic moment, cognition identifies itself, designating its biological, technical, social and cultural media. In the case of individual cognition, this medium, the self, consists of the person and his or her attributes: body, possessions, sociocultural networks, genealogy, history, etc. In the case of social cognition, the cognitive process is supported by a complex collective identity, a plural self, or "we", including both material (organizations, territories, artifacts, etc.) and symbolic (languages, narratives, rules, power centers, etc.) aspects.

Autopoietic cognition circulates in a loop in which the self and the cognitive process generate each other. On one hand, the self conditions the cognitive process, since there can be no cognition without a biological, technical or sociocultural medium. On the other hand, it is through the cognitive process that there is a "self" or a "we" that stands out against the meaning-filled phenomenal world being computed. In determining the identity that is its medium, cognition structures a primordial figure/ground relationship. It draws a circle around part of the dynamic totality it generates and declares: here I am.

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11 Whatever their forms and genres, including the elaborate types of narratives we call theories.

12 Remember that autopoiesis is production of the self. The term was used by the Chilean philosopher/biologists Humberto Maturana and Francisco Varela [VAR 1974, VAR 1979].

Symbolic autopoiesis involves a double suture[13]: “horizontally” between identity and otherness, and “vertically” between body and mind. Horizontally, it distinguishes and unites the self and the not-self. Vertically, it projects itself in the phenomenal or actual world (embodiment of individuals) and in turn expresses its identity in the abstract or virtual noumenal world (individuation of thought). Autopoietic cognition provides the link of interdependence between the development of a human community (at the very least, a single person) and that of its system of interpretation. In other words, autopoietic acts tie the development of cognition to the person who is responsible for the thought: in thinking and acting symbolically, a subject engages him- or herself. If we began to explore the cognitive loop starting from its autopoietic phase, we would see semantic energy spring from autopoietic acts, become virtualized in organized memory through narratives, be analyzed in ideas and outlined in conceptual circuits until it was reflected on the clear, empty surface of essences.

In the phase of autopoietic cognition, the reflexivity of knowledge consists of recognizing a twofold interdependence: one that intertwines the self and the not-self, and one that forms a loop linking the evolution of the cognitive process and development of the self. The reflexivity of autopoiesis, we might say, corresponds to the wisdom discussed in section 13.6. In contrast, non-reflexive autopoietic knowledge essentializes the subjective identities it determines (as if these identities were not computed by the cognitive process itself) and reifies its own cognitive system (as if the main goal of a cognitive system was not to learn to govern the destiny of the subject that produces it). Non-reflexive knowledge imagines here that the practical development of the “self” is independent of its own cognitive activity.

In my view, absolute relativism is a form of essentialism: instead of freezing and naturalizing the image of a “true” cognition or “neutral mirror of reality”, it idolizes a static multiplicity of supposedly equivalent socio-semantic systems without thinking about the interdependence among them or the level of development of the human society in which they exist. Even if relativists acknowledge the open perspectivist horizon in principle, they refuse to explicate the autopoietic dimension of cognition, because that would cause them to break with a status quo elevated as an ideal symmetry and to evaluate their own cognitive choices and those of other human communities in practice. Like a belief in the absolute truth of our own interpretation, absolute relativism ultimately comes down to “that’s the way it is”. It rejects both open complexity and responsibility for a choice rooted in presence.

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13 On the concept of symbol as the unifying interface between a more virtual reality and a more actual reality, see section 2.3.4.

14.3.8. *The dark side of power*

In this chapter I wanted to explore some methodological and epistemological dimensions of what could be a "revolution in the human sciences" based on the new tool for observation and coordination that is the IEML semantic sphere. In a sentence: the scientific model of cognition based on IEML, and the hypercortical observatory that uses this model as a tool, are intended to facilitate the reflexivity of symbolic cognition. This does not mean declaring total war on essentialism or opacity. It is probably impossible for human symbolic cognition to be reflected in its totality. If the advancement of knowledge is seen as the gradual extension of a luminous sphere over the complete darkness of ignorance, essentialism represents the shadowy, only partly reflexive edge of the light projected by the fire of symbolic cognition. The dark depths of the unknown are first conquered through a non-reflexive thrust of essentialist projection. It is only starting from this initial cognitive half-light that knowledge opens up into a semantic field in which each light wave reflects all the others.

Chapter 15

Observing Collective Intelligence

The Hypercortex coordinated by the semantic sphere was conceived from the outset as an instrument for scientific observation of the collective intelligence of creative conversations. What applies to creative conversations in the digital medium applies equally to any system of symbolic cognition, whether real or fictitious, personal or social. The question at issue in the discussion that concludes this first volume is none other than the possibility of scientific self-observation of the mind in general: what type of image will the observation of collective intelligence generate in the mirror of the Hypercortex?

As shown in Figure 15.1, the main purpose of this chapter is to explain the structure of the reflection of the Hypercortex in the Cortex, and vice versa. But before I come to that, I will review the main stages in the intellectual journey we have taken in Part 2 of this book.

15.1. The semantic sphere as a mirror of concepts

15.1.1. *Reflecting the world of ideas*

In Part 1 of this book, I emphasized the fact that human cognition was not only conscious in the sense of having a subjective capacity to perceive and feel, but also in the sense of having a reflexivity capable of representing its own categories and mental operations to itself. Reflexivity is fundamental to human symbolic cognition. Human thought is not only part of nature but it also offers this nature an organized representation reflecting its inexhaustible variety – including the thought that reflects it. In other words, this thinking mirror has the capacity to accommodate a cosmos, because only for human intelligence can there be a cosmos – rather than an indescribable chaos or a limited space of interactions with a closed environment. Symbolic cognition produces as many cosmoses as it does cultures. It should be understood that the metaphor of the mirror and reflection in no way implies the solid, objective, external existence of the world as it is thought of by any one cognitive system. Cognition in general, and symbolic cognition in particular, is necessarily based on a creative interpretation informed by a cultural history. This interpretation navigates between two reefs: total arbitrariness (not everything is permitted, not all forms of cognition are "viable") and the illusion of absolute truth (according to which any different interpretation is purely and simply an error).

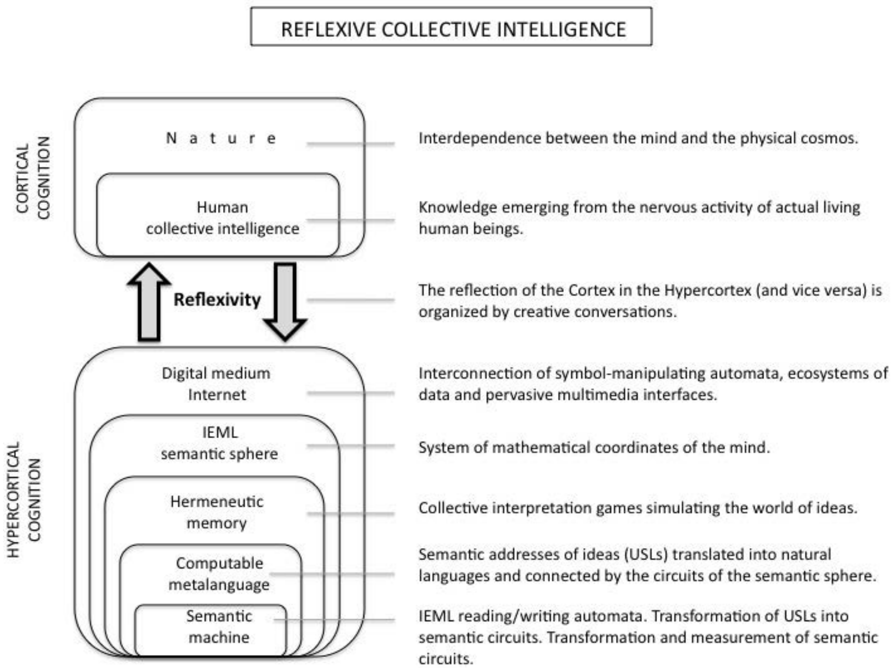

Figure 15.1. *Position of Chapter 15 on the conceptual map*

The first – and most difficult – problem I had to solve was to characterize the basic space in which the processes of human symbolic cognition take place. Through what self-examination by the mind could this radical foundation be found? How can we think rigorously about the container, the all-enveloping "place" of the universe of cosmoses? Where can we seek the formula for the cosmic mirror?

I started with the observation that human symbolic cognition is marked by a general capacity to manipulate and determine intellectual essences, or formal symbols[1]. Once the unity of the symbolic faculty was recognized, I hypothesized that there had to be a corresponding universe of concepts or signifieds, whose unity was based on it being the object of the symbolic faculty, since concepts can only be manipulated through meaningful forms. In addition, just as symbols are only manipulated for purposes of manipulation of concepts, the manipulation of concepts is in turn only a means for the effective and affective manipulation of data, because it is only when concepts categorize sensory data, or percepts, that the world of ideas emerges. Then affects circulate in memory and mobilize intelligence.

IEML can be considered a "semantic machine", an automatic writing that makes the conceptual addressing of the world of ideas scientifically possible. This machine controls a universal system of coordinates: the semantic sphere. The shortest description I can give of the semantic sphere is that it is a calculable topological structure in which each node functions as the identification code for a single concept and each connection between nodes represents an explicit semantic relationship. The concepts and their relationships are expressed simultaneously in all natural languages.

Besides its monadological unity, two properties were absolutely essential to the IEML semantic machine: first, the number of distinct nodes had to be practically unlimited and, second, it had to be able to automatically perform a maximum number of calculations on concepts and their relationships, using the IEML codes of those nodes. Clearly, the second condition was the more difficult one to meet. We could think of the relationship between concepts and the IEML codes that represent them as analogous to the relationship between numbers and the number system used to write them. Ideally, although (all) concepts are not numbers[2], we should be able to perform automatic operations on concepts and their relationships using their semantic codes as easily as we carry out automatic operations on numbers using their binary notation. As we saw earlier in the book[3], it is by a similar property that the philosopher and mathematician Leibniz defined his "universal characteristic". However – unlike Leibniz, but taking his experience into account – I had to design a system for encoding concepts that was distinct from the one that works so well for the notation of numbers. That is why IEML syntax is based on the structure of natural languages, but without their irregularity.

With regard to the calculability of the relationships between the nodes of the IEML system of semantic coordinates, we may think of the correspondence between

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1 See Chapter 3 and Figure 11.4 and the related discussion, below.

2 Numbers are a special case of concepts, and not the reverse.

3 See section 10.1.

the geometry of three-dimensional space and algebraic calculus[4]: there is a correspondence of the same kind between the IEML semantic topology and algebraic calculus (in the most abstract sense of the term). It should be kept in mind that the huge hypercomplex graph of the semantic sphere corresponds to the algebra of a system of symmetric transformations. Without this property of transparency in the calculation of its basic topology, without the possibility of functional translation of the movements and transformations of its concepts, without the conservation of invariants across its variations, human symbolic cognition could not be modeled – and thus conceived – as an object of science[5]. In addition, without this property of computability, the immense automatic calculating power that is now available to us in the digital medium could not be optimally used to explore our new cosmos: a unique and infinite nature that includes a reflection of the human collective intelligence[6].

15.1.2. *The IEML semantic sphere*

The nodes of the semantic sphere are called USLs. USLs are in fact all the different standard texts that can be produced mechanically using IEML syntax. A USL designates a collection of sets of sequences of six elementary symbols. The space of the IEML texts is a transformation group, because all its elements (USLs) are themselves sets of elements produced by the same combinatory mechanism. All set operations (union, intersection, symmetric difference, etc.) can be performed, inverted and combined on USLs. Operations of concatenation (triplication) and cuts can also be automated on the sequences of symbols. In addition, all the functions that transform one USL into another USL (and that therefore lead from one node to another of the great network of the semantic sphere) can be inverted and/or combined to form more complex calculable functions.

