PATTERNS OF HUMAN KNOWING IN THE INFORMATION SOCIETY

A Philosophical Study of the Epistemological Implications of the Information Revolution

by

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DEDICATION

Since human knowing has a lot to do with proof and understanding, this work is dedicated to Tabeth, my spouse, who has proved on various occasions that she understands me even when I misunderstand myself.

To Christopher, my son, who is making his first steps on the long journey of knowing and who thinks that once in a university he is going to study philosophy.

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TABLE OF CONTENTS

PRELUDE ONE

The thought of every age is reflected in its technique. The civil engineers of the ancient days were land surveyors, astronomers, and navigators; those of the seventeenth and early eighteenth centuries were clockmakers and lens grinders. In ancient times, the craftsmen made their tools in the image of the heavens. A watch is nothing but a pocket orrery moving by necessity as do the celestial spheres; and if friction and the dissipation of energy play a role in it, they are effects to be overcome so that the resulting motion of the hands may be as periodic and regular as possible. The chief technical result of this engineering after the model of Huyghens and Newton was the age of navigation, in which it was possible, for the first time, to compute longitudes with a respectable precision, and to convert the commerce of the great oceans from a thing of chance and adventure to a regular understood business. It is the engineering of the mercantilists.

To the merchant succeeded the manufacturer, and to the chronometer, the steam engine. From the Newcomen engine almost to the present time, the central field of engineering has been the study of prime movers. Heat has been converted into usable energy of rotation and translation, and the physics of Newton has been supplemented by that of Rumford, Carnot, and Joule. Thermodynamics makes its appearance, a science in which time is eminently irreversible; and although the earlier stages of this science seem to represent a region of thought almost without contact with the Newtonian dynamics, the theory of the conservation of energy and the later statistical explanation of the Carnot principle or second law of thermodynamics or principle of the degeneration of energy – that principle that makes the maximum efficiency obtainable by a steam engine depending on the working temperatures of the boiler and the condenser – all of these have fused thermodynamics and the Newtonian dynamics into the statistical and the non-statistical aspects of the same science.

If the seventeenth and the eighteenth centuries are the age of clocks, and the later eighteenth century the age of steam engines, the present age is the age of communication and control.[1]

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[1] Norbert Wiener, *Cybernetics or Control and Communication in The Animal and The Machine* 2nd ed. (New York: The MIT Press, 1961), p. 38-9.

PRELUDE TWO

To those who doubt whether there is progress in philosophy, it may be pointed out that in the three hundred years since Descartes died philosophical mankind has learned something. The word 'Descartes' is not equivalent to the word 'modernity', yet no other figure so symbolizes the spirit of modern thought: a broad departure from the Cartesian theses and assumptions implies an inner development of modern philosophy, a critique of modernity itself, and the readiness of this moment for a new stage of fundamental construction.

There is a near consensus – as near as philosophers ever ought to achieve – over some of Descartes' theses: for example that we can no longer accept neither the clean split between mind and body, which as a working hypothesis set laboratory science free for methodological cleanliness and a triumphant sweep of theory, nor the bisection of our physical experience into the sense-qualities, which are subjective, and the quantities, which are "out there" and "real", nor the precise mathematical perfection of every detail of physical sequence, inside and outside of organic bodies. These items of conventional Cartesianism are not false – we still use them. It is simply that they are not "the truth" and that we cannot tell the truth now available to us in terms of space, time, masses, and laws of formula of Galileo or Newton, of Lavoisier or Laplace, of Helmholtz or Tyndall, or even of Clerk-Maxwell. We require new concepts for physics, but also for the world at large new categories.[2]

[2] William Ernest Hocking, „Foreword" in Charles Hartshorne, *Reality as Social Process: Studies in Metaphysics and Religion* (New York: Hafner Publishing Company, 1971), p. 11.

PRELUDE THREE

While it is the triumph of the analytical and conceptual model …the computer can also force us to transcend that model. Information itself is indeed analytical and conceptual, but information is the organizing principle of every biological process. Life, as modern biology teaches, is embodied in a "genetic code", that is programmed information. Indeed, the sole definition of that mysterious reality "life" that does not invoke the supernatural is that it is matter organized by information. In a mechanical phenomenon the whole is equal to the sum of its parts and therefore capable of being understood by analysis. Biological phenomena are however "wholes." They are different from the parts of their parts. Information is indeed conceptual but meaning is not…[3]

[3] Peter F. Drucker, *The New Realities In Government and Politics in Economics and Business, in Society and World View* (New York: Harper & Row Publishers, 1989), p. 262.

INTRODUCTION

The invention and the diffusion of electronic computers and related information and communication technologies (ICTs) are not just technical innovations. They bring cultural changes that affect not only the way people behave, but also the way people think. The subsequent structural and cultural implications make the "information revolution" a fertile ground for philosophical investigation by identifying constitutive elements of an emerging new conceptual framework or ongoing features of a change in paradigm. Change in paradigm does not only involve changing ways of creating, storing, sharing, articulating, and applying knowledge, but also creating new tools of reflection such as metaphor and images. In this context, some parallels can be noticed between interactive systems and knowing as a social practice, the integrating nature of computer systems and what is known as "systems thinking" or the puzzling concept of "intelligent technology" mainly represented by "artificial intelligence" and "virtual reality".

Since the electronic computer and computer-related ICTs (information and communication technologies) have multimedia features that integrate sound, image, and written text, it is possible to integrate patterns of human knowing that begin with different patterns of experiencing. Such patterns lead from experiencing to understanding, judging, and often to evaluating, deciding, and acting. Since knowledge is a factor of production and a criterion of social mobility, it shapes the management of natural and cultural resources in a way that philosophy ceases to be an armchair activity. The philosopher, in this new context, is not an abstract speculator, but an active member of the community. Hence, the philosopher of knowledge or the epistemologist participates in the life of the community through teaching, social analysis, regular publications, and participation in debates of public interest.

This makes the philosopher an information provider, processor, and evaluator. From different nodes of information networks the philosopher is at the heart of new canons of rationality and effectiveness that create new metaphors, such as networked organizations, interactive processes, and feedback loops. Hence, the definition of knowledge in terms of information needs to be investigated seriously in order to establish clear rapports between information, cultural beliefs, scientific knowledge, technological developments, and popular wisdom. All these are tools of decision making and problem solving, and the way they are articulated and applied influences the way people make responsible choices and carry on ethically acceptable actions.

This thesis will attempt to articulate an information-based, dynamic and integrative model of epistemology. This model, on the one hand, intends to bring forward the notion of information as a paradigm of our time, and on the other hand, to show how this notion sets the ground for a dynamic and integrative epistemology that integrates contributions from many disciplines into the epistemological framework of the Canadian philosopher Bernard Lonergan. In the first chapter, with ample reference to Thomas Kuhn, the concept of paradigm change will be explained and then applied to the emergence of the scientific model and normative epistemology. It will be pointed out that modern science and normative epistemology have emerged as remedies to the arbitrariness of supernatural beliefs and the tyranny of authority in the description of reality and the articulation of knowledge. The period of crisis that span from the late medieval age and the early modern times generated puzzles that challenged the medieval synthesis based on supernaturalism and scholasticism in an unprecedented way. Philosophers and scientists (called natural philosophers) would no longer rely on revelation, tradition, and religious authority in their description of reality and the articulation of knowledge. New paradigms were needed as the medieval synthesis was no longer able to contain various movements of contestation, such as the reformation and the emergence of an urban intellectual elite that separated knowledge roles appealing to reason, from clerical status or reference to supernatural entities, revelation, tradition, and (religious) authority. In this context, modern science and normative epistemology emerged as reason-based ways of describing reality and articulating knowledge. They benefited from new tools of observation, such as the telescope and the microscope. Moreover, new technologies such as printing put an end to the esoteric character of knowledge by making devotional books that were previously reserved to the clergy available to the laity. These social processes and movements of contestation created a situation where reason became the sole foundation of human knowledge through observation, reasoning, and experimenting. These new methods aimed at establishing "a" permanent foundation for a "new" knowledge based on rational principles and not on supernatural beliefs or coercion by political and religious authority. This new foundation was expected to be solid enough to lead to indubitable, infallible, and incorrigible knowledge. Certainty or "clear and distinct" ideas were ideals for any knowledge claim according to the Cartesian tradition. Normative epistemology, in this context, defined knowledge as true justified belief. This definition was linked with Plato's distinction between knowledge (*episteme*) and opinion (*doxa*) or the refutation of skepticism. Normative epistemology aimed at describing reality as it is (objectivity) and discarding the limitations associated with one's spatial location, social status, moral values, and religious beliefs (universality). Furthermore, normative epistemology established a great mistrust of human senses by upholding that knowing is an activity of the mind. That is why the mechanical model with mathematics and logic as its systems of representation should be put in a historical perspective. Its claims to objectivity, universality, and truth are better understood when one has in mind its aim of providing remedies to the limits of the divine-organic model, which dominated scholasticism in the Middle Ages. The mechanical model, in the first instance, rejects metaphysical dualism, and establishes an order of causality that is embedded in the universe itself. In the second instance, the mechanical model postulates an isomorphism between the structure of the universe and the structure of the human mind. This approach implies the universality of reason against the privileged access to knowledge and truth of the authority of the church through its privileged access to "revealed" texts. The mechanical model, therefore, can be better understood as a response to scholasticism. Its rejection of a supernaturalism widely justifies its preference for empirical methods. Whereas the divine-organic model of the Middle Ages accepted revelation, tradition, and authority as suitable ways of accessing knowledge and truth, the mechanical model, replaces this trilogy by a different one: observation, reasoning, and experimenting.