Staying at the level of linguistic utterances, the signified of an IEML text includes not only its translations into natural languages but also the set of its explicit semantic relationships (translated into natural languages) to the other texts. The semantic sphere contains all the paradigmatic and syntagmatic connections among

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4 Philosopher and mathematician René Descartes is usually credited with the invention of algebraic geometry.

5 In the words of Galileo, one of the founders of modern science, "The great book of nature is written in the language of mathematics". For a historical and epistemological study on this point, see the interesting book by Georges Lochak, *La Géométrisation de la Physique* [LOC 1994]. See also Jean-Marc Lévy-Leblond's comments in note 8 in Chapter 2.

6 See Chapter 2.

texts[7]. The calculable operations carried out on sets of sequences (USLs) are at the same time operations carried out on the meanings those sets of sequences represent (concepts). The main idea to remember is that any path in the hypertextual space of the connections among USLs can be represented by a calculable function and that this function can have semantic relevance.

As I have frequently pointed out, while the data of the Web are opaquely addressed with URLs – which paved the way for a universal logical memory – the metadata of the IEML semantic sphere are transparently addressed with USLs – which paves the way for a universal hermeneutic memory. In fact, it is only by permitting the computation of data on the basis of their meanings (encoded as USLs) that the hermeneutic memory of the Hypercortex can become operational. The calculability of semantic metadata is not an end in itself: the practical goal is to bring the multimedia data of the Web into the world of calculability opened up by the IEML semantic sphere.

To categorize data, it was necessary to have a metalanguage that would express and differentiate meanings with precisely the same power as a natural language. The construction of a metalanguage that would meet the double requirement of computability of its semantics and unlimited openness of its expressive capacities has been no easy task. The problem was not so much designing a regular, and therefore calculable, language; there are already many examples in mathematics and computer science. The main problem was the requirement of a correspondence, or isomorphy, between the structure of this regular language (IEML) and the basic structure of the natural languages that are normally used to express complexities of meaning (but that do so irregularly). It is precisely this isomorphy between the regular language and natural languages – which will be studied in detail in Volume Two – that now makes the automation of the linguistic function possible. In other words, it enables the mechanical transformation between (i) any valid expression in IEML (a USL) and (ii) a circuit explicating the meaning of this expression and the semantic, grammatical and intertextual relationships of this USL with other USLs. I reiterate once again that in order to be readable, this explication of meaning and semantic relationships internal and external to the USL uses the words of a natural language (French, English, Arabic, Hebrew, Mandarin, etc.) chosen by the user.

The IEML semantic sphere thus functions as a system for encoding meaning that is designed to make the greatest possible number of operations on concepts and their semantic relationships automatically calculable. I note, finally, that all this is based, in practice, on the existence of a matrix of semantic circuits with predefined

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7 On syntagmatic and paradigmatic connections, see section 1.3.1, and Volume 2. I am talking here about meaning at the level of language and utterances. For meaning in the context of enunciation and narration, see Chapter 13 and the general conclusion of Volume 2.

meanings (the STAR dictionary) that is used for translating IEML texts into semantic circuits tagged in natural languages, and vice versa.

Far from being closed, autarkic, opaque codes with their own definitions, isolated from each other[8], USLs are points of view open to all other points of view, virtual centers where multitudes of semantic perspectives intersect. The USL is thus not only a code or a text. It is also the nucleus of a monad[9] whose radiating rhizomes[10] are generated by all the paradigmatic and syntagmatic functions that crisscross with it to interweave the semantic sphere.

The original basic terrain of symbolic manipulation is *one*. It is a semantic continuum in which languages translate each other as best they can; in which the metaphors, correspondences and resonances of literary traditions can be woven; in which human thought can carry its models from one discipline to another and make connections across registers, genres, traditions, paradigms and epistemes.

15.2. The structure of the cognitive image

If the Hypercortex is a mirror, it is a mirror of cognitive functions rather than material bodies. The first thing this mirror had to be able to reflect was the universe of concepts characteristic of human symbolic cognition. Now we have to move from the reflection of concepts to the reflection of the dynamics of relationships among ideas.

15.2.1. *The integration of data into calculable cognitive models*

The Hypercortex combines:

– a set of distributed data in a logical memory, the data of the Web, addressed with URLs;

– a set of distributed metadata in the IEML semantic sphere, which are addressed with USLs.

Using these data and metadata, collective interpretation games assemble ideas and connect them in noumenal circuits. As we have seen, ideas are represented in

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8 Unlike the URLs of the web of data.

9 On Leibniz's monads, see his little masterpiece, *The Monadology* [LEI 1714a].

10 I recall that the concept of the rhizome was developed philosophically by Gilles Deleuze and Félix Guattari in the introduction to *A Thousand Plateaus* [DEL 1987b]. As we will see in Volume 2, the circuits of the semantic sphere are rhizomatic graphs.

the Hypercortex by semantic information units (USL, C, URL) in which the URL – the address of the data – formalizes the percept, the semantic current C formalizes the affect and the USL formalizes the concept. The collective interpretation games that produce the information units are made up of two types of functions, which we will review using Figures 13.3, 9.3 and 7.5:

– Functions of perception construct semantic information units from data flows in real time. They can be divided into functions of categorization, which link USLs to URLs, and functions of production of current, which inject a semantic current C into the semantic circuit corresponding to the USL. This current formalizes the affective or emotional dimension of cognition.

– Functions of thought link semantic information units (data categorized and evaluated), creating narratives, theories and models that transform information into knowledge.

Collective interpretation games thus integrate data into models of cognitive systems in which both the qualitative dimensions (the circuits of USLs) and the quantitative dimensions (polarized intensive values of semantic current) belong to calculable transformation groups.

15.2.2. *The ternary structure of the cognitive image S/B/T*

15.2.2.1. *The ternary structure of the semantic information unit*

The structure of semantic information units (see Figure 11.5) imposes a ternary structure on the images of the cortical functions in the mirror of the Hypercortex. We have seen that these units (USL, C, URL) are made up of three parts: (i) USLs, encoded addresses of concepts in the IEML semantic sphere; (ii) URLs, Web addresses of multimedia data categorized by USLs; and (iii) C, the semantic current propagated in the circuits defined by USLs. The semantic current indicates the intensity (a cardinal number) and the polarity (an ordinal number[11]) of the energy that links the data (URLs) to the metadata (USLs).

The referential data – the URL – can be associated with the *thing* T of the IEML ternary dialectic (corresponding to the referent of the semiotic triad)[12]. The USL can be associated with the *sign* S of the IEML ternary dialectic, and the signifier of the semiotic triad. The semantic current, the binding energy that connects the sign to the referent, can be associated with the *being* B of the IEML ternary dialectic, and the interpreter of the semiotic triad.

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11 This ordinal number represents a value on a scale between a positive pole and a negative pole.

12 See section 1.2.2.1.

15.2.2.2. *The topological image: semantic circuits S*

The USL designates a semantic circuit, i.e. a topological form that stands out against the background of the IEML semantic sphere. A cognitive system can manipulate a large number of semantic information units. The set of USLs of the information units manipulated by the cognitive system forms the imprint or topological image of this cognitive system on the semantic sphere. The topological image can be associated with the semantic shadow or profile of the cognitive system. It delimits its universe of discourse in the form of a hypercomplex fractaloid circuit, each channel and junction of which has a determinate meaning readable in natural languages. This topological image, or semantic profile, can be transformed over time. In Figure 15.2, the topological image corresponds to the two poles on the left (S).

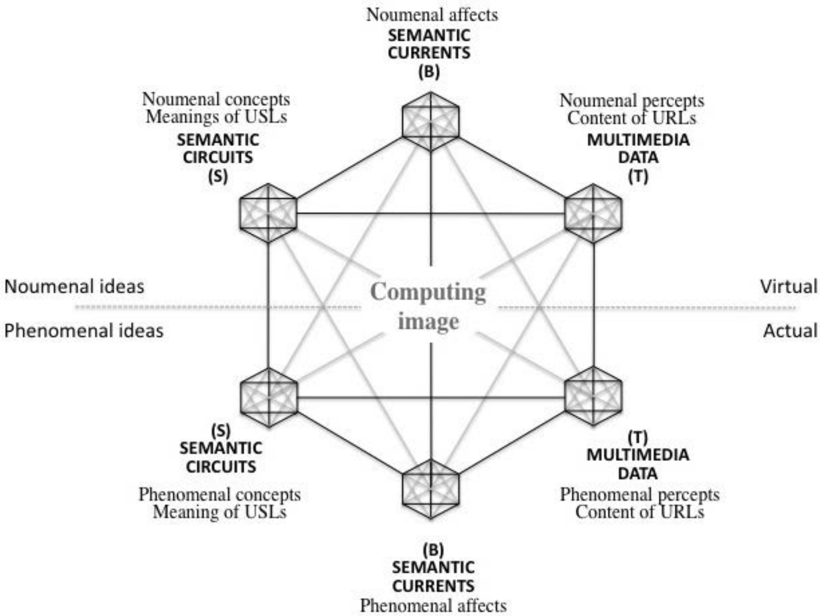

Figure 15.2. *Computing image of a cognitive system in the IEML-based Hypercortex*

15.2.2.3. *The energy image: semantic currents B*

The semantic currents of the set of information units manipulated by a cognitive system from its energy image. These currents follow the circuits that define the universe of discourse of the cognitive system. Just as the topological image traces a figure on the background of the semantic sphere, the energy image traces cycles, oscillations of intensities and values from which a dynamic figure emerges against the background of the topological image. The energy image of a cognitive system represents its intensive (force) and affective (attractive or repulsive) dimensions, with everything controlled by an axiology (criteria for measurement and rules of evaluation). The dynamics of distribution of the value and intensity of the current – the energy images – “animate” the topological images from within. In Figure 15.2, the energy image corresponds to the two poles in the center (B).

15.2.2.4. *The referential image: multimedia data T*

The set of multimedia data (including fictional or imagined data) addressed by the information units manipulated by a cognitive system constitutes its reference corpus. When this corpus is projected on the topological/energy image of the cognitive system, it becomes the referential image of the cognitive system. Like the topological and energy images, the referential image is dynamic. It fills the representation of a cognitive system with sensory texture and documentary materiality. In Figure 15.2, the referential image corresponds to the two poles on the right (T).

15.2.3. *The dual structure of the cognitive image U/A*

The source of the ternary structure of the cognitive image is the composition of the semantic information unit (sign–USL/being–C/thing–URL). Its dual structure, on the other hand, comes from the distinction between the functions of perception (actual) and the functions of thought (virtual) of collective interpretation games.

The application of functions of perception to input data flows in real time produces phenomenal ideas, and these ideas together make up a phenomenal image of the cognitive system. The phenomenal image varies with the data and evolves with the refinement of the functions of perception.

In contrast, the application of functions of thought to phenomenal and noumenal ideas produces a noumenal reflection of the cognitive system. The information units of the noumenal image have exactly the same composition as those of the phenomenal image. The only difference is the fact that in the phenomenal image, it is actual input data that go into the production of the information units, while in the noumenal image, the multimedia data mobilized by the semantic circulations are remembered or simulated (they are virtual, i.e. imagined). Narration, theory and thought (modeled by functions of association) imagine relationships among ideas, whether these ideas are noumenal or phenomenal. The noumenal image varies with the phenomenal image and evolves with the refinement of the functions of thought. In Figure 15.2, the phenomenal image is in the area of the actual A (the bottom half), while the noumenal image is in the area of the virtual U (the top half).