Changes in paradigms do not occur due to questions of fashion and personal taste, but to well entrenched conceptions of the universe. Paradigms determine what is acceptable and accepted as part of reality. The criteria used to define reality set the limits to what can be included in an intelligible discourse. In other words, the criteria used to define reality also determine which systems of representation represent the best structure and behavior of the universe. Against the privileged access of the clergy through revelation, the mechanical model postulates an impersonal and timeless form of knowledge that does not depend on the qualities or the situation of the knower. In other words, universal and objective knowledge is necessary in the sense that it does not depend on any contingency. It differs from personal opinion, propaganda, or prejudice. As a specialized and systematized type of knowledge, objective and universal knowledge conflicts with other systems of explanation, such as myth and religion. In brief:

> (1) Objectivity calls for putting one's idiosyncratic predilections and parochial preferences aside in forming one's beliefs, evaluations, and choices. It is a matter of proceeding in line not with one's inclinations, but with the dictates of impartial reason.
>
> (2) The universality of reason must be recognized: What is rational for one person to do, to believe, or to value will thereby also of necessity be equally rational for the rest of us who might find ourselves in the same circumstances. For rationality is inherently "objective": It does not reconfigure itself to meet idiosyncratic predilections of particular individuals.[1]

However, although modern science and normative epistemology have been great allies, standard epistemology textbooks present these disciplines as a-historical discourses that, in the name of objectivity and universality, attest to the rational development of a disembodied mind. The method of rational construction, which is often used, fails to link modern science and normative epistemology to the context of their emergence, depriving readers of their awareness of the puzzles that modern science and normative epistemology as emerging paradigms try to solve. This thesis attempts to overcome this shortcoming by establishing a parallelism between the movements of contestation and technological developments that have led to the decline of the medieval synthesis and the

development of modern science and normative epistemology as its alternatives. The disintermediation of knowledge brought by a decrease in reference to religious authority as a foundation of knowledge created a conflict between individual experience and institutionalized knowledge in a way that the option for the former by Descartes created a situation where knowing was presented as the activity of individual minds. This thesis argues that normative epistemology is mistaken by focusing on individual minds since it reduces human knowledge to univocal propositions that are formulated by the fixation of meaning and reference. It shows that the realm of human knowing is much broader than the propositional form that reduces knowing to knowing matters of fact, i.e. "knowing that", although it can be shown that even if one upholds that knowing is "knowing that", predication itself is paradigm-bound as paradigms determine what is included or excluded in the description of reality and the articulation of knowledge. This thesis, moreover, suggests a dynamic and integrative model of epistemology that defines knowledge not in its propositional form, but as a process of accumulating insights, which integrates emotional (*pathos*), intellectual (*logos*), evaluative (*ethos*), and pragmatic (*praxis*) dimensions. This model is based on the thought of Bernard Lonergan, who contends that human knowing involves four operations, namely experiencing, understanding, judging, and acting, and that the human mind acts at four levels of consciousness, i.e. the empirical, the intellectual, the reasonable, and the responsible level. Lonergan's epistemology, in my view, provides a framework for an epistemology of successions that puts various rivaling schools of thought, such as empiricism, rationalism, critical theory, and pragmatism on one dynamically integrated continuum instead of considering them as unresolvable binary dichotomies that have led to the well

entrenched opposition of rationalism vs. empiricism, idealism vs. positivism, principles vs. facts, ideas (concepts) vs. objects, and theory vs. practice.

Moreover, normative epistemology and modern science define reality – minds included – according to a mechanical model. This mechanical model defines reality in terms of matter, motion, and universal mechanical laws. The mechanical paradigm, to use Kuhn's terms, is a suitable alternative to the metaphysical dualism embedded in supernaturalism. By naturalizing or materializing substance, mechanical models focus on invariant aspects of reality that they consider as substances or universals. There is a well entrenched belief that universal laws are permanent and that they can be formulated into simple mathematical relations similar to Newton's laws of motion, for instance. Mechanical models have become popular as many mechanical machines, such as the steam engine, have provided possibilities of generating motion from matter, unlike in previous periods where motion was associated with supernatural powers, such as the soul or *anima* in Latin (before the steam engine, only animated beings would move themselves or move others). However, mechanical models are limited as they can only handle simple, regular, and ordered processes as the latter operate according to linear patterns of causality, which are similar to mathematical operations and logical rules of inference. This assumed similarity is based on the widespread idea that the universe is a mechanical machine and that the mechanical laws of the universe are similar to the rules of logical inference. Mechanical models fail to handle complex and dynamically integrated systems and processes since the latter function in a way that the high level of interaction of their components does not allow the isolation of the parts and the formulation of the relations between inputs and outputs into simple mathematical relations and rules of logical inference. Complex and dynamically integrated systems and processes function according to a cybernetic model where inputs and outputs influence each other by following differential rules that determine relations of control through information and feedback. These differential rules imply that cybernetic systems and processes are always in flux as they try to maintain their defining characteristics in certain thresholds as a way of avoiding destruction or transformation into something else and, at the same time, interact with their environment by following feedback processes that lead to the transformation of the systems and processes themselves or to the transformation of the environment by these systems and processes.

The second chapter suggests a model of human knowing that is based on information and cybernetics. Unlike the mechanical model, which postulates a simple, regular, and ordered universe that is based on this model, a cybernetic-based model builds on the complexity and dynamism inherent in natural processes, and complements the limitations of the mechanical model. A cybernetic model defines reality not only in terms of matter and motion, but in terms of matter, motion, logic, and symbolism. A cybernetic model does not only look at matter in motion (the mechanical dimensions), but also at matter as it organizes itself into complex systems and processes (structure), as it changes its structural patterns over time (behavior), and at matter as it fulfils human purposes in terms of satisfying needs and maximizing capabilities (function/goal). A cybernetic model provides a better description of the process of human knowing as information processing since by defining information as negative entropy, i.e. a degree of organization, Wiener implies that any organized system or process conveys an amount of information that is commensurate to its degree of organization. Therefore, totally disorganized and random processes are unintelligible as they do not convey any information. On the contrary, simple, regular, and ordered systems and processes such as those that naturally operate or are built according to mechanical models can be fully intelligible as their high level of organization leaves them with negligible levels of entropy or with no entropy at all in a way that they lend themselves to univocal predication and analytic methods providing the possibility of being understood with levels of certainty that approximate the Cartesian search for "clear and distinct" ideas or a level of accuracy similar to the one of mathematical operations and logical rules of inference. Opting for cybernetic models as an alternative to mechanical models implies an information-based model of reality based on Wiener's definition of the measure of information as negative entropy and an information-based model of knowledge based on the intelligibility of the systems and processes under study, on the one hand, and the ability of the knower to process information by enriching the immediate data of experience with value and meaning for the purpose of decision-making and problem-solving. This approach to knowledge is different from normative epistemology's reduction of knowledge to its propositional form - a corollary of Descartes' reduction of wisdom to certainty – since knowing, according to this model, leads to insights that can be theoretical or practical, individual or collective by following the integration of new data of immediate experience into an existing explanatory framework with the possibility of confirming the data or having the data disrupt the existing explanatory framework in a way that either the data itself or the explanatory framework is called into question.

A cybernetic model presents human knowing as a dynamic, integrative, cumulative, recurrent, and iterative process, unlike the Cartesian model, which reduces the whole process of knowing to its outcome, i.e. true justified beliefs or “clear and distinct” ideas. Understanding knowing as a multilevel and multi-operational process creates a possibility of understanding the link between Lonergan’s epistemology and an info-computationalist model as the various steps of the information process, i.e. enriching data with meaning and value and subjecting them to purposes of decision-making and problem-solving, imply shifting from one level of consciousness to another by giving a semantic dimension to immediate data of experience through understanding (generating meaning), i.e. shifting from the first level (empirical) of consciousness to the second (intellectual) level, and creating value by judging, choosing, deciding (the third “rational” level of consciousness according to Lonergan), and achieving goals by acting or voluntarily deciding not to act (the fourth “responsible” level of consciousness on Lonergan’s scale). Establishing a parallelism between Lonergan’s epistemology and an info-computationalist model of human knowing implies a dynamic and integrative model of epistemology that rejects the reduction of knowledge to its logico-deductive dimensions and calls for integrating scientific and common sense knowledge. These two forms of knowledge are different both in their scope and their *telos* since scientific knowledge is universal in scope and depends on universal laws of inference while common sense knowledge only applies to very contextualized problems and depends much more on individual judgment rather than on rules. Moreover, whereas Descartes presents a model of the philosopher in general and the epistemologist in particular as a solitary thinker conducting thought, this dynamic and integrative model of epistemology acknowledges that some aspects of human knowing occur at the subconscious level as Polanyi has pointed out in the *Tacit Dimension.*[2] Furthermore, this model rejects Descartes' idea of founding certainty or clear and distinct ideas on self-evident axioms that we intuit by pointing out that the context of discovery is preceded in Lonergan's view by a tension of inquiry and that, according to the genetic epistemology of Jean Piaget, logico-deductive knowledge given its abstract nature occurs at a relatively high level of mental development. It builds on a certain amount of sensorimotor knowledge through the human ability to apprehend relations between objects through the mediation of representations of the characteristics of these objects. The second chapter, therefore, challenges a Platonic understanding of mathematics as having an existence of its own or as an intuitive approach that claims that basic axioms are self-evident and indicates that mathematics is a human enterprise that is built through the formalization of space by using metaphors, such as numbers as points on a line or numbers as sets.

Defining knowing as information processing implies not only taking into account substantive, structural, behavioral, and functional dimensions, but also enriching data with value and meaning for the purpose of decision making and problem solving. This dynamic and integrative model of epistemology rejects the Cartesian strategy of cutting oneself off from objects and defines knowledge according to Lonergan's concept of self-appropriation. Self-appropriation implies that knowing is not an activity of a mind isolated or isolable from the body, but an activity of the whole organism in interaction with the environment. This idea of the whole organism interacting with the environment in the way it was developed by Jean Piaget provides a biological foundation of knowledge instead of postulating a *de facto* opposition of the mind to the body or an *a priori* definition of the mind as non-physical, a vestige of the medieval supernatural soul, which is often presented as an ethereal reality that lacks physical extension.

The third chapter builds on complexity as defined by a cybernetic model and shows that there are links between mechanical models and analytic methods. This linking of mechanical models and analytic methods implies that rejecting mechanical models calls for changing paradigms at the methodological level. This chapter contends, following von Bertalanffy[3], that analytic methods not only apply to systems and processes of which parts can be clearly delineated due to their low levels of interaction, but also to systems and processes that follow linear patterns of causation. The only systems and processes that are analyzable are mechanical systems and processes as they fulfill the two criteria of analycity. Given the fact that mechanical models have negligible levels of entropy, they convey optimal levels of information and are the only ones that can generate knowledge at those levels of accuracy that Descartes suggested. Otherwise, highly complex systems and processes are not analyzable unless some of their characteristics are fixed or isolated from the systems and processes themselves. This need of fixing characteristics or isolating aspects under study involves translating these characteristics and aspects into a medium that lends itself to univocal predication, logical rules of inference, and mathematical operations. This strategy, often adopted in normative epistemology implies reducing knowledge to its logico-deductive dimensions, i.e. reducing wisdom to certainty, fixing meaning and reference, reducing knowing to thinking, and hermetically isolating the mind from the body. However, a cybernetic model of reality involves defining reality as a complex process of information and control through feedback,[4] and this process is not defined in terms of materialist and mechanistic dimensions, but it takes into account aspects of order and purpose as well. This approach looks at the issue of complexity from its substantive, structural, behavioral, and functional/teleological points of view.[5] Acknowledging these patterns of complexity leads to a methodological strategy that apprehends reality in terms of dynamic and integrative processes, of which mechanical systems and processes are special cases. This methodological strategy that is called "systems thinking" avoids the simplicity involved in analysis, i.e. cutting systems and processes into pieces, since most systems and processes are not reducible to their components. Moreover, proponents of analytic models and methods uphold an anti-metaphysicalism that reduces reality to invariant aspects that are considered as substances and universals and assumes that these universals are mathematical. However, a dynamic and integrative epistemology does not only look at matter at rest or in motion, but also at matter as it organizes itself into various patterns that convey information that is commensurate to their degree of organization. From this point of view one can analyze only systems and processes that are analyzable, i.e. systems and processes with parts that can easily be separated and reassembled given their low level of interaction and the linear pattern of their causal relations. Systems and processes that are inherently complex, dynamic, and integrative can only be understood by following a model that takes into account their substantive, structural, behavioral, and functional/teleological aspects. That is why the third chapter suggests a paradigm shift from the analysis/synthesis dichotomy to systems thinking.

By examining the notion of information from an interdisciplinary point of view, the fourth chapter brings us to the core. This assessment reaches a definition of information as patterns of (self-) organizing matter and energy, which confirms Wiener's definition of information as "negative entropy", i.e. negative disorder, i.e. a certain degree of order.[6] Limiting information to patterns of (self-)organizing matter and energy only provides a static understanding of information that reduces information processes to the spatial arrangements of macromolecules, neurons and pulses, objects in the environment, and parts in artifacts, which determine the structure of the processors. Examining information from three facets, i.e. mapping, interpreting, and evaluating, shows that the notion of information embodies patterns of being, behaving, and becoming in a way that it constitutes a suitable foundation for a dynamic and integrative epistemology that takes into account structural, behavioral, and teleological/teleogenic processes. This model of epistemology challenges normative epistemology's definition of knowledge in terms of (accurate) representation of reality and instead suggests a dynamic and integrative model of the process of human knowing as accumulating insights through information processing. This dynamic and integrative model of epistemology takes into account processes that occur at the macromolecular, neural, cultural, and technological levels, unlike normative epistemology, which confines the process of human knowing to individual human minds that are assumed to be hosted by individual human bodies in individual human beings. Even when the process of human knowing is considered as it occurs in individual human beings, dynamic and integrative epistemology takes into account the possible integration of formal scientific forms of knowing and their informal counterparts, and on the other hand, it does not exclude the rationality embodied in artifacts, such as special organizations designed in order to fulfill special goals. This rationality embedded in artifacts calls for an integration of individual human rationality with institutional rationality.

END NOTES

[1] Nicholas Rescher, *Objectivity: The Obligations of Impersonal Reason* (Notre Dame: University of Notre Dame Press, 1997), p. 3.

[2] Michael Polanyi, *The Tacit Dimension* (New York: Double Day, 1966).

[3] Ludwid von Bertalanffy, *General System Theory: Foundations, Development, Applications* (New York: George Braziller, 1968), p. 19.

[4] Norbert Wiener, *Cybernetics or Control and Communication in The Animal and The Machine* 2nd ed. (New York: The MIT Press, 1961), p. 38.

[5] Rescher, p. 1.

[6] Wiener, ibid.

CHAPTER ONE

MODERN SCIENCE AND THE HEGEMONY OF NORMATIVE EPISTEMOLOGY

A. INTRODUCTION

There are intrinsic links between modern science and normative epistemology. Modern science as a conceptual framework rejects the metaphysical assumptions of the medieval synthesis i.e. supernaturalism. Supernaturalism can be defined as a conception of reality that refers to entities such as God, spirits, angels and so forth. Rejecting supernaturalism implies that both the description of reality and the articulation of knowledge have to remain within the boundaries of natural entities and processes. On the one hand, objects of knowledge are natural; while, on the other hand, the process of human knowing itself is also natural. Therefore, there is no need either in the description of reality or the articulation of knowledge to refer to supernatural entities or powers. From the point of view of modern science and normative epistemology, supernaturalism is based on arbitrary beliefs that cannot be proved either on an empirical or rational basis. The articulation of knowledge within the context of naturalism implies a crucial distinction. Theories of knowledge within the naturalist framework distinguish objects of knowledge from knowing subjects. Proponents of this distinction assume that objects of knowledge, on the one hand, are physical entities with material composition and spatial extension. The knowledge subjects have of objects, on the other hand, is not physical but mental. Most of the time, objects of knowledge and their "mental" representations are distinguished using the spatial metaphors of "external" objects and "internal" mental representations. Distinguishing objects of knowledge from the knowledge knowing subjects have of them set the stage for normative epistemology.

Normative epistemology as an academic discipline aims at studying the nature, the possibility, the conditions and the limits of human knowledge. Normative epistemology finds in modern science a great ally for two reasons. First, modern science is considered as a better (some many even say the best) form of explanation as compared to mythical narrative or religious belief for instance. Secondly, both normative epistemology and modern science reject supernaturalism because the latter cannot be proved on empirical and rational grounds. However, justifying a theory on empirical and rational grounds is itself an epistemological position. Normative epistemology and modern science share naturalism both as a metaphysical assumption and an epistemological position. In both normative epistemology and modern science there is a direct inference from metaphysical naturalism to epistemological naturalism. Metaphysical naturalism therefore, restricts reality within the realm of natural phenomena, and the process of human knowing is one of them. Therefore, normative epistemology as a naturalist theory of human knowing cannot found human knowing on revelation, tradition or religious authority as it was done during the middle ages. Instead, the process of human knowing, in addition to being a natural process is a rational process that relies only on human reason. Reason is conceived as a human natural ability to know and the process of human knowing is a rational process that leads to what Pandit calls "our subjective knowledge."[1] Subjective knowledge refers to the process of knowing as it occurs "within" one individual knower.

However, subjective knowledge fails to overcome the arbitrariness and the tyranny embedded in founding knowledge on supernatural beliefs or religious, political and moral authority. It simply replaces the arbitrariness of the supernatural beliefs by the arbitrariness of the knower individual experiences and the tyranny of authority by the tyranny of the subject. That is why modern science and normative epistemology, in addition to upholding that the process of human knowing is (or has to be) natural and rational require that genuine processes of human knowing lead to objective knowledge. Human knowledge, therefore, cannot be based on the personal idiosyncrasies, the moral values, the cultural background, the social class, the expectations, the opinion or the location of the knower. Human knowing has to be an object-oriented process that overcomes arbitrariness and tyranny by describing the world "as it is". For normative epistemology, human knowing, as a natural and rational process, has either inevitably to generate objective knowledge or it is not a process of knowing at all. Objective knowledge, in the context of modern science and normative epistemology, is not based on supernatural beliefs since the latter would imply arbitrariness; or reliance to religious, moral and political authority. The latter would imply founding knowledge and truth on tyranny rather than on reality. The search for objective knowledge discards practices such as divination and establishes a scientific method that comprises observation, reasoning and experimenting. In other words, the only authority acceptable in the context of modern science and normative epistemology is the authority of reason and nature. Arbitrariness and tyranny as foundations of knowledge and truth are to be avoided through empirical proof and rational persuasion.

As disciplines based on natural, rational and objective processes of human knowing, modern science and normative epistemology share: (1) a conception of the universe as a natural autonomous and automatic system that needs no explanation or justification outside itself; (2) a theory of knowledge as a natural and rational process that leads to accurate representations of reality as a way of generating objective knowledge. Moreover, in addition to their commitment to naturalism, rationality, and objectivity, modern science and normative epistemology avoid parochialism in the process of knowing. In addition to being natural (as opposed to supernatural), rational, and objective, the type of knowledge that modern science and normative epistemology seek is (3) universal. According to Prigogine and Stengers, modern science and normative epistemology seek "a form of deductive knowledge that contained a degree of certainty unaffected by convictions, expectations, or passions".[2] In the technical jargon of philosophy, the type of knowledge has been called ***Objective*** *Knowledge*[3]. In other words, the scientific view of reality in Nagel's words, "*The View from Nowhere*"[4]. It ignores the peculiarities of the knower be they religious beliefs, moral values, social class, cultural background, or personal interest. The context where the process of knowing occurs is irrelevant because objective knowledge is also meant to be universal. In other words, it transcends the particularities of time and space and is accessible to anyone who is capable of following rigorously some detailed method of investigation. Moreover, the degree of certainty that it leads to is so high that it does not depend on any contingency. This degree of certainty matches the Cartesian requirement that knowledge must be indubitable, infallible and incorrigible.[5] Universal and objective knowledge is necessary in the sense that it does not depend on any contingency. It differs from personal opinion, propaganda, or prejudice. As a specialized and systematized type of knowledge, objective and universal knowledge conflicts with other systems of explanation such as myth and religion. In brief,

> (1) Objectivity calls for putting one's idiosyncratic predilections and parochial preferences aside in forming one's beliefs, evaluations, and choices. It is a matter of proceeding in line not with one's inclinations but with the dictates of impartial reason.
> (2) The universality of reason must be recognized: What it is rational for one person to do, to believe, or to value will thereby also of necessity be equally rational for the rest of us who might find ourselves in the same circumstances. For rationality is inherently "objective": It does not reconfigure itself to meet idiosyncratic predilections of particular individuals.[6]

However, in its task of articulating genuine knowledge through describing the world "as it is," normative epistemology is confronted with different contentions on what the world "really" is. This implies diversity in philosophical conceptions of "the" world (if one assumes that there is only one), reality and being. World, reality and being are very important philosophical notions because the position one holds on these notions determine not only one's philosophy but also one's behaviour. This chapter aims at assessing the emergence of normative epistemology within the framework of modern science. Although Thomas Kuhn has restricted the concept of paradigm shift within science, this chapter argues that a scientific approach to the world, reality and knowledge is itself a paradigm i.e. “universally recognized achievements that for a time provide model problems and solutions to a community of practitioners”.[7] The particularity of the scientific paradigm can be understood either by comparing epistemological practices and theories of the scientific period with their pre-scientific counterparts or by observing knowledge theories and practices in societies where modern science is of recent import. For the case at hand, this chapter attempts to link modern science and normative epistemology by referring to aspects of their historical context. It does not base normative epistemology on the opposition of knowledge (*episteme*) to “mere” opinion (*doxa*), as it is the case in standard epistemology textbooks because knowledge and opinion are not mutually exclusive. Some opinions such as those based on careful inquiry by experts indeed constitute knowledge. This chapter attempts a different point of view that upholds that modern science and normative epistemology are responses to a series of issues and conflicts pertaining to the nature of the world, reality, and knowledge in a context of social and intellectual upheavals that upset the medieval synthesis. Moreover, in the context of modern naturalism, the role of normative epistemology is not to refute scepticism. Modern scepticism is part of the paradigmatic framework in which normative epistemology emerged. It is an invitation for proof because the paradigm shifts introduced by modern science and normative epistemology call for a “new” foundation of knowledge that eliminates reliance to arbitrary religious beliefs and coercion by political or religious authority.