We need to be clear on the concept of *phenomenon*. Etymologically, the word *phenomenon* comes from a Greek verb meaning appear. In a sense, all ideas and all connections among ideas are phenomena of the mind, and for human beings there are no phenomena other than what appears in the mind. How could it be otherwise? When I say that all ideas are phenomena, the word *phenomenon* is meant in an absolute sense. I do, nevertheless, make a distinction between phenomena and noumena. Phenomena are our immediate interpretations of empirical data or percepts that arise over sequential time. Noumena are relationships among phenomena that we establish on the basis of narrative or theoretical patterns (these are chains of thoughts that organize or contextualize perceptions and other thoughts). When I contrast phenomena and noumena, the word *phenomenon* is meant in a relative sense. This opposition between empirical phenomena (in the actual realm) and theoretical or fabulating thought (in the virtual realm) is traditional, and it is very useful in practice. That is why I am using it. This should not, however, hide the fact that, on one hand, even empirical phenomena are interpretations – since they are categorized and evaluated – and on the other hand, even noumena are phenomena (in the absolute sense) – since they arise in the mind: like all ideas and connections among ideas, they result from cognitive operations.

15.3. The two eyes of reflexive observation

I have described the structure of the image of a cognitive system as it results from the combination of semantic information units (which formalize ideas) and the hermeneutic functions that produce these information units. This image corresponds to the syntactic or computing dimension of the IEML model of the mind. In Figure 15.1, at the beginning of the chapter, this is represented as an upward arrow going from the Hypercortex to the Cortex. Creative conversations can organize the image of their own cognitive functioning as they wish, so that it reflects their universe of discourse. Let us now suppose that the universe of discourse of a creative conversation is focused on the theme of human development, as in Figure 15.3. In this case, the image corresponds to the specifically semantic or humanities dimension of our model of social cognition. In Figure 15.1, this is represented as a downward arrow going from the Cortex to the Hypercortex.

The two types of image, computer and humanistic, will be able to be explored interactively, with the possibility of zooming in on details or obtaining composite views. Even better, the computer image and the humanities image contain each other. As we can see in Figures 15.2 and 15.3, the six poles are represented by hexagons. In Figure 15.2, each of the six hexagons represents Figure 15.3, but analyzed from six different points of view: phenomenal circuits, noumenal circuits, phenomenal currents, noumenal currents, phenomenal corpus and noumenal corpus. Symmetrically, in Figure 15.3 each of the six hexagons represents Figure 15.2, broken down into six images: epistemic capital, ethical capital, practical capital, biophysical capital, social capital and communication capital.

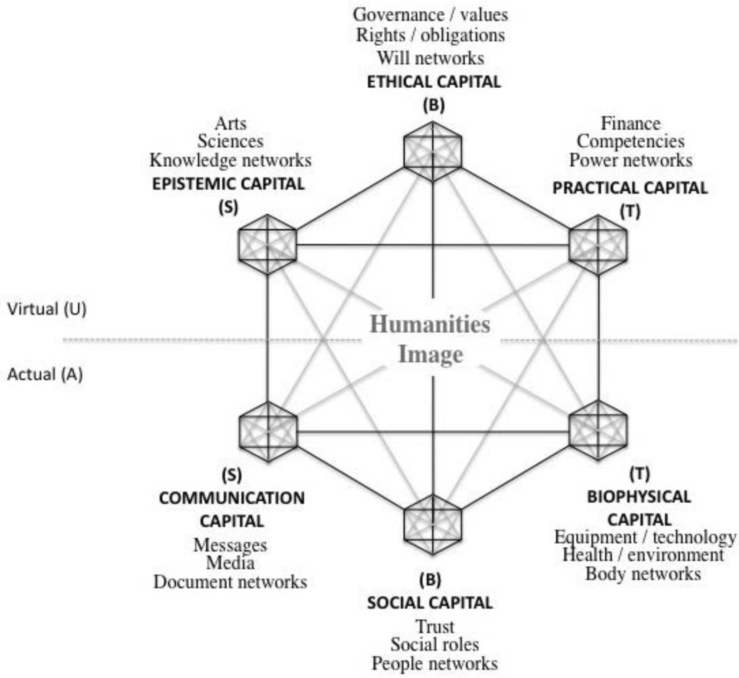

Figure 15.3. *Humanities image of a cognitive system in an IEML-based Hypercortex*

For a creative conversation, the image of its cognition in the Hypercortex functions as a tool for representation of both the self (since it depicts the self's own cognitive processes) and its environment (since it categorizes, measures and contextualizes the data it processes). Again, this cognitive image is dynamic, first because it is transformed according to the input data flows and second because the functions that determine it can be modified and evolve over time. We can now imagine that a good part of the work of conception and refinement of collective interpretation games will consist of organizing resonances and coherences between the virtual and actual (or noumenal and phenomenal) dimensions of cognitive systems, and exploring different forms of flexible, productive alignment of their dimensions as *sign*, *being* and *thing* (or their topological, energy and referential dimensions).

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The nature of the mind is *one*, but it is also explorable, open and infinitely complex. If we want to produce scientific images of the mind, we have to construct an observation instrument that can channel this inexhaustible complexity. In other words: to reflect a hypercomplex universe, we need a hypercomplex mirror of cosmic dimensions. It is precisely this role of a mirror adapted to its object that the Hypercortex will play. In Kantian language, the Hypercortex resembles the "transcendental subject" of human knowledge. The images of collective intelligence reflected back by the symmetrical surface of the IEML semantic sphere must, however, be conceived in an open, plural, emergent and fractal way. As complex as it is, the scientific image of a cognitive system in the Hypercortex will necessarily be limited. A particular cognitive system will only be projected on a subset of the semantic sphere, and will only organize part of the available data. Its finite representation will clearly show that it is contingent, that it is the result of a (more or less controlled) choice from among an infinity of other possible cognitive systems and myriad of other real cognitive systems, all organized differently. The existence of a common framework of calculable modeling will thus not preclude this framework being used differently at each level and according to each distinct point of view. The accommodating unity of the cosmic mirror will reflect back an indefinitely open multiplicity of cognitive images.

The Hypercortex will serve as a scientific observatory, enabling cognitive systems, whether individual or collective, to empirically observe and compare their own processes of knowledge production and management. Creative conversations will thus be able to use the Hypercortex as a dynamic medium for the modeling and self-observation of their collective intelligence. On the other side of the mirror, researchers and engineers will organize this observatory using concrete technical and scientific methods. They will be able to assemble, dismantle, dissect and criticize the perfectible mechanisms of the Hypercortex.

Now that the cultural purpose and the scientific and technical functions of the semantic sphere have been fully explained and justified, Volume 2 of this work will be devoted to the linguistic and mathematical description of IEML from a practical engineering perspective.

Bibliography

[ACK 1989] ACKOFF R.L., "From data to wisdom", *Journal of Applied Systems Analysis*, vol. 16, p. 3-9, 1989.

[ALL 2008] ALLEMANG D., HENDLER J., *Semantic Web for the Working Ontologist*, Morgan Kaufmann, Burlington, MA, USA, 2008.

[AND 2005] ANDERSON J.R., *Cognitive Psychology and Its Implications*, Worth Publishers, New York, USA, 2005.

[ARI 2009a] ARTISTOTLE, *Nicomachean Ethics*, translator: ROSS W.D., http://classics.mit.edu/Aristotle/nicomachaen.html, 2009.

[ARI 2009b] ARTISTOTLE, *On Interpretation*, translator: EDGHILL E.M., http://classics.mit.edu/Aristotle/interpretation.1.1.html, 2009.

[ARI 2009c] ARTISTOTLE, *On The Soul*, translator: SMITH J.A., http://classics.mit.edu/Aristotle/soul.html, 2009.

[ARZ 1999] ARZI-GONCZAROWSKI Z., "Perceive this as that – analogies, artificial perception, and category theory", *Annals of Mathematics and Artificial Intelligence*, vol. 26, no. 1-4, p. 215-252, 1999.

[ATA 1998] ATALLAH M.J., *Algorithms and Theory of Computation Handbook*, CRC Press, Boca Raton, FL, USA, 1998.

[ATL 1972] ATLAN H., *L'Organisation Biologique et la Théorie de l'Information*, Hermann, Paris, France, 1972.

[ATL 1979] ATLAN H., *Entre le Cristal et la Fumée*, Seuil, Paris, France, 1979.

[ATL 2010] ATLAN H., *De la Fraude: le Monde de l'Onaa*, Seuil, Paris, France, 2010.

[ATL 2011] ATLAN H., *The Sparks of Randomness*, Stanford University Press, Stanford, CA, USA, 2011.

[AUB 1963] AUBENQUE P., *La Prudence chez Aristote*, Presses Universitaires de France, Paris, France, 1963.

[AUG 2002] AUGUSTINE, *On the Trinity*, GARETH B.M. (ed.), Cambridge University Press, New York, USA, 2002.

[AUN 2000] AUNGER R., *Darwinizing Culture: The Status of Memetics as a Science*, Oxford University Press, New York, USA, 2000.

[AUR 1990] AUROBINDO S., *The Life Divine*, Lotus Light Publications, Wilmot, WI, USA, 1990.

[AUR 1994] AUROUX S., *La Révolution Technologique de la Grammatisation*, Mardaga, Liège, Belgium, 1994.

[AUR 2000] AUROUX S., *Histoire des Idées Linguistiques*, 3 volumes, Mardaga, Brussels, Belgium 1995-2000.

[AUS 1962] AUSTIN J.L., *How to Do Things with Words*, Oxford University Press, Oxford, 1962.

[AXE 1962] AXELOS K., *Héraclite et la Philosophie*, Minuit, Paris, France, 1962.

[BAC 1932] BACHELARD G., *Le Pluralisme Cohérent de la Chimie Moderne*, Vrin, Paris, France, 1932.

[BAC 2000] BACRY H., *La Symétrie dans tous ses États*, Vuibert, Paris, France, 2000.

[BAL 1900] DE BALZAC H., *Louis Lambert*, P.F. Collier, New York, USA, 1900.

[BAR 2002] BARABÁSI A.-L., *Linked: The New Science of Networks*, Perseus, Cambridge, MA, USA, 2002.

[BAR 2000] BARDINI T., *Bootstrapping, Coevolution, and the Origins of Personal Computing*, Stanford University Press, Stanford, CA, USA, 2000.

[BAR 1972] BARTHES R., *Critical Essays*, Northwestern University Press, Evanston, IL, USA, 1972.

[BAR 1990] BARTHES R., *The Fashion System*, University of California Press, Berkeley, USA, 1990.

[BAT 1972] BATESON G., *Steps to an Ecology of Mind*, Chandler, New York, USA, 1972.

[BAT 1979] BATESON G., *Mind and Nature: A Necessary Unity (Advances in Systems Theory, Complexity, and the Human Sciences)*, Hampton, Cresskill, NJ, USA, 1979.

[BAU 1981] BAUDRILLARD J., *For a Critique of the Political Economy of the Sign*, Telos Press, St. Louis, MO, USA, 1981.

[BÉA 2002] BÉAL M.-P., CARTON O., “Determinization of transducers over finite and infinite words”, *Journal of Theoretical Computer Science*, vol. 289, no. 1, pp. 225-251, October 2002.

[BEL 1960] BELAVAL Y., *Leibniz Critique de Descartes*, Gallimard, Paris, France, 1960.

[BEN 2006] BENKLER Y., *The Wealth of Networks: How Social Production Transforms Markets and Freedom*, Yale University Press, New Haven, USA, 2006.

[BEN 1958] BENVENISTE É., "Catégories de pensée et catégories de langue", *Les Études Philosophiques*, Vol. 4, Presses Universitaires de France, Paris, France, October-December 1958.

[BEN 1971] BENVENISTE É., *Problems in General Linguistics*, University of Miami Press, Coral Gables, FL, USA, 1971.