B. MODERN SCIENCE AND NORMATIVE EPISTEMOLOGY

1. Modern Science and Paradigm Change

Epistemology has intrinsic links with metaphysics because aiming at describing the world as “it is” implies that one knows what and how “the” world “is.” Otherwise a comparison between the object of inquiry and the results of inquiry would be impossible. One would never be able to know whether one's inquiry has been successful or not. Moreover, epistemology is not made of abstract theories but of practices as well. Modern science, as a paradigm explains, for instance, why a modern normative epistemologist would seek knowledge in a library, an academic journal, or a laboratory, instead of consulting the Oracle of Delphi. Theories of knowledge depend on what is included or excluded in the definition of reality or the knowable and the practices that are believed to lead to knowledge are influenced by one's metaphysical assumptions. In other words, there is an intrinsic link between metaphysical assumptions and epistemological positions because both are subject to changing paradigms.[8] For instance, the medieval synthesis founded knowledge on supernaturalism and found revelation, tradition and authority as adequate ways of accessing knowledge and truth. Even in texts where the natural law is mentioned such as in the philosophy of Thomas Aquinas for instance, natural law is believed to be inscribed by God in the universe or human consciousness through the act of creation. This way of looking at reality is different from modern naturalism that rejects supernaturalism and attempt to establish new foundation for natural processes of human knowing in a natural world.

Standard epistemology textbooks often suggest that normative epistemology as a discipline emerges from the opposition of knowledge (*episteme*) to mere opinion (*doxa*). This distinction that some authors retraces as far as to Plato indicates that opinions are deficient. More is needed for them to reach the status of knowledge. However, this distinction misses the fact that knowledge and opinion are not mutually exclusive. Some opinions indeed – such as those held by experts after careful inquiry – constitute knowledge. Therefore, the aim of an epistemological study such as this one is not to examine means of upgrading opinions to make them knowledge but examining how normative epistemology as a particular conception of knowledge and its criteria of validity emerged in a context of social and intellectual upheaval.

This study will not also attempt to refute scepticism. Scepticism has been challenged on the ground that the sceptics give up their position as they carry on their living endeavours basing their decisions to beliefs and assumptions that they consider as true. This study will attempt to examine a possibility of looking at normative epistemology as an academic discipline that emerged in a context where philosophical debates were dominated by a series of contentious issues pertaining to the definition and description of reality and the articulation of knowledge and truth. The distinction between *episteme* and *doxa* is an important retrospect because it shows that epistemological questions that are as old as philosophy itself can still emerge at various periods of human history. This retrospect shows that although epistemological concerns are universal in scope (i.e. transcending historical periods and places) the way they are formulated and resolved depend on changing paradigms. For instance, contemporary normative epistemologists who operate in the context of modern science are unlikely to resort to practices such as Platonic contemplation or Socratic practice of consulting the Oracle at Delphi because there are institutions such as universities and research centres where professional philosophizing takes place. Moreover, differences in practices of philosophical enquiries, despite similarities in concerns, point to the fact that although some philosophical debates that are still going on may be very old, there have always been changing paradigms both in the description of reality and the articulation of knowledge.

The notion of paradigm change in science was introduced and popularized by Thomas Kuhn in his *The Structure of Scientific Revolutions*.[9] According to Kuhn, paradigms are "universally recognized achievements that for a time provide model problems and solutions to a community of practitioners".[10] Kuhn distinguishes in science three phrases in the evolution of a scientific paradigm. There is a pre-scientific era which lacks a central paradigm. During the pre-scientific period disparate practices and beliefs form the body of knowledge with no apparent way of organizing them in a systematic way. The vocabulary used to describe knowledge theories and practices in the pre-scientific period is also disparate because it lacks the rigors of scientific definition and the univocal nature of scientific terms. The pre-scientific period is followed by a period of normal science. Normal science is the most productive period in the evolution of a paradigm. Not only the paradigm solves the puzzles it was intended to solve but its domain of application extends much beyond the original interests of the inventors of a paradigm. Moreover, normal science unifies the field of knowledge by bringing forwards a paradigm that is applicable across disciplines. Kuhn chooses a good example of paradigm change. He illustrates his view of a paradigm shift with the replacement of the belief in the presence phlogiston in combustible elements to the belief that oxygen is the key element in this phenomenon of combustion.[11] Not only this belief explains the original phenomenon of fire i.e. oxygen as an energy-generating substance but the application of this discovery goes beyond its original domain of application. The combustion of oxygen as a source of energy explains also, for instance, the phenomenon of metabolism within animals. In a layman's language metabolism can be explained as a phenomenon of generating energy in an animal's body by burning foods with the oxygen an animal breathes. The period of normal science is succeeded by a period crisis where an accumulation of anomalous results leads to the questioning of the paradigm itself instead of attributing anomalous results to the mistakes of the researcher. Crisis within a dominant paradigm is, therefore, an opportunity for discovery rather than an obstacle. It points to the fact that the existing paradigm, although successful on a variety of issues and in various areas still has some "empirical residue". This empirical residue indicates that the dominant paradigm has not yet reached the status of a unified scientific theory and that additional modes of explanation are necessary.

Although Kuhn's theory has been very popular and generated a fertile debate among both philosophers and scientists, Kuhn does not seem to recognize that modern science itself is a paradigm. Modern science emerged at a period of crisis. Kuhn's domain of inquiry is scientific theory themselves, but, in my view, Kuhn's method and assumptions can be applied to the overall domain of knowledge. The scientific paradigm has solved a lot of puzzles and a possible extension of the domain of application of Kuhn's theory of paradigm change implies looking at science in its context of emergence and at the ways paradigms have been changing not only within modern science itself but also in overall theories of knowledge. While Kuhn focused on changing paradigm within modern science, there is a possibility of examining changing paradigms in epistemology. This approach is different from a rational reconstruction of a universalistic (a-historical) epistemological theory that puts side by side Platonic questions and Cartesian responses forgetting that the role of paradigms is indeed puzzle solving, as Kuhn pointed out. Epistemology, as a discipline that has been evolving throughout history implies not starting the debate with a Platonic distinction between knowledge (*episteme*) and opinion (*doxa*). This distinction may be appealing in our context where pluralism of opinion is part of our culture and where we have sophisticated technologies to pin down errors of perception and reasoning. However, normative epistemology can be understood as a puzzle solving intellectual tool that emerged in the context of modern science with the aim of solving existing puzzles. Both normative epistemology and modern science solve puzzles by approaching issues of reality, knowledge and truth in a way that avoids the arbitrariness of supernatural beliefs and the tyranny of authority.

2. Modern Science and the Decline of the Medieval Synthesis

The particularity of a scientific approach – despite its universal horizon - can be better understood when scientific approaches are compared to knowledge practices and assumptions of pre-scientific periods or to knowledge practices and assumptions in societies where scientific culture is of recent import. There are, in fact, intrinsic links between metaphysical assumptions and epistemological positions. Metaphysical assumptions define reality i.e. the known or at least the knowable while epistemological position establish theories of knowledge which are relationship between the knowable (reality) and process of human knowing. Most of the time, processes of human knowing are characterized as internal processes "within" the knower. Although this spatial metaphor of "external" objects and "internal" knowledge processes is detrimental, Aaron points out that:

> there is a strong assumption that anyone who sets out to give an account of human knowledge must do so in terms of either rationalism or empiricism. In addition these theories tend to be linked with metaphysical theories, rationalism with idealism and empiricism with positivism. So the philosopher is faced with two alternatives and two only; he has to choose between rationalism, and the metaphysic that goes along with it, and empiricism, and its accompanying metaphysic.[12]

Aaron contention is a fair assessment of contemporary normative epistemology. By pointing to the intrinsic links between metaphysical assumptions and epistemological positions, Aaron shows that what is involved in the definition and description of reality gets also involved in the articulation of knowledge. Therefore, normative epistemology should be understood in the context of modern science because as rejections of supernaturalism, normative epistemology and modern science lend each other tools. In addition to their rejection of supernaturalism, one salient feature of supernaturalism and scholasticism that modern science and normative epistemology oppose is the presentation of knowledge as something hidden. This approach that locates knowledge in an atmosphere of mystery is rooted in an older philosophical debate that opposes reality to appearance. Epistemology as philosophy of knowledge should, of course, tackle knowledge of reality (and not just knowledge of appearances) but the concept of reality itself remains problematic. It is subject to changing paradigms. For instance, referring to the metaphysical dualism that dominated scholasticism, Cornwell pointed out that, during the middle ages:

> Philosophy … treated ideas as if they had the same sort of reality as a child's coloured building blocks. It was held that there was a real distinction between a thing's substance and its observable appearances – shape, size, texture; that a thing's essence could be distinguished from its existence; that ideas like justice, beauty, truth, had a sort of separate existence in a universalized world of pure forms, independent of individual minds and actual objects and actions. It was thus easy, without the aid of sense experience, that a supernatural realm, far more important and durable, lay beyond the veil of appearance.[13]

The metaphysics of supernaturalism is dualistic. By assuming the existence of two worlds, one supernatural and another natural, supernaturalism locates reality in the supernatural world and the natural world is reduced to mere appearance. The epistemological implication of supernaturalism is that knowing implies accessing a hidden reality. Accessing this hidden reality is possible either through this reality manifesting - i.e. revealing - itself or through some intermediaries that can act as bridges (pontiffs) between the natural realm of appearance and the supernatural realm of reality. This need for mediation explains why in the pre-scientific period revelation and the mediation of religious authority were accepted means of accessing knowledge and truth. Supernaturalism's belief in a universe that is ultimately grounded in God's act of creation creates a situation where knowing to universe implies often referring to its origin. Moreover, this understanding of the universe with referring to its origin i.e. God's creation makes clerical status not only a religious function but also a knowledge function. In fact, in the context of the late medieval thought McGrath pointed to "the apparent inability to distinguish catholic dogma from theological opinion".[14] This coupling of religious and knowledge functions as mediation to the supernatural creates a situation where the body of knowledge does not make a difference between theological debates and cosmological theories. At this stage, the disciplinary distinctions and autonomy that modern scientific disciplines currently enjoy are not clearly delineated and the separation of the sacred and the secular which is a normal feature of modern culture is not yet established.