[BER 2001] BERGSON H., *Time and Free Will: An Essay on the Immediate Data of Consciousness*, Dover, Mineola, NY, USA, 2001 (original French edition 1888).

[BER 2004] BERGSON H., *Matter and Memory*, Dover, Mineola, NY, USA, 2004 (original French edition 1896).

[BER 2007] BERGSON H., *Creative Evolution*, K.A. PEARSON, M. KOLKMAN, M. VAUGHAN (eds), Palgrave Macmillan, Basingstoke, New York, USA, 2007 (original French edition 1907).

[BER 1996] BERNERS-LEE T., "Universal resource identifiers: axioms of Web architecture", WWW Consortium, http://www.w3.org/DesignIssues/Axioms.html#opaque, 1996.

[BER 1999] BERNERS-LEE T., *Weaving the Web*, Harper, San Francisco, USA 1999.

[BER 1968] VON BERTALANFFY L., *General System Theory: Foundations, Development, Applications*, George Braziller, New York, USA, 1968.

[BIC 1995] BICKERTON D., *Language and Human Behavior*, University of Washington Press, Seattle, 1995.

[BIE] BIEZUNSKI M., NEWCOMB S., "IEML-STAR Parser", http://starparser.ieml.org (the program is open source: Apache licence 2.0).

[BLA 1962] BLANCHÉ R., *Axiomatics*, Routledge and Kegan Paul, London, 1962.

[BLA 1970] BLANCHE R., *La Logique et son Histoire d'Aristote à Russell*, Armand Colin, Paris, France, 1970.

[BLA 2003] BLANCHOT M., *The Book to Come,* Stanford University Press, Stanford, CA, USA, 2003.

[BLO 2000] BLOOM H., *Global Brain: The Evolution of Mass Mind from the Big Bang to the 21st Century*, John Wiley & Sons, New York, USA, 2000.

[BOD 2006] BODEN M., *Mind as Machine: A History of Cognitive Science*, Oxford University Press, New York, USA, 2006.

[BON 1994] BONABEAU E., THERAULAZ G., *Intelligence Collective*, Hermès, Paris, France, 1994.

[BON 1999] BONABEAU E., DORIGO M., THERAULAZ G., *Swarm Intelligence: From Natural to Artificial Systems*, Oxford University Press, New York, USA, 1999.

[BOR 1998a] BORGES J.L., "The Aleph", in: *Collected Fictions*, pp. 274-286, Viking, New York, USA, 1998 (original Spanish edition, 1945).

[BOR 1998b] BORGES J.L., "The garden of forking paths", in: *Collected Fictions*, pp. 119-128, Viking, New York, USA, 1998 (original Spanish edition, 1944).

[BOR 1998c] BORGES J.L., "The library of Babel", in: *Collected Fictions*, pp. 112-118, Viking, New York, USA, 1998 (original Spanish edition, 1944).

[BOT 1992] BOTTÉRO J., *Mesopotamia: Writing, Reasoning, and the Gods*, University of Chicago Press, Chicago, USA, 1992.

[BOU 1996] BOURDIEU P., *The Rules of Art: Genesis and Structure of the Literary Field*, Polity Press, Cambridge, UK, 1996.

[BOW 2005] BOWKER G., *Memory Practices in the Sciences*, MIT Press, Cambridge, MA, USA, 2005.

[BOY 1935] BOYANCE P., "Une allusion à l'oeuf orphique", *Mélanges d'Archéologie et d'Histoire*, no. 52, pp. 95-112, 1935.

[BUR 2009] BURGESS J., GREEN J., *YouTube*, Polity Press, Malden, MA, USA, 2009.

[BUS 1945] BUSH V., "As we may think", *Atlantic Monthly*, July 1945.

[BUT 1991] BUTLER G., *Lecture Notes in Computer Science*, 559, Springer, 1991.

[CAL 1989] CALLON M., *La Science et ses Réseaux: Genèse et Circulation des Faits Scientifiques*, La Découverte, Paris, France, 1989.

[CAR 2000] CARRUTHERS M., *The Craft of Thought: Meditation, Rhetoric, and the Making of Images*, 400-1200, Cambridge University Press, Cambridge, UK, USA, 2000.

[CAS 2004] CASSIN B., *Vocabulaire Européen des Philosophies*, Seuil/Le Robert, Paris, France, 2004.

[CAS 1996] CASSIRER E., *The Philosophy of Symbolic Forms* (3 volumes), Yale University Press, New Haven, USA, 1953-1996 (original German edition, 1929).

[CAS 1998] CASTELLS M., *The Information Age* (3 volumes), Blackwell, Cambridge, MA, 1996-1998.

[CAS 2009] CASTELLS M., *Communication Power*, Oxford University Press, New York, USA, 2009.

[CAS 1987] CASTORIADIS C., *The Imaginary Institution of Society*, MIT Press, Cambridge, MA, USA, 1987.

[CGP 1980] CENTRE GEORGES POMPIDOU, "Cartes et figures de la terre", *Catalogue de l'Exposition du Centre Georges Pompidou*, Centre Georges Pompidou, Paris, France, 1980.

[CHA 1997] CHANG A., *Histoire de la Pensée Chinoise*, Seuil, Paris, France, 1997.

[CHA 1976] CHANGEUX J.-P., DANCHIN A., "Selective stabilization of developing synapses as a mechanism for the specification of neuronal networks", *Nature*, Vol. 264, pp. 705-712, 1976.

[CHA 1985] CHANGEUX J.-P., *Neuronal Man: The Biology of Mind*, Pantheon, New York, USA, 1985 (original French edition, 1983).

[CHA 1984] CHARTRAND G., *Introductory Graph Theory*, Dover, New York, USA, 1984.

[CHO 1963] CHOMSKY N., SCHÜTZENBERGER M.-P., "The algebraic theory of context-free languages", in: *Computer Programming and Formal Languages*, P. BRAFFORT and D. HIRSCHBERG (eds), pp. 118-161, North Holland, Amsterdam, The Netherlands, 1963.

[CHO 2000] CHOMSKY N., *New Horizons in the Study of Language and Mind*, Cambridge University Press, Cambridge, UK, 2000.

[CHO 1957] CHOMSKY N., *Syntaxic Structures*, Mouton, The Hague, The Netherlands, 1957.

[COO 2004] COOPER S.B., *Computability Theory*, Chapman and Hall/CRC, London, 2004.

[COU 1901] COUTURAT L., *La Logique de Leibniz d'Après des Documents Inédits*, Alcan, Paris, France, 1901.

[CVE 1997] CVETKOVIC D., ROWLINSON P., SIMIC S., *Eigenspaces of Graphs*, Cambridge University Press, Cambridge, UK, 1997.

[CYR 1993] CYRULNIK B., *The Dawn of Meaning*, McGraw-Hill, New York, USA, 1993.

[DAL 2005] DALKIR K., *Knowledge Management in Theory and Practice*, Elsevier, New York, USA, 2005.

[DAM 1994] DAMASIO A.R., *Descartes' Error: Emotion, Reason, and the Human Brain*, Putnam, New York, USA, 1994.

[DAR 1859] DARWIN C., *On the Origin of Species*, 1859, available at: http://darwin-online.org.uk/EditorialIntroductions/Freeman_OntheOriginofSpecies.html (original edition).

[DAR 1871] DARWIN C., *The Descent of Man*, 1871, available at: http://darwin-online.org.uk/contents.html#descent (original edition).

[DAV 2000] DAVIS M., *Engines of Logic: Mathematicians and the Origin of the Computer* (1st edition), W.W. Norton, New York, USA, 2000.

[DAW 1976] DAWKINS R., *The Selfish Gene*, Oxford University Press, New York, USA, 1976.

[DEK 1997] DE KERCKHOVE D., *Connected Intelligence*, Somerville House, Toronto, 1997.

[DEA 1997] DEACON T.W., *The Symbolic Species*, Norton, New York, USA, 1997.

[DEG 1999] DEGENNE A., FORSÉ M., *Introducing Social Networks*, SAGE publications, London, 1999.

[DEL 1977] DELEUZE G., GUATTARI F., *Anti-Oedipus*, Viking, New York, USA, 1977.

[DEL 1987a] DELEUZE G., PARNET C., *Dialogues II* (revised edition), Columbia University Press, New York, USA, 1987.

[DEL 1987b] DELEUZE G., GUATTARI F., *A Thousand Plateaus*, Athlone, London, 1987.

[DEL 1988] DELEUZE G., *Le Pli: Leibniz et le Baroque*, Minuit, Paris, France, 1988.

[DEL 1990] DELEUZE G., *The Logic of Sense*, Columbia University Press, New York, USA, 1990.

[DEL 1994] DELEUZE G., *Difference and Repetition*, Columbia University Press, New York, USA, 1994.

[DER 1973] DERRIDA J., *Speech and Phenomena, and Other Essays on Husserl's Theory of Signs*, Northwestern University Press, Evanston, USA, 1973.

[DER 1976] DERRIDA J., *Of Grammatology*, Johns Hopkins University Press, Baltimore, MD, USA, 1976.

[DER 1978] DERRIDA J., *Writing and Difference*, University of Chicago Press, Chicago, USA, 1978.

[DER 2004] DERRIDA J., *Dissemination*, Continuum, London, 2004.

[DES 2005] DESCOLA P., *Par-delà Nature et Culture*, Gallimard, Paris, France, 2005.

[DEW 1876] DEWEY M., *A Classification and Subject Index for Cataloguing and Arranging the Books and Pamphlets of a Library*, Amherst, MA, USA, 1876.

[DIA 1999] DIAMOND J., *Guns, Germs and Steel*, Norton, New York, USA, 1999.

[DIC 2008] DICHEV C., XU J., DICHEVA D., ZHANG J., "A study on community formation in collaborative tagging systems", *Proceedings of the IEEE/WIC/ACM International Conference on Web Intelligence*, vol. 3, pp. 13-16, Sydney, Australia, 2008.

[DIE 2005] DIESTEL R., *Graph Theory*, Springer-Verlag, Heidelberg, Germany, 2005. Available at: http://diestel-graph-theory.com.

[DIE 1982] DIEUDONNE J. *et al.*, *Penser les mathématiques*, Seuil, Paris, France, 1982.

[DRE 2009] DRECHSLER M., Les pratiques du socialbookmarking dans le domaine de l'éducation, PhD thesis, Paul Verlaine University, Metz, 2009.

[DRE 1992] DREYFUS H., *What Computers Still Can't Do: A Critique of Artificial Reason* (revised edition), MIT Press, Cambridge, MA, USA, 1992.

[DUN 1999] DUNS SCOTUS J., *Prologue de l'Ordinatio*, Presses Universitaires de France, Paris, France, 1999.

[DUP 2009] DUPUY J.-P., *On the Origins of Cognitive Science: The Mechanization of the Mind*, MIT Press, Cambridge, MA, USA, 2009.

[DUR 2008] DURKHEIM É., *The Elementary Forms of Religious Life*, Oxford University Press, Oxford, UK, 2008 (original French edition, 1912).

[ECO 1989] ECO U., *The Open Work*, Harvard University Press, Cambridge, MA, USA, 1989.

[ECO 1992] ECO U., *Le Signe: Histoire et Analyse d'un Concept*, Livre de Poche, Paris, France, 1992 (original Italian edition, 1971).

[EDE 1987] EDELMAN G., *Neural Darwinism*, Basic Books, New York, USA, 1987.

[EIS 1983] EISENSTEIN E., *The Printing Revolution in Early Modern Europe*, Cambridge University Press, New York, USA, 1983.

[ELI 1934] ELIOT T.S., *The Rock*, Faber and Faber, London, 1934.