In the context of the late medieval age, the role of epistemology can be defined as an attempt to assess how supernatural reality reveals itself in natural appearance. Even in context where concepts such as "natural law" are used (by Thomas Aquinas, for instance) medieval naturalism is different from the modern naturalism that opposes supernaturalism. Medieval naturalism upholds that natural laws are inscribed in nature by God through the act of creation. The perfection of these laws as manifested by order, simplicity and regularity in the universe is a manifestation of God's own perfection. From the point of view of medieval naturalism, regular and ordered processes such the regular succession of day and night, the regularity of seasons, the harmony and rhythm of the heartbeat and so forth are considered as manifestations of God's perfection. Modern naturalism, on the other hand, rejects altogether supernatural beliefs. Moreover, it assumes that the universe is an autonomous and automatic system. Therefore, laws of the universe, according to modern naturalism, are not manifestation of God's perfection, but "universal" laws. Modern naturalism, therefore, aims at explaining natural phenomena in the universe by referring to universal laws and not the will of a divinity or special people who are believed to access of hidden realm of supernatural reality.

Supernaturalism, therefore, can be rejected on empirical and rational grounds, but its epistemological consequences i.e. founding knowledge on revelation, religious authority and tradition did not pave the way to scientific methods smoothly. The crisis that generated modern science and normative epistemology was first and most of all a crisis of authority. This aspect is most of the time overlooked by the supports of a a-historical universalistic approach to epistemology that attempts a rational reconstruction of the epistemological enterprise as a series of arguments and counterarguments. McGrath pointed out that:

> the later medieval period may be regarded as characterized by a two-fold crisis of authority. First, a lack of clarity concerning the nature, location and exercise of theological authority at a time of rapid intellectual development led to considerable diversification of theological opinions, and confusion concerning the status of these opinions.[15]

This doctrinal diversity and confusion explains Descartes' search for new and ultimate foundations. Descartes looked for foundations because he was standing at on a shaky ground. For more than ten centuries, scholasticism had played the role of normal science. It had generated fruitful philosophical debates based on crucial philosophical distinctions such as substance vs. form, knowledge vs. opinion, actuality vs. potency, substance vs. accidents, essence vs. existence, faith vs. reason, reality vs. appearance, eternity vs. time, and the soul vs. the body. This dualistic pattern still prevails in contemporary philosophical debates where distinctions such as rationalism vs. empiricism, idealism vs. positivism, principles vs. facts, ideas (concepts) vs. objects, theory vs. practice, regularly occur. The shaking of the supernatural assumptions that supported scholasticism left Descartes in doubt. Minds of philosophers and scientists were left to wary as clerical status as a knowledge function was challenged by the rise of an urban professional groups and the influence of lay theologians.[16] Erasmus, for instance, played a great knowledge role without coupling it with clerical status.[17] Moreover, the maze of mystery that surrounded knowledge functions was dissipated. On the one hand, "the introduction of printing was at least a catalyst, and also an agent, of intellectual and social change."[18] Printing made available to the laity the bible and devotional books that were previously restricted to the clergy. Among professional groups and lay theologians, "there was a new interest in studying both scripture and the fathers directly, rather than through a 'filter' of glosses and commentaries".[19] Therefore, the main contribution of the reformation to the emergence of modern science and normative epistemology is a certain disintermediation of knowledge. This disintermediation implied reliance on one's rational abilities rather than on interpretation by religious authority. Moreover, this disintermediation of knowledge created conditions for the replacement of religious authority as a source of knowledge by personal experimentation. It is worthy noting that in the late middle age and early modern times, religious and knowledge functions were still entangled. Personal experimentation was encouraged by people of various abodes independently of the position they held on questions of knowledge and truth. Martin Luther, for instance, encouraged personal experimentation by urging his followers to read the scriptures themselves instead of relying to the interpretation by religious authority. Ignatius Loyola, on the other hand, tried to get the best of both personal experimentation and authority by subjecting his followers, the

Jesuits, to lifelong lengthy periods of study and yet imposing them under oath strict obedience to the leaders of the Jesuit order.

Disintermediation of knowledge created a conflict between individual knowledge and institutionalized knowledge. On the one hand, individuals who claimed to be enlightened by reason moved from place to place challenging established beliefs and practices.[20] On the other hand, some strong institutions such as the Roman Catholic Church were willing to defend "the" truth by all means including violence. This period of crisis was propitious to the emergence of a new paradigm. On the one hand, it layed naked the tyranny of authority in the articulation of knowledge and truth, and, on the other hand, it denounced the arbitrariness of supernatural beliefs That is why, the foundation of normative epistemology in modern science should not be understood as emanating from the distinction between knowledge (*episteme*) and opinion (*doxa*) or as a refutation of skepticism. Modern skepticism by questioning the reliability of senses or by pointing to the risk of an infinite regress in our reasoning processes is part and parcel of the modern paradigm that bases knowledge on proof. Skepticism and normative epistemology are two sides of the same coin. Proof according to modern science and normative epistemology is limited to empirical evidence and rational persuasion. The reference to the Greek origins of both the distinction between *episteme* and *doxa* and skepticism is a strategy of rejecting supernaturalism and scholasticism by rediscovering the greatness of antiquity. This is a type of renaissance in philosophy as it had occurred in arts from the 14th century. These distinctions, as reclaimed by normative epistemology are additional exigencies for a theory of knowledge that bases itself not on the arbitrariness of supernatural beliefs or on the tyranny of the coercion by authority. Instead, human knowledge should be based on proof and rational persuasion which can be provided by observation, reasoning and experimenting.

3. Modern Science, Empiricism and Logocentrism

The modern predilection for empirical methods can be explained by the rejection of supernaturalism, on the one hand, and the belief in one's capacity to know (without the intermediation of authority). Empiricism is based on the restriction of reality to what can be observed. Since supernatural entities cannot be observed they are not part of reality from an empirical point of view. Empirical methods restrict themselves to the "what" questions. Empirical methods, in other words, replace revelation, tradition and authority with observation as a reliable method to find knowledge and to access truth. It is worthy noting the in the early modern times, techniques and instruments of observation such as the microscope and the telescope expanded incredibly the dimensions of the universe. These techniques of observation allowed philosophers to deal with the dimensions of the universe at infinitesimal levels including the infinitely big (the universe itself) and the infinitely small world of particles. Empirical methods and techniques of observations reinforced naturalism as a philosophy of the universe. Cosmologists such as Galileo and Copernicus spread theories of the universe that challenged the religion-based beliefs and assumptions.

Empirical methods are the reflection of the assumption that reality is immediately available to human experience. Therefore, there is not need for the intermediation of revelation, tradition and authority. Empirical methods replace revelation, tradition and authority by observation. Different instruments of observation such as the telescope or the microscope only introduce changes in magnitude. They do not add or subtract anything from the objects and processes being observed. Instead, they assist human abilities because of our limited visual abilities and short memory. In addition to instruments that extend our abilities, we have designed other instruments that represent intangible processes and elements into media that make them directly observable. For instance, the thermometer assists in observing the increase or the decrease of temperature on a longitudinal scale. By using the movement of mercury in a tube as a way of measuring the increase or the decrease of heat or cold, head and cold have been translated into a spatial medium that lends itself to graphic representation as part of a one dimension strait line.

However, empirical methods were confronted with one serious challenge: the fallibility of our senses. Among early modern scientists and philosophers, no one challenged observation as a foundation of knowledge. However, what remained puzzling was the question of the reliability of human senses and instruments of observation. Not only instruments of observation could be defect but also human senses were fallible. It is Descartes who systematized doubt about the reliability of our senses. Descartes challenged the reliability of human senses basing himself on simple observations such as objects changing shape and size when observed from varying distances or a straight stick looking bend in water. Descartes' skepticism about the reliability of human senses had a great impact on the epistemological status of sensations. Descartes' problem was not whether observation is a genuine method for accessing knowledge and truth; but how to establish a new foundation of knowledge and truth given the dismay of the medieval synthesis and the decline of power of the Church. For Descartes, therefore, sensations would not constitute that foundation because our senses were unreliable and could not dissipate doubt. What puzzled Descartes was how to overcome doubt and establish "clear and distinct" ideas despite the fact that our senses are not always reliable. Moreover, Descartes was aware that our reasoning may end in an infinite regress and we could even be deceived by an evil genius. Descartes introduced in addition to observation, a set of rules for conducting thought. For Descartes, one would reach knowledge by conducting thought methodically. In addition to following the Cartesian method one then would reach knowledge i.e. "clear and distinct ideas" through meditation.

Descartes proposals are rarely examined against the background of supernaturalism and scholasticism. In standard epistemology textbooks, the problem of knowledge is presented either as a search for knowledge (*episteme*) and not just opinion (*doxa*) or epistemology is presented as having the sole role of refuting skepticism. However, Descartes is answering concrete challenges raised by concrete people. The Cartesian paradigm, like any other paradigm, attempts to solve puzzles. Descartes, who was previously trained in scholasticism is faced with the decline of what he perceived as a foundation and is looking for new foundations. However, like the scholastics Descartes maintains a strong metaphysical dualism that makes him believe in the existence of two substances one material, and another "thinking substance" that is mental. At the same time, Descartes, as a mathematician, is aware of the mathematical developments of his time. In this context, Descartes is at a crossroads because he sets questions in scholastic terms (metaphysical dualism that implies two substances) and at the same time he seeks solutions that lead to the accuracy and certainty of mathematical science. That is why Descartes, as the father of modern rationalism (some may say the father of modern philosophy) managed to shift the foundation of knowledge from a cosmological-theological ground of the nature of reality itself (ontology) to the relationship between material objects and their mental representations (epistemology). Descartes, therefore, founds normative epistemology by (1) promoting personal experimentation through one's "privileged access" of the contents of one's consciousness; (2) discrediting the epistemological status of sensations given the unreliability of our senses and instead defining knowledge in terms of certainty or clear and distinct ideas; (3) supporting a method of conducting thought that is similar to mathematical demonstration where complex statements are inferred from simple ones following infallible rules of inference.

Descartes, therefore, by privileging individual experience over the tyranny of authority and the arbitrariness of supernatural beliefs, portrays the philosopher in general and the epistemologist in particular as a solitary thinker. This approach has been singled out by Dancy and Sosa. They note in the introduction to their *A Companion to Epistemology*[21] that:

> the jacket illustration is symptomatic of our general approach. Here we have the solitary thinker working in private. Isn't he a wonderful example of the CARTERSIAN approach to epistemology which is so characteristic of the Anglo-American analytic tradition, and which is so vehemently rejected on the Continent?[22]

In other words, solipsism is a major characteristic of the way normative epistemology is portrayed in the Cartesian tradition. One is assumed to have a transparent mind and a privileged access to the contents of one's consciousness. This approach maintains that knowledge is hidden not in the supernatural realm but in individuals' minds. There is a spatial metaphor that considers the human mind and consciousness as an inner arena, a place to be filled with representations be they sensations or ideas. However, Dancy and Sosa immediately refute the idea of the knower as a solitary thinker. They put forwards two arguments against solipsism. In their view:

> There are two points to be against it. First, the attempt to escape from the clutches of the Cartesian paradigm is as common within the analytic tradition as it is outside. Second, our solitary thinker is not as solitary as all that. He is reading a book, which could be taken to show that he is not relying entirely on his own resources, as the Cartesian mind is supposed to do[23]

Therefore, Descartes definition of knowledge as "clear and distinct" ideas is very restrictive. It creates a type of armchair epistemology of a solitary thinker who scrutinizes his own thoughts as a way of looking for the ones that are beyond doubt. This approach can lead to a tyranny of the subject that is similar to the tyranny of authority in the pre-scientific age. Another salient aspect of normative epistemology is that Descartes reduces human knowing to its mental dimensions i.e. thinking or perceiving. As Dancy and Sosa point out once more, "the picture exemplifies a conception of knowledge as something to be gained by rational enquiry and perception rather than by practical life and action."[24] They add that:

> This 'logocentrism' may be a more insidious feature of the Cartesian approach, and certainly the emphasis on practice and action is distinctive of continental epistemology … as is emphasis on social considerations.[25]

Logocentrism is an important feature of both modern science and normative epistemology as they both look for laws. Modern science searches for laws of nature while normative epistemology looks for the laws that that regulate the relationships between material objects and their mental representations. There is an assumed isomorphism between the laws of nature and the laws of the mind, and this isomorphism determines the relationships between material objects and their "mental" representations. However, although logocentrism, though its derivative "logics", is intrinsically associated with human rationality, it is worthy noting that the *logos* in the original Greek context is first and most of all a principle of unity of reality. As such it is a principle of creation but also a principle of intelligibility. Some biblical narratives repeat this idea but interpreting God's act of creation as putting order in chaos. The principle of the *logos* wrongly translated in Latin as *ratio* and later on in the first chapter of John's gospel as *verbum* by Saint-Jerome, associates the ontological category of the unity of reality (*logos*) with the epistemological category of intelligibility (*ratio*) and later on with language (*verbum*). This trilogy implies an often assumed association of intelligibility, rationality and language. This outright association of the unity of reality and its intelligibility with language can be challenged by looking at the main tasks of modern science. Despite the dominance of logocentrism both in modern science and normative epistemology, it is worth noting that the search for laws is only one task of modern science among three. As Armstrong has noted, "[n]atural science traditionally concerns itself with at least three tasks."[26] According to Armstrong:

> The first task is to discover the geography and history of the universe, taking 'geography' to cover all space and 'history' to cover all time, including future time. Astronomy is beginning to give us a picture of how the universe as a whole is laid out in space and time. Some other natural sciences give us an overview of more restricted spatio-temporal areas.[27]

The first task of modern science, according to Armstrong, is mainly descriptive or narrative. This task that was traditionally devoted to metaphysics has been overtaken by modern science. Modern science, therefore, provides normative epistemology with better (or the "best") descriptions of the universe. For instance, rejection of the metaphysical dualism that opposed the supernatural to the natural led to the belief that there is only one natural universe. This eliminates from epistemology any reference to supernatural entities because they are not part of reality from a modern scientific point of view. In other words, supernatural entities do not belong to the realm of the known or the knowable and, therefore, normative epistemology would be making a mistake by referring to them. The second task of modern science is complementary to the first. It is:

> To discover what sorts of things and what sorts of property there are in the universe and how they are constituted, with particular emphasis upon the sorts of thing and sorts of property in terms of which other things are explained. (These explainers may or may be not be ultimate explainers.)[28]

From this point of view, modern science has been dominated by a theory that I shall call materialist-atomism. This is a belief that ultimate reality is constituted by small material particles i.e. the atoms. Material-atomism coupled with the description of the "geography" and the "history" of the universe in terms of Newton's laws of motion and Darwin's theory of evolution has created the dominance of mechanical and evolutionist models. Mechanics as an overall theory of the universe implies defining reality in terms of matter in motion. Mechanics implies, for instance, defining heat as molecular motion.[29] The mechanical model has been so dominant that it was applied far beyond its original discovery in physics. For instance, many biological processes were understood as material particles in motion creating a possibility of reducing biology to physical chemistry. Even contemporary studies in neuroscience and cognitive science understand their task as "mechanizing the mind."[30] Although the evolutionary model was first applied in biology and not in physics, it can be considered as a mechanical theory if one reverts to Aristotle definition of motion not only as change in spatio-temporal location but also as any change such as the growth of an organism as Kuhn pointed out. [31] What is interesting from the point of view of modern science and normative epistemology is that both the mechanical and the evolutionary models provides a definition of reality and natural processes that does not refer to supernatural beliefs. Moreover, these models, in their description of reality, do not refer to abstract entities such as Aristotle's belief that reality consists of being in the process of fulfilling their purposes.

The third task of modern science, which is the most evoked in philosophy of science, is:

> to state the laws which the things in space and time obey. Or, putting it in the terms used in describing the second task, the third task is to state the laws which link sort of thing with sort of thing, and property with property.[32]

Therefore, modern science combines the threefold task of providing a cosmology i.e. a model of the universe, a metaphysic (materialist-atomism for the case at hand) and an epistemology understood not only in terms of knowing objects and their properties but also in terms of knowing the relationships between these properties. In addition to being naturalistic, modern science is materialist, mechanistic and deterministic. It upholds that reality is ultimately constituted by material particles. This view turns any metaphysic of substance into materialism. This view was reinforced by the attempt to identify and describe in fine details all the material elements in the universe. Modern scientists have managed to achieve this task by establishing the periodical table of elements. However, material atoms, as identified by modern chemistry do not tell the whole story of the universe. They tell quite a lot about the structure of the universe i.e. the "geography" in Armstrong's words, but there is also the functioning of the universe. It is at this level of function that mechanical models originally borrowed from physics has been a dominant suggestion. The factors that contributed to the dominance of the mechanical model are not easy to identify but its definition of reality in terms of matter and motion was as outright rejection of supernaturalism on the one hand, and on the other, its attempt to provide evidence based on the rigor of mathematical proof was an unprecedented remedy to the tyranny of authority. No wonder that modern science and normative epistemology have inherited from Newton the belief that any motion can be measured. Not only one can reduce all natural processes and human behaviour to material particles in motion, but also if one broadens the concept of motion to change and biological growth as Aristotle did, there is a way of integrating mechanical and evolutionary models. This implies, on the one hand, that all natural processes can be described as physical processes, because "geographically" much of the universe functions following Newton's mechanical laws; and, on the other hand, since "historically" evolutionary processes can be reduced to mechanical processes by broadening the concept of motion to the way Aristotle (the father of biology) used it, biological processes can be reduced to physical processes. Following these two possibilities of reduction, physicalism imposes itself as a foundational theory. Therefore, modern science by modelling itself on Newton's mechanics is deterministic. Its functioning implies establishing invariant relationships between the properties of material objects and these invariant relationships are natural laws. They regulate the universe without the intervention of the will of a divinity or a *homonculus*. Normative epistemology, through its finding a great ally in modern science, shares with the latter its third task i.e. knowing not only the properties of things but also the relationships between these properties.