[ENG 1962] ENGELBART D., Augmenting human intellect, Technical Report, Stanford Research Institute, Stanford, CA, USA, 1962.

[FEI 2007] FEIGENBAUM L. *et al.*, “The semantic web in action”, *Scientific American*, pp. 90-97, December 2007.

[FEL 1998] FELLBAUM C., *Wordnet: An Electronic Lexical Database*, MIT Press, Cambridge, MA, USA, 1998.

[FIN 1972] FINGARETTE H., *Confucius: The Secular as Sacred*, Waveland Press, Long Grove, IL, USA, 1972.

[FOE 1981] VON FOERSTER H., *Observing Systems: Selected Papers of Heinz von Foerster*, Intersystems Publications, Seaside, CA, USA, 1981.

[FOU 1972] FOUCAULT M., *The Archaeology of Knowledge*, Pantheon, New York, USA, 1972.

[FOU 2007] FOURQUET F., “Critique de la raison cognitive”, in: *Le Capitalisme Cognitif* (2nd edition), Y. MOULIER BOUTANG (ed.), pp. 265-276, Editions Amsterdam, Paris, France, 2007.

[FRE 1952] FREGE G., *Philosophical Writings of Gottlob Frege*, P. GEACH and M. BLACK (eds.), Blackwell, Oxford, UK, 1952.

[FRE 1955] FREUD S., *The Interpretation of Dreams*, Basic Books, New York, USA, 1955.

[FUK 1995] FUKUYAMA F., *Trust: The Social Virtues and the Creation of Prosperity*, Hamish Hamilton, London, 1995.

[GAD 1988] GADAMER H.-G., *Truth and Method*, Crossroad, New York, USA, 1988.

[GAL 1990] GALILEO G., “The Assayer”, in: *Discoveries and Opinions of Galileo*, Anchor Books, New York, USA, 1990 (original edition, 1623).

[GAL 2003] GALISON P., *Einstein’s Clocks, Poincaré’s Maps*, Norton, New York, USA, 2003.

[GAR 1987] GARDNER H., *The Mind’s New Science: A History of the Cognitive Revolution*, Basic Books, New York, USA, 1987.

[GAR 1967] GARFINKEL H., *Studies in Ethnomethodology*, Prentice-Hall, Englewood Cliffs, NJ, USA, 1967.

[GIL 1962] GILL A., *Introduction to the Theory of Finite-State Machines*, McGraw-Hill, New York, USA, 1962.

[GLE 1987] GLEICK J., *Chaos: Making a New Science*, Viking, New York, USA, 1987.

[GOL 1995] GOLEMAN D., *Emotional Intelligence*, Bantam, New York, USA, 1995.

[GOL 1996] GOLUB G.H., VAN LOAN C.F., *Matrix Computations* (3rd edition), John Hopkins University Press, Baltimore, MD, USA, 1996.

[GOO 1977] GOODY J., *The Domestication of the Savage Mind*, Cambridge University Press, New York, USA, 1977.

[GOO 1987] GOODY J., *The Logic of Writing and the Organization of Society*, Cambridge University Press, New York, USA, 1987.

[GRA 1973] GRANOVETTER M., "The strength of weak ties", *American Journal of Sociology*, Vol. 78, pp. 1360-1380, May 1973.

[GRE 1999] GREENE B., *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory*, Vintage, London, 1999.

[GRO 1993] GRONDIN J., *L'Universalité de l'Herméneutique*, Presses Universitaires de France, Paris, France, 1993.

[GRO 2006] GRONDIN J., *L'Herméneutique*, Presses Universitaires de France, Paris, France, 2006.

[GUA 1995] GUATTARI F., *Chaosmosis: An Ethico-Aesthetic Paradigm*, Indiana University Press, Bloomington, USA, 1995.

[GUS 1988] GUSDORF G., *Les origines de l'Herméneutique*, Payot, Paris, France, 1988.

[GWI 2004] GWIN C., *Sharing Knowledge: Innovations and Remaining Challenges*, World Bank, Washington, DC, USA, 2004.

[HAL 2007] HALPIN H., ROBU V., SHEPHERD H., "The complex dynamics of collaborative tagging", *Proceedings of the 16th International WWW Conference*, pp. 211-220, 2007.

[HAL 2010] HALPIN H., CLARK A., WHYLER M., "Towards a philosophy of the Web: representation, enaction, collective intelligence", *Web Science Conference 2010*, Raleigh, NC, USA, April 26-27, 2010.

[HAM 2004] HAMBERGER K., "Le continent logique: À propos de quadratura Americana d'Emmanuel Désveaux", *Journal de la Société des Américanistes*, Vol. 90-2, pp. 103-114, 2004.

[HAR 2003] HARNAD S., "Symbol-grounding problem", *Encylopedia of Cognitive Science*, Nature Publishing Group, Macmillan, London, 2003.

[HAV 1988] HAVELOCK E.A., *The Muse Learns to Write: Reflections on Orality and Literacy from Antiquity to the Present*, Yale University Press, New Haven, CT, USA, 1988.

[HAY 1937] HAYEK F., "Economics and knowledge", *Economica IV*, new ser., pp. 33-54, 1937.

[HAY 1979] HAYEK F., *Law, Legislation and Liberty* (3 volumes), Routledge and Kegan Paul, London, 1979.

[HEN 1968] HENNIE F.C., *Finite-State Models for Logical Machines*, John Wiley & Sons, New York, USA, 1968.

[HER 2004] HERLOCKER J.L., KONSTAN J.A., TERVEEN L.G., RIEDL J., "Evaluating collaborative filtering recommander systems", *ACM Transactions on Information Systems*, vol. 22, no. 1, pp. 5-53, 2004.

[HES 1969] HESSE H., *The Glass Bead Game* (Magister Ludi), Holt, Rinehart and Winston, New York, USA, 1969 (original German edition, 1943).

[HEY 1996] HEYLIGHEN F., BOLLEN J., "The World-Wide Web as a super-brain: from metaphor to model", in: *Cybernetics and Systems*, R. TRAPPL (ed.), Austrian Society for Cybernetic Studies, pp. 911-917, Vienna, Austria, 1996.

[HJE 1953] HJELMSLEV L., *Prolegomena to a Theory of Language*, Waverly Press, Baltimore, MD, USA, 1953.

[HJE 1971] HJELMSLEV L., *Essais Linguistiques*, Minuit, Paris, France, 1971 (original Danish edition, 1959).

[HOD 1992] HODGES A., *Alan Turing: The Enigma*, Random House, London, 1992.

[HOL 1991] HOLZMANN G.J., *Design and Validation of Computer Protocols*, Prentice Hall, Englewood Cliffs, NJ, USA, 1991.

[HOP 2001] HOPCROFT J.E., MOTWANI R., ULLMAN J.D., *Introduction to Automata Theory, Languages, and Computation* (2nd edition), Addison-Wesley, Boston, USA, 2001.

[HOY 1957] HOYLE F., BURBIDGE M., BURBIDGE W., FOWLER A., "Synthesis of the elements in stars", *Reviews of Modern Physics*, vol. 29, no. 4, pp. 547-650, October 1957.

[HUT 1995] HUTCHINS E., *Cognition in the Wild*, Cambridge MIT Press, MA, USA, 1995.

[ICH 1967] *I Ching: The Book of Changes*, Princeton University Press, Princeton, NJ, USA, 1967.

[IFR 1998] IFRAH G., *The Universal History of Numbers: From Prehistory to the Invention of the Computer*, Harvill Press, London, 1998.

[INN 1950] INNIS H., *Empire and Communication*, University of Toronto Press, Toronto, Canada, 1950.

[JAK 1981] JAKOBSON R., *Essais de linguistique générale* (2 volumes), Minuit, Paris, France, 1981.

[JAY 1976] JAYNES J., *The Origin of Consciousness in the Breakdown of the Bicameral Mind*, Houghton Mifflin, Boston, USA, 1976.

[JEN 2006] JENKINS H., *Convergence Culture: Where Old and New Media Collide*, New York University Press, New York, USA, 2006.

[JOH 1983] JOHNSON-LAIRD P.N., *Mental Models*, Harvard University Press, Cambridge, MA, USA, 1983.

[JOH 2001] JOHNSON S., *Emergence: The Connected Lives of Ants, Brains, Cities and Software*, Scribner, New York, USA, 2001.

[JUA 2010] JUANALS B., NOYER J.-M., *Technologies de l'Information et Intelligences Collectives*, Hermès-Lavoisier, Paris, France, 2010.

[JUN 1968] JUNG C.G., *Psychology and Alchemy*, Princeton University Press, Princeton, NJ, USA, 1968.

[KAN 2006] KANDEL E.R., *In Search of Memory: The Emergence of a New Science of Mind*, Norton, New York, USA, 2006.

[KAN 2004] KANT I., *The Critique of Pure Reason*, Barnes and Noble, Mineola, NY, USA, http://www.gutenberg.org/etext/4280, 2004 (original German edition, 1781).

[KAP 2009] KAPETANIOS E., "On the notion of collective intelligence: opportunity or challenge?", *International Journal of Organizational and Collective Intelligence (IJOCI)*, vol. 1, pp. 1-14, no. 1, 2009.

[KAP 2010] KAPETANIOS E., KOUTRIKA G., *Information Sciences.* Special issue on collective intelligence, vol. 180, issue 1, Elsevier, Amsterdam, The Netherlands, 2010.

[KAP 1994] KAPLAN R., MARTIN K., "Regular models of phonological rule systems", *Computational Linguistics*, vol. 20, no. 3, pp. 331-378, 1994.

[KAP 1999] KAPLAN R., *The Nothing That Is: A Natural History of Zero*, Oxford University Press, New York, USA, 1999.

[KEL 1994] KELLY K., *Out of Control: The New Biology of Machines, Social Systems and the Economic World*, Addison Wesley, New York, USA, 1994.

[KER 2001] KERBRAT-ORECCHIONI C., *Les Actes de Langage dans le Discours*, Nathan Université, Paris, France, 2001.

[KHA 2006] KHARE R., "Microformats: the next (small) thing on the semantic Web?", *IEEE Internet Computing,* vol. 10, issue 1, pp. 68-75, January-February 2006.

[KLE 1956] KLEENE S., *Representation of Events in Nerve Nets and Finite Automata*, Princeton University Press, Princeton, NJ, USA, 1956.

[KOR 1933] KORZYBSKI A., *Science and Sanity: An Introduction to Non-Aristotelian Systems and General Semantics*, International Society for General Semantics, San Francisco, USA, 1933.

[KOY 1958] KOYRÉ A., *From the Closed World to the Infinite Universe*, Harper, New York, USA, 1958.

[KRO 2000] VON KROGH G., ICHIJO K., NONAKA I., *Enabling Knowledge Creation: How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation*, Oxford University Press, New York, USA, 2000.

[KUH 1962] KUHN T., *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago, USA, 1962.

[KUR 1999] KURIYAMA S., *The Expressiveness of the Body and the Divergence of Greek and Chinese Medicine*, Zone Books, New York, USA, 1999.

[KUR 2006] KURZWEIL R., *The Singularity is Near: When Humans Transcend Biology*, Penguin, New York, USA, 2006.

[LAK 1987] LAKOFF G., *Women, Fire and Dangerous Things: What Categories Reveal About the Mind*, University of Chicago Press, Chicago, USA, 1987.

[LAK 2003] LAKOFF G., JOHNSON M., *Metaphors We Live By*, University of Chicago Press, Chicago, USA, 2003.

[LAN 1991] LANGACKER R.W., *Foundations of Cognitive Grammar* (2 volumes), Stanford University Press, Stanford, USA, 1987-1991.

[LAR 1999] LARSON R.C., ODONI A.R., *Urban Operations Research*, Massachusetts Institute of Technology, Cambridge, MA, USA, http://web.mit.edu/urban_or_book/www/book/, 1997-99 (first published 1981).