4. Normative Epistemology and Logico-Deductive Processes

Normative epistemology becomes relevant from the point of view of a third level of abstraction that is different from the first level where properties of material objects are represented, and the second level where meaningful representations are understood. The task of normative epistemology, therefore, is not making representations and understanding them, but, evaluating the accuracy of representation (how genuine is the relationship of properties of material objects and their representations) and assessing the meaningfulness of meaningful representations. Normative epistemology, therefore, has a semantic function. This conception of normative epistemology, therefore, makes epistemology a meta-cognitive enterprise that implies not knowing the objects themselves and their properties (this is the role of cognitive science) but knowing the laws of the mind that are involved in the process of knowing itself. The assumption behind this conception of normative epistemology is the possibility of understanding relationships between properties of material objects through understanding the relationships between the representations of these properties. At a purely epistemological level, it does not matter whether these representations are sensations or ideas because actually the nature of mental representations is still controversial both in philosophy of mind and in epistemology. However, despite the fact that epistemologists and philosophers of mind still agree on the nature of mental representations, mathematical models, for instance, provide a possibility of operating at a level of abstraction that rivals the one sought by epistemologists who locate the laws of the mind at the highest possible level of abstraction. The conception of normative epistemology as a meta-cognitive process leads to a highly abstract view of normative epistemology that locates epistemic structures much beyond the realms accessible by perception and rational inquiry. Some philosophers such as Pandit hold such a very highly abstract view of epistemology. For Pandit, in addition to "world1: of physical things/processes"[33] and "world2: of minds/mental states of consciousness, belief, etc."[34] there is "world3: of epistemic structures [i.e.] linguistically neutral structures as abstract as propositions and theories (and problems)"[35]

This abstract view of epistemology obscures the paradigmatic nature of metaphysical assumptions and epistemological positions. This abstract view turns epistemology into an impersonal and a-historical discourse in the name of objectivity and universality. This approach ends up with a type of objectivity without objects and a universality without a universe. This view implicitly assumes that abstraction generates necessity, or at least that it expresses it! Epistemology elevated to this highly abstract level aims at proving the veracity of statements or propositions and the validity of logical inferences by (1) restricting knowledge statements to univocal propositions, and (2) restricting rules of inference to logical and mathematical laws that are (wrongly) assumed to be isomorphic to necessary laws of the mind. The assumption that logical and mathematical rules of inference are replications of a necessity that embedded both in the universe and in the human mind is based on wrong assumptions about both mathematics and the mind. Wrong assumptions about mathematics include the belief that, "[m]athematics is abstract and disembodied – yet it is real;"[36] This assumption postulates the existence of a separate world of mathematics that is different from realm of naturalism, materialism, mechanics and deterministic universal laws. This assumption that has generated enthusiasm among mathematicians who have tackled philosophical issues like Penrose, implies that epistemological structures, defined at the highest level of abstraction are similar to mathematical structures. This would imply that human knowledge displays the same necessary laws as those found in logical rules of inference and mathematical operations. This conception, that one can call Platonic or realism implies that there is a mathematical world of necessity of which real human mental processes are only an approximation. In other words, Platonists and realists contend that:

> Mathematics has an objective existence, providing structure to this universe and any other possible universe, independent of and transcending the existence of human beings or any other beings.[37]

The view that postulates an independent existence of mathematics implies that mathematics is not a creation of the human mind or human culture. Rather, the realists or Platonists uphold that mathematics is embedded in the universe and what the human mind does is just to discover it or to approximate it at its best. This belief that mathematics is somewhere awaiting to be discovered is based on a top-down approach that implies that "human mathematics is just a part of abstract, transcendental mathematics."[38] Therefore, mathematics like Platonic forms has an independent existence that can only be approximated by humans. Using Platonic vocabulary the realists or Platonists assume that human mathematics is a shadow of transcendental mathematics. This idea of an independent existence is reinforced by the view that mathematics is embedded in the fabric of the universe. According to this view:

> Mathematics is part of the physical universe and provides a rational structure to it. There are Fibonacci series in flowers, logarithmic spirals in snails, fractals in mountain ranges, parabolas in home runs, and π in the spherical shape of stars and planets and bubbles.[39]

Mathematics, according to this view, not only has an independent existence but also it is embedded in both the order of the universe and the order of the human mind. According to this belief, "mathematics even characterizes logic, and hence structures reason itself – any form of reason by any form of being"[40] This expansion of mathematical principles to the order of the human mind is explained somehow by the association of the unity and the intelligibility of the universe with language. The *logos*, *ratio* and *verbum* trilogy constitute the fabric of human rationality in a way that, "[t]o learn mathematics is therefore to learn the language of nature, a mode of thought that would have to be shared by any highly intelligent beings anywhere in the universe."[41] This leads to the conclusion that, [b]ecause mathematics is disembodied and reason is a form of mathematical logic, reason itself is disembodied. Hence, machines can, in principle think."[42]

These misunderstandings, although they are rarely challenged, have not been proved on empirical and rational ground. First and most of all, mathematics do not express some form of necessity and universality that are found "out there." Mathematics operates perfectly in very restricted areas of similar kinds. In other words, although necessary laws can be found in logical rules of inference and mathematical operations, this necessity is embedded in mathematics itself as a medium and not in the order of things themselves. One cannot make a mathematical model of anything without imposing constraints to natural processes and systems. One such of constraint is fixing reference in a way that matters of fact can be expressed in univocal propositional statements. Fixing reference implies fixing meaning and fixing meaning leaves no place for individual value judgements. Assuming that numbers have necessary relations between themselves is based on a Platonic understanding of mathematics as constituting a world of universals and necessary rules of inference that the real world can only approximate. This top-down approach to mathematics and human rationality implies that reality goes from abstraction to realisation, a replication or rather a vestige of the Aristotelian view that essence precedes existence. The implication of this relation between abstraction and realisation is that the imperfections and imprecise aspects of the real world are imperfect representations of a mathematical world of clear and distinct ideas (univocal propositional statements) and necessary rules of inference. However, early mathematical experience, such as in elementary school is a bottom-up process. Children learn to count using concrete objects such as balls, oranges and their own fingers before they delve into abstract calculation. It is only when the mind has reached sufficient levels of development that a person can perform abstract calculations. Early mathematical experience brings the challenge of abstracting numbers from the maze of complex reality. The difficulty of abstracting and operating following the necessary laws of mathematics cannot be assumed to be natural to the human mind. This capacity is actually very low among students and adults with limited mathematical talent or in people with no or very low level of academic training. Mathematics is a medium with its assumptions and rules and like any other medium it has to be learned. If really mathematics were embedded in the order to the universe and in the structure of the mind, then, mathematics would have been very easy to learn. However, experience in schools and universities show that mathematics is not always an easy subject to learn.

In fact, mathematics is part of what Piaget calls logico-mathematical knowledge.[43] According to Piaget:

> From the types of acquired cognitive behaviour and especially from the higher forms of intelligence, two aspects should be defined – essentially different from each other in the part taken in the elaboration by the actions of the subject or the organism, on one hand, and by the objects themselves or their environment, on the other. These aspects of knowledge the logico-mathematical and the exogenetic (empirical apprenticeship and experimental behaviour)[44]

Piaget's differentiation of logico-mathematical knowledge and exogenetic knowledge points to the fact that all knowledge is not mathematical although mathematics is often elevated to a very high level of abstraction that associates it with universality and necessity. In fact:

> Logico-mathematical structures, which imply, ipso facto, a preponderant share of activity and organization which are internal (if not entirely endogenetic …) can be seen (although constantly fused with exterior data from which they can only be distinguished on the higher levels of thought) at all stages of acquired behaviour or even of perception – perhaps even of certain instincts. For instance, Gestalt perceptives consist of geometrization; the practical intelligence of chimpanzees dominates the detour problems, which imply the intervention of a "group of displacements"; the sensorimotor schemata follow their own logical pattern; and so on.[45]

Logico-mathematical knowledge, therefore, is not the whole of human knowledge. There is also exogenetic knowledge that is based on empirical apprenticeship and experimental behaviour. In other words, logico-mathematical knowledge is not the only type of knowledge that humans are capable of. In addition to logico-mathematical knowledge, Piaget mentions sensorimotor knowledge which he divides in two phases one pre-operative and another operative. Logico-mathematical knowledge, therefore, occurs at a relatively high level of mental development. It builds on a great deal of pre-operative and operative sensorimotor knowledge. The conceptualization of space and the perception of objects in space play a great role in the development of logico-mathematical knowledge. What is interesting, from Piaget's point of view, is that the acquisition of logico-mathematical knowledge does not suppress sensorimotor knowledge. On the contrary it builds on it through a process of organizing the immediate data of experience. In real processes of human knowing there is hardly a separation between the two forms of knowledge because these forms dynamically integrate themselves as the human organism apprehends its environment. Even when one is performing functions that would appeal to logico-mathematical knowledge such as mathematical calculations and logical inferences, there is constantly an appeal to sensorimotor knowledge. Sensorimotor knowledge is not imperfect knowledge of which logico-mathematical knowledge is an essence or a perfect model. Sensorimotor knowledge is an altogether different form of knowledge. The differentiation between the two forms of knowledge depends of their degree of mediation of immediate data of experience. Sensorimotor knowledge is mainly associated with perception of material objects and leads to representations. Its mode of apprehending the world is empirical. Logico-mathematical knowledge, on the other hand, deals with universal aspects of descriptions and relations and applies rules of inference that are (assumed to be) universal and to express the universality and the necessity embedded in the order of the universe and in the human mind. Most of the time, sensorimotor knowledge is excluded by normative epistemologists from the realm of knowledge on the ground that its perceptual nature relegates it to the realm of irrationality. However, this view has been challenged by neurophysiologists, cognitive scientists and experimental psychologists who have provided evidence for the plurality of human knowledge from their respective disciplines. For neurophysiologists, the polymorph nature of human knowledge is embedded in the topography of the human brain. The two brain hemispheres play different functions in cognitive and behavioral processes. Detailed neurophysiologic research has been undertaken to identify how these different hemispheres control various biological and behavioural functions. One of the theories brought forward is to the distribution of the analytic and synthetic modes of apprehending reality following cerebral hemispheres. According to Harris:

> the left hemisphere operates in a more logical, analytical, computerlike fashion, analyzing stimulus information input sequentially and abstracting the relevant details, to which it attaches verbal labels; the right hemisphere is primarily a synthesizer, more concerned with the overall stimulus configuration, and organizes and processes information in terms of gestalts, or wholes.[46]

Moreover, experimental psychologists have reinforced this view by putting forwards theories of multiple-intelligence. Howard Gardner, for instance, shows that human intelligence is linguistic, logical-mathematical, spatial, musical, bodily-kinesthetic, intrapersonal, interpersonal, and naturalist. His view is corroborated by Bernard Lonergan's contention that human knowing includes various operations such as experiencing, understanding, judging, choosing, deciding and acting[47] because the human mind operates at four levels of consciousness namely the empirical, the intellectual, the rational and responsible. [48] Lonegan's four levels of consciousness point to the fact the reducing human knowing to logico-mathematical knowledge implies reducing the whole process of human knowing to the second level of consciousness i.e. the intellectual level. However, a dynamic and integrative epistemology would imply that normative epistemology through reducing the whole of human knowing to logico-mathematical knowledge remains incomplete.