[LAS 2002] LASZLO K.C., LASZLO A., "Evolving knowledge for development: the role of knowledge management in a changing world", *Journal of Knowledge Management*, vol. 6, no. 4, pp. 400-412, 2002.

[LAT 1985] LATOUR B., "Les 'vues' de l'esprit. Une introduction à l'anthropologie des sciences et des techniques", *Culture Technique*, no. 14, pp. 4-30, http://www.bruno-latour.fr/articles/article/18-VUES-ESPRIT.pdf, June 1985.

[LAT 1987] LATOUR B., *Science in Action*, Harvard University Press, Cambridge, MA, USA, 1987.

[LEI 1695] LEIBNIZ G.W., "Système nouveau de la nature et de la communication des substances", *Journal des savants*, http://fr.wikisource.org/wiki/Système_nouveau_de_la_nature?match=en, originally published June 1695.

[LEI 1714] LEIBNIZ G.W., "Principes de la nature et de la grâce." *L'Europe Savante,* Nov., art. VI, http://fr.wikisource.org/wiki/Principes_de_la_nature_et_de_la_grâce?match=en, 1764.

[LEI 1764] LEIBNIZ G.W., "Nouveaux essais sur l'entendement humain", http://fr.wikisource.org/wiki/Nouveaux_Essais_sur_l'entendement_humain?match=en, written 1704, originally published 1764.

[LEI 2000] LEIBNIZ G.W., *De l'Horizon de la Doctrine Humaine*, Lavoisier, Paris, France, 2000 (original edition, 1693).

[LEI 1898] LEIBNIZ G.W., *The Monadology and other Philosophical Writings*, Clarendon Press, Oxford, http://fr.wikisource.org/wiki/Monadologie/Édition_Bertrand_1886, 1898 (original French edition, 1714).

[LES 2004] LESSIG L., *Free Culture: How Big Media Uses Technology and the Law to Lock Down Culture and Control Creativity*, Penguin, New York, USA, 2004.

[LÉV 1963] LÉVI-STRAUSS C., "Social structure", in: *Structural Anthropology*, pp. 277-324, Basic Books, New York, USA, 1963.

[LÉV 1966] LÉVI-STRAUSS C., *The Savage Mind*, University of Chicago Press, Chicago, USA, 1966.

[LÉV 1969] LÉVI-STRAUSS C., *The Elementary Structures of Kinship*, Beacon Press, Boston, USA, 1969.

[LÉV 1987] LÉVI-STRAUSS C., *Introduction to the Work of Marcel Mauss*, Routledge and Kegan Paul, London, 1987.

[LEV 2000] LEVINE R., LOCKE C., SEARLS D., WEINBERGER D., *The Cluetrain Manifesto: The End of Business as Usual*, Perseus Books, Cambridge, MA, USA, 2000.

[LÉV 1998] LÉVY-LEBLOND J.-M., "La nature prise à la lettre", *Alliage*, no. 37-38, http://www.tribunes.com/tribune/alliage/37-38/jmll.htm, 1998.

[LÉV 1982] LÉVY P., "L'informatique et l'occident", *Esprit*, pp. 41-69, July 1982.

[LÉV 1986a] LÉVY P., "Analyse de contenu des travaux du Biological Computer Laboratory (BCL)", in: *Cahiers du CREA*, Vol. 8, pp. 155-191, 1986.

[LÉV 1986b] LÉVY P., "L'Œuvre de Warren McCulloch", *Cahiers du CREA*, Vol. 7, pp. 211-255, 1986.

[LÉV 1987] LÉVY P., *La Machine Univers. Création, cognition et culture informatique*, La Découverte, Paris, France, 1987.

[LÉV 1990] LÉVY P., *Les Technologies de l'Intelligence. L'Avenir de la Pensée à l'Ère Informatique*, La Découverte, Paris, France, 1990.

[LÉV 1991] LÉVY P., *L'Idéographie Dynamique. Vers une Imagination Artificielle?*, La Découverte, Paris, France, 1991.

[LÉV 1992a] LÉVY P., AUTHIER M., *Les Arbres de Connaissances*, La Découverte, Paris, France, 1992.

[LÉV 1992b] LÉVY P., *De la Programmation Considérée comme un des Beaux-arts*, La Découverte, Paris, France, 1992.

[LÉV 1994] LÉVY P., "Plissé fractal, ou comment les machines de Guattari peuvent nous aider à penser le transcendantal aujourd'hui", *Chimères*, no. 21, pp. 167-180, 1994.

[LÉV 1997] LÉVY P., *Collective Intelligence: Mankind's Emerging World in Cyberspace*, Perseus Books, Cambridge, MA, USA, 1997.

[LÉV 1998] LÉVY P., *Becoming Virtual: Reality in the Digital Age*, Plenum Trade, New York, USA, 1998.

[LÉV 1999] LÉVY P., LABROSSE D., *Le Feu Libérateur*, Arléa, Paris, France, 1999.

[LÉV 2000] LÉVY P., *World Philosophie: le Marché, le Cyberespace, la Conscience*, Odile Jacob, Paris, France, 2000.

[LÉV 2001] LÉVY P., *Cyberculture*, University of Minnesota Press, Minneapolis, USA, 2001.

[LÉV 2002] LEVY P., *Cyberdémocratie: Essai de Philosophie Politique*, Odile Jacob, Paris, France, 2002.

[LÉV 2006] LÉVY P., *IEML Dictionary*. http://www.ieml.org/spip.php? article 7; in French, http://www.ieml.org/spip.php? article 26; in a multilingual open-source database developed by Christian Desjardins at the Canada Research Chair in Collective Intelligence at the University of Ottawa, http://dictionary.ieml.org, 2010 (in progress). See also the first hypertext version of 2006 in French, http://www.ieml.org/french/elements.html, and in English, http://www.ieml.org/english/elements.html, programmed by Michel Biezunski and Steve Newcomb at the CRC-CI at the University of Ottawa (to explore, click on *relations*, *cycles*, *ideas* and *paradigms* on the left).

[LÉV 2007] LÉVY P., "Société du savoir et développement humain", in: *Le Canada et la Société des Savoirs*, P. IMBERT (ed.), University of Ottawa Research Chair, Canada: Social and Cultural Challenges in a Knowledge-Based Society, pp. 115-175, 2007.

[LÉV 2009] LÉVY P., "Toward a Self-referential Collective Intelligence: Some Philosophical Background of the IEML Research Program", *Computational Collective Intelligence, Semantic Web, Social Networks and Multiagent Systems*, pp. 22-35, First International Conference, ICCCI, Wroclaw, Poland, Oct. 2009, proceedings, Berlin-Heidelberg-New York: Springer, 2009.

[LÉV 2010a] LÉVY P., "The IEML research program: from social computing to reflexive collective intelligence", in: *Information Sciences, Special Issue on Collective Intelligence*, E. KAPETANIOS and G. KOUTRIKA (eds), vol. 180, no. 1, Elsevier, Amsterdam, The Netherlands, pp. 71-94, available online with some additions: http://www.ieml.org/spip.php? article1562, January 2010.

[LÉV 2010b] LÉVY P., IEML semantic topology. A formal model of the circuits of the information economy, CI Lab Technical Report, http://www.ieml.org/spip.php? article 152, 2010.

[LÉV] LÉVY P., IEML-STAR Parser, http://starparser.ieml.org/ (open source). This parser was developed by Michel Biezunski and Steve Newcomb under the scientific supervision of Pierre Lévy at the Canada Research Chair in Collective Intelligence at the University of Ottawa.

[LI 2008] LI C., BERNOFF J., *Groundswell: Winning in a World Transformed by Social Technologies*, Harvard Business Press, Boston, MA, USA, 2008.

[LIB 1996] DE LIBERA A., *La Querelle des Universaux, de Platon à la Fin du Moyen Âge*, Seuil, Paris, France, 1996.

[LIB 1999] DE LIBERA A., *L'Art des Généralités. Théories de l'Abstraction*, Aubier, Paris, France, 1999.

[LIC 1960] LICKLIDER J., "Man–computer symbiosis", *IRE Transactions on Human Factors in Electronics*, vol. 1, pp. 4-11, 1960.

[LIN 2001] LIN N., *Social Capital: A Theory of Social Structure and Action*, Cambridge University Press, Cambridge, 2001.

[LIU 2004] LIU A., *The Laws of Cool: Knowledge Work and the Culture of Information*, University of Chicago Press, Chicago, USA, 2004.

[LLU 1990] LLULL R., *Ars Magna* (2 volumes), Editorial Patrimonio Nacional, Kaydeda, Madrid, 1990.

[LOC 1994] LOCHAK G., *La Géométrisation de la Physique*, Flammarion, Paris, France, 1994.

[LOG 2004] LOGAN R.K., *The Alphabet Effect*, Hampton Press, Cresskill, NJ, USA, 2004 (1st edition, 1986).

[LOG 2007] LOGAN R.K., *The Extended Mind: The Emergence of Language, the Human Mind and Culture*, University of Toronto Press, Toronto, Canada, 2007.

[LUH 1995] LUHMAN N., *Social Systems*, Stanford University Press, Stanford, CA, USA, 1995.

[LYO 1988] LYOTARD J.-F., *The Differend: Phrases in Dispute*, University of Minnesota Press, Minneapolis, USA, 1988.

[LYO 1984] LYOTARD J.-F., *The Postmodern Condition: A Report on Knowledge*, University of Minnesota Press, Minneapolis, USA, 1984.

[MAC 1962] MACHLUP F., *The Production and Distribution of Knowledge in the United States*, Princeton University Press, Princeton, NJ, USA, 1962.

[MAC 1982] MACHLUP F., *Knowledge: Its Creation, Distribution, and Economic Significance*, Princeton University Press, Princeton, NJ, USA, 1982.

[MAN 1969] MANN T., *Doctor Faustus*, Penguin, London, 1969 (original German edition, 1947).

[MAN 2001] MANOVITCH L., *The Language of New Media*, MIT Press, Cambridge, MA, USA, 2001.

[MAR 2006] MARLOW C., NAAMAN M., BOYD D., DAVIS M., “HT06, Tagging Paper, Taxonomy, Flickr, Academic Article, ToRead”, *Proceedings of the 17th Conference on Hypertext and Hypermedia*, pp. 31-40, 2006.

[MAR 1964] MARTINET A., *Elements of General Linguistics*, University of Chicago Press, Chicago, USA, 1964.

[MAR 1867] MARX K., *Das Kapital*, http://en.wikisource.org/wiki/Das_Kapital, (Original German edition, 1867).

[MAR 1973] MARX K., *Grundrisse: Foundations of the Critique of Political Economy*, Vintage Books, New York, USA, 1973 (orginal edition, 1858).

[MAT 1980] MATURANA H., VARELA F., *Autopoiesis and Cognition*, Kluwer, Dordrecht, The Netherlands, 1980.

[MAT 1988] MATURANA H., VARELA F., *The Tree of Knowledge: The Biological Roots of Human Understanding*, Shambhala, Boston, USA, 1988.

[MAU 1950] MAUSS M., *Sociologie et Anthropologie*, Presses Universitaires de France, Paris, France, 1950.

[MAU 1990] MAUSS M., *The Gift*, Routledge, Abingdon, Oxon 1990.

[MCC 1986] MCCLELLAND J.L., RUMELHART D.E., PDP RESEARCH GROUP, *Parallel Distributed Processing: Explorations in the Microstructure of Cognition* (2 volumes), MIT Press, Cambridge, MA, USA, 1986.

[MCC 1943] MCCULLOCH W., PITTS W., "A logical calculus of ideas immanent in nervous activity", *Bulletin of Mathematical Biophysics*, vol. 5, pp. 115-133, 1943.

[MCC 1965] MCCULLOCH W., *Embodiments of Mind*, MIT Press, Cambridge, MA, USA, 1965.

[MCL 1962] MCLUHAN M., *The Gutenberg Galaxy*, University of Toronto Press, Toronto, Canada, 1962.

[MCL 1964] MCLUHAN M., *Understanding Media: The Extensions of Man*, New American Library, New York, USA, 1964. (Critical edition: W.T. GORDON (ed.), Gingko Press, Berkeley, CA, USA, 2003).

[MCL 2005] MCLUHAN M., *The Classical Trivium: The Place of Thomas Nashe in the Learning of his Time*, W.T. GORDON (ed.), Gingko Press, Berkeley, CA, USA, 2005 (originally PhD thesis, 1943).

[MEL 1997] MEL'CUK I., *Vers une Linguistique Sens-Texte* (Leçon inaugurale), Collège de France, Paris, France, http://olst.ling.umontreal.ca/textes-a-telecharger/, 1997.

[MES 2007] MESSIER J., "Un bibliothécaire parmi les humanistes: Gottfried Wilhelm Leibniz (1646-1716)", *Argus*, University of Montreal, April 2007.

[MIN 1967] MINSKY M., *Finite and Infinite Machines*, Prentice Hall, Englewood Cliffs, NJ, USA, 1967.

[MIR 1995] MIRMAN R. *Group Theory: An Intuitive Approach*, World Scientific Editions, London, Hong Kong, Singapore, 1995.

[MKA 2008] MKADMI A., SALEH I., *Bibliothèque Numérique et Recherche d'Informations*, Hermès Lavoisier, Paris, France, 2008.

[MON 1971] MONOD J., *Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology*, Knopf, New York, USA, 1971.

[MOR 2000] MOREY D., MAYBURY M., THURAISINGHAM B., *Knowledge Management: Classic and Contemporary Works*, MIT Press, Cambridge, MA, USA, 2000.

[MOR 1991] MORIN E., *La Méthode* (6 volumes), Seuil, Paris, France, 1977-2004, In particular *Les idées*, vol. 4, 1991.

[MOU] MOULIER-BOUTANG Y., *Cognitive Capitalism*, Polity Press, Cambridge, forthcoming.

[MOU 2010] MOULIER-BOUTANG Y., *L'Abeille et l'Économiste*, Carnets Nord, Paris, France, 2010.

[NEL 1980] NELSON T., *Literary Machines*, Mindful Press, Sausalito, CA, USA, 1980.

[NEU 2009] NEUMAN Y., NAVE O., "Metaphor-based meaning excavation", *Information Sciences*, vol. 179, pp. 2719-2728, 2009.

[NEU 1944] VON NEUMANN J., MORGENSTERN O., *Theory of Games and Economic Behavior*, Princeton University Press, Princeton, NJ, USA, 1944.

[NEU 1946] VON NEUMANN J., "The principles of large-scale computing machines", Reprinted in: *Annals of the History of Computing*, vol. 3, no. 3, pp. 263-273, 1946.

[NEU 1958] VON NEUMANN J., *The Computer and the Brain*, Yale University Press, New Haven, CT, USA, 1958.

[NEU 1966] VON NEUMANN J., BURKS A.W., *Theory of Self-Reproducing Automata*, University of Illinois Press, Urbana, IL, USA, 1966.

[NEU 1973] VON NEUMANN J., First Draft of a Report on the EDVAC, Contract no.W-670-ORD-4926, between the United States Army Ordnance Department and the University of Pennsylvania, Moore School of Electrical Engineering. Partly reproduced in *The Origins of Digital Computers: Selected Papers,* ed. B. RANDELL, Berlin-Heidelberg: Springer Verlag, pp. 375-382, 1973.

[NGU 2009] NGUYEN N.T., KOWALCZYK R., CHEN S.-M., "Computational collective intelligence", *First International Conference, ICCCI 2009*, Wroclaw, Poland, October 2009, proceedings: Springer, Berlin-Heidelberg, Germany, NY, USA, 2009.

[NIE 1911] NIETZSCHE F., *The Complete Works of Friedrich Nietzsche*, Macmillan, New York, USA, 1911.

[NIS 1970] NISHIDA K., *Fundamental Problems of Philosophy: The World of Action and the Dialectical World*, Sophia University, Tokyo, Japan, 1970.

[NIS 1990] NISHIDA K., *An Inquiry into the Good*, Yale University Press, New Haven, CT, USA, 1990.

[NON 1995] NONAKA I., TAKEUCHI H., *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, New York, USA, 1995.

[NON 1998] NONAKA I., KONNO N., "The concept of 'Ba': building foundation for knowledge creation", *California Management Review*, vol. 40, no. 3, pp. 40-54, 1998.

[NOR 1980] NORA S., MINC A., *The Computerization of Society: A Report to the President of France*, MIT Press, Cambridge, MA, USA, 1980.

[OEC 2001] ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, *The Well-being of Nations: The Role of Human and Social Capital*, OECD, Paris, France, 2001.

[ONG 1982] ONG W., *Orality and Literacy: the Technologizing of the Word*, Methuen, London and New York, 1982.

[OST 2006] ELINOR O., HESS C., *Understanding Knowledge as a Commons: From Theory to Practice*, MIT Press, Cambridge, MA, USA, 2006.

[OTL 1934] OTLET P., *Traité de Documentation, le Livre sur le Livre*, Éditions du Mundaneum, Brussels, Belgium, 1934 (republished by the Centre de Lecture Publique de la Communauté Française de Belgique, 1989).

[OTL 1936] OTLET P., *Monde: Essai d'Universalisme*, Éditions du Mundaneum, Brussels, Belgium, 1936.

[PAN 1992] PANACCIO C., *Les Mots, les Concepts et les Choses: la Sémantique de Guillaume d'Occam et le Nominalisme d'Aujourd'hui*, Bellarmin-Vrin, Paris, France/St. Laurent, Quebec, 1992.

[PAN 1999] PANACCIO C., *Le Discours Intérieur. De Platon à Guillaume d'Ockam*, Seuil, Paris, France, 1999.

[PAP 1980] PAPERT S., *Mindstorms: Children, Computers, and Powerful Ideas*, Basic Books, New York, USA, 1980.

[PAS 1670] PASCAL B., *Pensées*, 1670.

[PAS 2008] PASCU C., *An Empirical Analysis of the Creation, Use and Adoption of Social Computing Applications*, European Commission, Joint Research Centre and Institute for Prospective Technological Studies, Luxembourg, Luxembourg, 2008. http://ftp.jrc.es/EURdoc/JRC46431.pdf

[PAU 2009] PAULEEN D., "Personal knowledge management: putting the 'person' back into the knowledge equation", *Online Information Review*, vol. 33, no. 2, pp. 221-224, 2009.

[PEI 1998] PEIRCE C., *The Essential Peirce: Selected Philosophical Writings*, Indiana University Press, Bloomington, IN, USA, 1998.

[PER 1946] PERSE S.-J., *Vents*, Gallimard, Paris, France, 1946.

[PER 2006] PERUZZI A., "The meaning of category theory for 21st century philosophy", *Axiomathes*, vol. 16, no. 4, pp. 424-459, 2006.

[PET 2009] PETERS I., *Folksonomies: Indexing and Retrieval in Web 2.0*, K.G. Saur, Munich, Germany, 2009.

[PIA 1952] PIAGET J., *The Origins of Intelligence in Children*, International Universities Press, New York, USA, 1952.

[PIA 1970a] PIAGET J., *Genetic Epistemology*, Columbia University Press, New York, USA, 1970.

[PIA 1970b] PIAGET J., *Structuralism*, Basic Books, New York, USA, 1970.

[PIA 1992] PIAGET J., HENRIQUES G., ASCHER E., *Morphisms and Categories: Comparing and Transforming*, L. Erlbaum Associates, Hillsdale, NJ, USA, 1992.

[PLA 1963] PLATO, *The Collected Dialogues of Plato, Including the Letters*, Princeton University Press, Princeton, NJ, USA, 1963.

[POP 1972] POPPER K., *Objective Knowledge: An Evolutionary Approach*, Clarendon Press, Oxford, 1972.

[POR 1977] PORAT M., RUBIN M., *The Information Economy*, U.S. Government Printing Office, Washington DC, USA, 1977.

[PRI 1984] PRIGOGINE I., STENGERS I., *Order Out of Chaos: Man's New Dialogue with Nature*, Bantam Books, Toronto, Canada/New York, USA, 1984.

[PUT 2000] PUTNAM R.D., *Bowling Alone: The Collapse and Revival of American Community*, Simon & Schuster, New York, USA, 2000.

[RAM 1968] RAMNOUX C., *Héraclite, l'Homme Entre les Choses et les Mots*, Les Belles Lettres, Paris, France, 1968.

[RAN 1982] RANDELL B., *Origins of Digital Computers: Selected Papers*, Springer-Verlag, Berlin-Heidelberg, Germany, 1982.

[RAN 1931] RANGANATHAN S.R., *The Five Laws of Library Science*, Edward Goldston, London, 1931.

[RAN 1933] RANGANATHAN S.R., *Colon Classification*, Madras Library Association, Madras, India, 1933.

[RAS 1987] RASTIER F., *Sémantique Interprétative*, Presses Universitaires de France, Paris, France, 1987.

[RAS 1990] RASTIER F., "La triade sémiotique, le trivium et la sémantique linguistique", in: *Nouveaux actes Sémiotiques*, no. 9, pp. 55, Presses Universitaires de Limoges, Limoges, France, 1990.

[RAS 2005] RASTIER F., "Herméneutique et linguistique: dépasser la méconnaissance", *Texto!*, vol. X, no. 4, http://www.revue-texto.net/Dialogues/Debat_Hermeneutique/Rastier_Herm-et-ling.html, December 2005.

[RED 2009] REDECKER C. *et al.*, Learning 2.0: The Impact of Web 2.0 Innovations on Education and Training in Europe, JRC Scientific and Technical Reports, European Commission, Brussels, Belgium, 2009.

[RHE 2002] RHEINGOLD H., *Smart Mobs, The Next Social Revolution*, Perseus Books, Cambridge, MA, USA, 2002.

[RIC 1969] RICHTA R., *Civilization at the Crossroads: Social and Human Implications of the Scientific and Technological Revolution*, International Arts and Sciences Press, White Plains, NY, USA 1969 (original Czech edition, 1966).

[RIC 1974] RICOEUR P., *The Conflict of Interpretations: Essays in Hermeneutics I*, Northwestern University Press, Evanston, IL, USA, 1974.

[RIC 1991] RICOEUR P., *From Text to Action: Essays in Hermeneutics II*, Northwestern University Press, Evanston, IL, USA, 1991.

[ROC 1997] ROCHE E., "Compact factorization of finite-state transducers and finite-state automata", *Nordic Journal of Computing*, vol. 4, no. 2, pp. 187-216, 1997.

[ROS 2000] DE ROSNAY J., *The Symbiotic Man: A New Understanding of the Organization of Life and a Vision of the Future*, McGraw-Hill, New York, USA, 2000.

[ROT 2003] ROTMAN J.J., *Advanced Modern Algebra*, Prentice Hall, Englewood Cliffs, NJ, USA, 2003.

[RUS 2010] RUSSELL S., NORVIG P., *Artificial Intelligence: A Modern Approach* (3rd edition), Prentice Hall, Upper Saddle River, NJ, USA, 2010.

[SAP 2004] SAPIR E., *Language: An Introduction to the Study of Speech*, Dover Publications, Mineola, NY, USA, 2004 (original edition, 1921).

[SAU 1959] DE SAUSSURE F., *Course in General Linguistics*, Philosophical Library, New York, USA, 1959.

[SAU 2003] DU SAUTOY M., *The Music of the Primes: Searching to Solve the Greatest Mystery in Mathematics*, Fourth Estate, London, 2003.

[SCH 2004] SCHREIBMAN S., SIEMENS R., UNSWORTH J., *A Companion to Digital Humanities*, Wiley-Blackwell, Hoboken, NJ, USA, 2004.

[SEA 1969] SEARLE J., *Speech Acts*, Cambridge University Press, London, 1969.

[SEA 1983] SEARLE J., *Intentionality*, Cambridge University Press, London, 1983.

[SEG 2007] SEGARAN T., *Programming Collective Intelligence, Building Smart Web 2.0 Applications*, O'Reilly Media, Sebastopol, CA, USA, 2007.

[SEN 1999] SEN A., *Development as Freedom*, Anchor Books, New York, USA, 1999.

[SER 1969] SERRES M, *Hermès I, La Communication*, Minuit, Paris, France, 1969.

[SER 1974] SERRES M, *Hermès III, La Traduction*, Minuit, Paris, France, 1974.

[SER 1977] SERRES M, *Hermès IV, La Distribution*, Minuit, Paris, France, 1977.

[SER 1980] SERRES M, *Hermès V, Le Passage du Nord-Ouest*, Minuit, Paris, France, 1980.

[SER 1982] SERRES M, *The Parasite*, Johns Hopkins University Press, Baltimore, USA, 1982.

[SER 1995] SERRES M, *A History of Scientific Thought: Elements of a History of Science*, Blackwell, Oxford, 1995.

[SER 2001] SERRES M, *The System of Leibniz*, Clinamen, Manchester, 2001.

[SET 2000] SETH L., "Ultimate physical limits to computation", *Nature*, vol. 406, pp. 1047-1054, 2000.

[SET 2002] SETH L., "Computational capacity of the universe", *Physical Review Letters*, vol. 88, 237901, 2002.

[SHA 1949] SHANNON C.E., WEAVER W., *Mathematical Theory of Communication*, University of Illinois Press, Urbana, USA, 1949.

[SHI 1995] SHIMIZU H., "Ba-principle: new logic for the real-time emergence of information", *Holonics*, Vol. 5/1, pp. 67-69, 1995.

[SHI 2005] SHIRKY C., *Ontology Is Overrated*, http://shirky.com/writings/ontology_overrated.html, 2005.

[SHI 2008] SHIRKY C., *Here Comes Everybody: The Power of Organizing Without Organizations*, Penguin, New York, USA, 2008.

[SHI 2010] SHIRKY C., *Cognitive Surplus*, *Creativity and Generosity in a Connected Age*, Penguin, New York, USA, 2010.

[SIM 1982] SIMON H., *Models of Bounded Rationality*, MIT Press, Cambridge, MA, USA, 1982.

[SIM 1958] SIMONDON G., *Du Mode d'Existence des Objets Techniques*, Aubier, Paris, France, 1958.

[SIM 2005] SIMONDON G., *L'Individuation à la Lumière des Notions de Forme et d'Information*, Jérôme Millon, Paris, France, 2005 (thesis publication: 1958).

[SLO 2009] SLOWINSKI R., "Rough set approach to knowledge discovery about preferences", in: *Computational Collective Intelligence, Semantic Web, Social Networks and Multiagent Systems*, N.T. NGUYEN, K. RYSZARD, S.-M. CHEN (eds), *First International Conference, ICCCI 2009*, Wroclaw, Poland, October 2009, Proceedings, pp. 1-21, Springer, Berlin-Heidelberg, Germany/NY, USA, 2009.

[SMI 1759] SMITH A., *The Theory of Moral Sentiments*, A. Millar, London, 1759.

[SMI 1776] SMITH A., *The Wealth of Nation*, Whitestone, Dublin, Ireland, 1776.

[SMI 2011] SMITH B.C., *The Age of Significance: An Essay on the Origins of Computation and Intentionality*, MIT Press, forthcoming. http://www.ageofsignificance.org.

[SMI 2008] SMITH G., *Tagging: People-powered Metadata for the Social Web*, New Riders, Berkeley, CA, USA, 2008.

[SOW 1984] SOWA J.F. *Conceptual Structures: Information Processing in Mind and Machine*, Addison-Wesley, Reading, MA, USA, 1984.

[SOW 2000] SOWA J.F. *Knowledge Representation: Logical, Philosophical, and Computational Foundations*, Brooks/Cole Publishing Co., Pacific Grove, CA, USA, 2000.

[SPE 1996] SPERBER D., *Explaining Culture: A Naturalistic Approach*, Blackwell, Oxford, UK/ Cambridge, MA, USA, 1996.

[SPI] SPIVACK N. Online: http://www.novaspivack.com.

[STE 1987] STENGERS I., *D'une Science à l'Autre: des Concepts Nomades*, Seuil, Paris, France, 1987.

[STE 1996] STENGERS I., BENSAUDE-VINCENT B., *A History of Chemistry*, Harvard University Press, Cambridge, MA, USA, 1996.

[STE 2000] STENGERS I., *The Invention of Modern Science*, University of Minnesota Press, Minneapolis, USA, 2000.

[STE 2010] STENGERS I., *Cosmopolitics*, University of Minnesota Press, Minneapolis, USA, 2010.

[STE 2011] STENGERS I., *Thinking with Whitehead: A Free and Wild Creation of Concepts*, Harvard University Press, Cambridge, MA/London, UK, 2011.

[STA 2009] STRANG G., *Introduction to Linear Algebra* (4th edition), Wellesley-Cambridge Press, Wellesley, MA, USA, 2009.

[SUR 2004] SUROWIECKI J., *The Wisdom of the Crowds*, Random House, London, 2004.

[SVE 2000] SVENONIUS E., *The Intellectual Foundation of Information Organization*, MIT Press, Cambridge, MA, USA, 2000.

[TAP 2007] TAPSCOTT D., WILLIAMS A.D., *Wikinomics: How Mass Collaboration Changes Everything*, Portfolio, New York, USA, 2007.

[TEI 1999] TEILHARD DE CHARDIN P., *The Human Phenomenon*, Sussex Academic Press, Brighton, UK/Portland, OR, USA, 1999.

[TOV 2008] TOVEY M., *Collective Intelligence: Creating a Prosperous World at Peace*, EIN Press, Oakton, VA, USA, 2008.

[TUR 1950] TURING A., "Computing machinery and intelligence", *Mind LIX*, vol. 236, pp. 433-460. http://loebner.net/Prizef/TuringArticle.html, October 1950.

[TUR 1937] TURING A., "On computable numbers, with an application to the Entscheidungsproblem", *Proceedings of the London Mathematical Society*, vol. s2-42, no. 1, pp. 230-265, 1936-37.

[UNI 2002] UNITED NATIONS, Human Development Report 2002, Oxford University Press, New York, USA/Oxford, UK, 2002.

[VAR 1974] VARELA F.J., MATURANA H., URIBE R., "Autopoiesis: the organization of living systems, its characterization and a model", *Biosystems*, vol. 5, pp. 187-196, 1974.

[VAR 1975] VARELA F.J., "A calculus for self-reference", *International Journal of General Systems*, vol. 2, pp. 5-24, 1975.

[VAR 1979] VARELA F.J., *Principles of Biological Autonomy*, North-Holland, New York, USA, 1979.

[VAR 1989] VARELA F.J., *Autonomie et Connaissance*, Seuil, Paris, France, 1989.

[VAR 1991] VARELA F.J., ROSCH E., THOMPSON E., *The Embodied Mind: Cognitive Science and Human Experience*, MIT Press, Cambridge, MA, USA, 1991.

[VAT 1991] VATTIMO G., *Éthique de l'Interprétation*, La Découverte, Paris, France, 1991 (original Italian edition, 1989).

[VYG 1986] VYGOTSKY L., *Thought and Language*, MIT Press, Cambridge, MA, USA, 1986. (original Russian edition, 1934).

[WAL 2008] WALLISER B., *Cognitive Economics*, Springer, Berlin, Germany, 2008.

[WAL 2002] WALLON H., *Les Origines du Caractère chez l'Enfant. Les Préludes du Sentiment de Personnalité*, Presses Universitaires de France, Paris, France, 2002 (first edition, 1934).

[WAT 1980] WATSON J.D., *The Double Helix: A Personal Account of the Discovery of the Structure of DNA*, Atheneum, New York, USA, 1980 (first edition, 1968).

[WEI 2007] WEINBERGER D., *Everything Is Miscellaneous: The Power of the New Digital Disorder*, Times Books/Henry Holt, New York, USA, 2007.

[WEI 1999] WEINSTEIN E.W., *CRC Concise Encyclopedia of Mathematics*, CRC Press, Boca Raton, FL, USA, 1999.

[WEI 1976] WEIZENBAUM J., *Computer Power and Human Reason: From Judgment to Calculation*, W.H. Freeman, San Francisco, USA, 1976.

[WEL 2001] WELLMAN B., "Computer networks as social networks", *Science*, 293, vol. 14, pp. 2031-2034, September, 2001.

[WEL 2011] WELLMAN B., RAINIE L., *Networked: The New Social Operating System*, MIT Press, Cambridge, MA, USA, forthcoming.

[WEN 1998] WENGER E., *Communities of Practice: Learning, Meaning, and Identity*, Cambridge University Press, London, 1998.

[WHI 1967a] WHITEHEAD A.N., *Adventures of Ideas*, Free Press, New York, USA, 1967 (original edition, 1933).

[WHI 1967b] WHITEHEAD A.N., *Science and the Modern World*, Free Press, New York, USA, 1967 (original edition, 1925).

[WHI 1979] WHITEHEAD A.N., *Process and Reality. An Essay in Cosmology*, Free Press, New York, USA, 1979 (original edition, 1929).

[WHO 1956] WHORF, B., *Language, Thought, and Reality: Selected Writings of Benjamin Lee Whorf*, J.B. CARROLL (ed.), MIT Press, Cambridge, MA, USA, 1956.

[WIE 1943] WIENER N., ROSENBLUETH A., BIGELOW J., "Behavior, purpose and teleology", *Philosophy of Science*, Vol. 10, pp. 18-24, 1943.

[WIE 1948] WIENER N., *Cybernetics, or Control and Communication in the Animal and the Machine*, John Wiley & Sons, New York, USA, 1948.

[WIE 1950] WIENER N., *The Human Use of Human Beings: Cybernetics and Society*, Doubleday, New York, USA, 1950.

[WIE 1996] WIERZBICKA A., *Semantics: Primes and Universals*, Oxford University Press, New York, USA, 1996.

[WIL 1971] WILSON E.O., *The Insect Societies*, Harvard University Press, Cambridge, MA, USA, 1971.

[WIL 1975] WILSON E.O., *Sociobiology: The New Synthesis*, Harvard University Press, Cambridge, MA, USA, 1975.

[WIN 1986] WINOGRAD T., FLORES F., *Understanding Computers and Cognition: A New Foundation for Design*, Ablex, Norwood, NJ, USA, 1986.

[WIT 1953] WITTGENSTEIN L., *Philosophical Investigations*, Blackwell, Oxford, 1953.

[WIT 1961] WITTGENSTEIN L., *Tractatus Logico Philosophicus*, Routledge and Kegan Paul Ltd, London, 1961.

[WOL 2002] WOLFRAM S., *A New Kind of Science*, Wolfram Media, Champaign, IL, USA, 2002.

[YAT 1974] YATES F., *The Art of Memory*, University of Chicago Press, Chicago, USA, 1974.

[ZAR 2004] ZARA O., *Le Management de l'Intelligence Collective*, M2 Editions, Paris, France, 2004.

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