Moreover, people can actually supplement limited ability for abstraction by using external aids that appeal to their sensorimotor knowledge as they solve logico-mathematical problems. Therefore, counting on one's fingers or performing an addition by putting successively many objects in a box, or simply writing numbers on a paper attest to the fact that numbers are not ontologically abstract entities. They are a normative medium that can allow the understanding of relationships between properties of material objects by understanding relationships between representations of these objects. This medium operates properly only in a restricted world of similar kinds that implies fixing reference and meaning, and hence, eliminating value. This process of fixing meaning and eliminating value is achieved through fixing reference and the subtle way it is done in real mathematical operations is not mentioning reference at all and implicitly assuming that 2 + 3 = 5 regardless of what real objects 2, 3, and 5 refer to. In brief, as Lakoff and Nunez have pointed out:

> Symbolic logic is not the basis of all rationality, and it is not absolutely true. It is a beautiful metaphorical system, which has some rather bizarre metaphors. It is useful for certain purposes but quite inadequate for characterizing anything like the full range of mechanisms of human reason.[49]

This contention by Lakoff and Nunez seems radical and rebellious since logical inference and mathematics have penetrated our culture to the extent that very few philosophers and scientists can dare to challenge the validity of the systems of mathematics and mathematical logic. Challenging these systems does not imply denigrating their achievements which are unprecedented in various areas of modern science and technology. It is acknowledging that sometimes mathematics has been elevated beyond its power and abilities. Moreover, given the metaphysical dualism entrenched in modern philosophy despite its rejection of supernaturalism there is still some contempt for human natural abilities other than reason. The natural human realm was considered as an imperfect copy of the supernatural divine realm in the middle ages. Likewise, the search for certainty and precision in modern science led to the postulation of the existence of transcendental mathematics of which the imperfections of our measurement and calculations is a copy. However, as Lakoff and Nunez have noted:

> Human beings can have no access to a transcendent Platonic mathematics, if it exists. A belief in Platonic mathematics is therefore a matter of faith, much like religious faith. There can be no scientific evidence for and against the existence of a Platonic mathematics.[50]

Therefore, there is no mathematics other than human mathematics. The postulation of a Platonic mathematic is based on a belief in transcendence that is associated with religion. Its corollaries are an idea of a perfect heaven as opposed to an imperfect earth or an idea of a perfect God as opposed to imperfect human beings. This transcendental dualism manifests itself in other philosophical categories such as the opposition of essence to existence or substance to accidents. The same transcendental dualism manifests itself in some opposition of the mental to the physical in philosophy of mind. These oppositions imply defining the mental in terms of lack of spatial extension unlike the physical that can be defined by spatial and temporal characteristics. However, the rejection of supernaturalism itself would have led to a form of naturalism devoid of transcendental dualism. Transcendence should be limited to the way humans are able to transcend their limitations in space and time. For instance, through signs and symbols that are at the origin of purposeful and meaningful communicative processes, humans transcend their temporal and spatial boundaries and reach out to other persons humans on the one hand; and, on the other hand, humans create techniques and technologies that allow the person to dig into the abyss of history and collective memory and at the same time to face challenges and seize opportunities of the present and to make plans for the future. Many of our contemporaries are not aware that usual practices such as preparing budgets, making timetables, booking appointments with other people are expressions of this self-transcendence because they are ways of handling the future while we are still in the present. The same applies to practices such as keeping records and archives that are ways of handling the past while our lives move forwards in the future. Therefore, there is no need to associate transcendentalism with supernaturalism or the existence of a Platonic world that humans are trying to duplicate. There are creation of humans such as technologies and signs and symbols that allow humans to transcend their limitations both in time and space. In other words, there are no transcendental mathematics because:

> The only mathematics that human beings know or can know is, therefore, a [human] *mind-based mathematics*, limited and structured by human brains and minds. The only scientific account of the nature of mathematics is therefore an account, via cognitive science, of human mind-based mathematics. Mathematical ideas analysis provides such an account.[51]

Therefore, admitting that there is no transcendental Platonic mathematics as Penrose would postulate or mathematical principles embedded in the order of the universe and in the human mind gives some credit to Cartestian intuitionism. Assailed by doubts Descartes sought new foundations. However, Cartesian foundations did not become famous because they were new but because they are (at least according to Descartes himself) absolute. Descartes' programme consisted therefore in replacing doubt by certainty. Therefore, Descartes attempt to establish absolute foundations for human knowledge came with costs: (1) Descartes reduced philosophy's traditional vocation i.e. love of wisdom to certainty; (2) he popularized a mechanistic model of mental processes by claiming that as complex natural processes can be explained by the behaviour of atoms, complex mental processes and human knowledge itself can be explained as combinations of self-evident axiomatic propositions that the human mind intuit; and (3) Descartes sought objectivity not in the objects themselves but through an introspective process of accessing contents of his own consciousness. Therefore, Pundit is right in characterizing the type of individually-based type of knowledge that dominated the Cartesian tradition as "our subjective knowledge."[52] It would sound anathema to describe the father of modern philosophy as one who bases objectivity on a subjective process but that is what Cartesian *Meditations* are about. Descartes reduces knowledge to certainty by defining knowledge in terms of "clear and distinct ideas." The Cartesian influence on normative epistemology is unprecedented since the search for clear and distinct ideas lead normative epistemology to defining knowledge as true-justified-beliefs, with the condition that these beliefs have to be infaillible, indubitable, incorrigible.

C. CHARACTERISTICS AND LIMITS OF NORMATIVE EPISTEMOLOGY

1. Knowledge as true-justified belief

a) Normative Epistemology and the Gettier Problem

The emergence of normative epistemology within the context of modern science aimed at founding human knowledge on scientific principles against the background of the arbitrariness of supernatural beliefs and the tyranny of authority. Therefore normative epistemology is not founded on the distinction between knowledge (*episteme*) and (mere) opinion (*doxa*) because *episteme* and *doxa* are not always in opposition. In many instances, some opinions constitute real knowledge. It is a truism that the metaphysic of modern science and normative epistemology is naturalism since the two reject supernaturalism as a point of departure. However, the form of naturalism that modern science and normative epistemology uphold is materialism given the success of materialist-atomism in physical chemistry.

Moreover, normative epistemology as a philosophy of human knowledge aims at establishing the principles that regulate the representation of the material physical objects into mental forms such as sensations and ideas. These principles are expected to share the objectivity and the universality of the principles that modern science finds in the universe. Therefore, while modern science provides normative epistemology with better (or the best) descriptions of the universe and has proved to be a good system of explanation, normative epistemology goes beyond the descriptive, predictive and prescriptive roles of modern science. Normative epistemology operates at the meta-disciplinary level as it assesses the nature, the possibility, the conditions and the limits of human knowledge. As Crumley noted:

> Epistemology is a normative discipline. Unlike psychology or sociology, which merely describes and explains how we acquire our beliefs, epistemology attempts to identify the principles for evaluation of our beliefs. The evaluative or normative task of epistemology is perhaps its most characteristic feature.[53]

In the attempt to identify the principles that found human knowledge, epistemology not only redefines itself as modern science provides tools for describing reality and articulating knowledge but despite the diversity of metaphysical assumptions (idealism vs. positivism for instance) and diversity of epistemological positions (rationalism vs. empiricism, for example) there four salient features of normative in its actual state as an academic discipline. These characteristics include: defining knowledge as true justified belief; as a corollary of reducing knowing to logico-deductive processes in addition to assuming that that knowing is an activity of the mind. However, these characteristics can be challenged in various ways following Putnam's advice to take into account the "division of linguistic labour" and "paradigms that are supplied by our environment"[54]

Beliefs have been defined as "representations of the world around us".[55] This definition implies that "they are mental states – states of mind – with particular contents or information."[56] However, it is worth noting that the context in which modern science and normative epistemology emerged had made beliefs a contentious issue. The tyranny of authority that finally brought scholasticism into disrepute had made beliefs a contentious issue and sometimes a matter of life and death as religious wars were waged all over Europe. Moreover, new techniques of inquiry had challenged in an unprecedented way the arbitrariness of supernatural beliefs. In addition to the decline of the medieval synthesis as represented by scholasticism, doctrinal diversity within the Roman Catholic Church created a lot of "empirical residue" that called for paradigm changes. Modern science and normative epistemology aimed, in this period of crisis, to safeguard knowledge and truth from the arbitrariness of supernatural beliefs and the tyranny of authority. The tyranny of authority was real because some institutions such as the Roman Catholic Church were read to defend "the truth" using all means including violence. Therefore, modern science and normative epistemology are better understood as paradigms that aim at solving puzzles generated by the decline of scholasticism rather than as impersonal a-historical discourses that portray the necessity and the universality embedded in the order of the universe and the functioning of the human mind.

The conflicts of the early modern times, although they may today be classified as religious in their nature had important epistemological implications. Not only the medieval times did not have the disciplinary differentiation that characterizes our time but also religious disputes had cosmological, metaphysical, and ethical tenets that questioned the status of God in the universe and human destiny. Moreover, there was a confusion of roles as religious and knowledge functions were not separated. In the dominantly agriculturalist and rural societies of the late middle ages, the clergy cumulated both religious and knowledge roles. Actually the clergy somehow monopolized education given the fact that most people were not only illiterate but they could not speak Latin which was the medium of knowledge transmission at that time. Therefore, challenging cosmological beliefs and assumptions was not only an intellectual endeavor (an academic exercise) but it implied heads on collusion with the political and religious establishment. Therefore, normative epistemology in this context emerged as a foundational discipline i.e. its aim was not only reaching accurate description, making reliable predictions and useful prescriptions as modern science does, but establishing criteria for confirming or invalidating these descriptions, predictions and prescriptions.

Defining knowledge as true-justified-belief is known in epistemology as the Gettier problem.[57] Gettier delineates outright the aim of normative epistemology i.e. "to state necessary and sufficient conditions for someone's knowing a given proposition."[58] Gettier formulates the epistemological problem following a definition that many contemporary philosophers trace from Plato. Schematically the Gettier problem implies three conditions for given proposition to count as knowledge:

(a) S knows that P IFF (i) P is true,

(ii) S believes that P, and

(iii) S is justified in believing that P.[59]

Gettier looks at two alternative formulations of the epistemological problem by Chisholm and Ayer. For Chisholm:

(b) S knows that P IFF (i) S accepts P,

(ii) S has adequate evidence for P,

and

(iii) P is true.[60]

And for Ayer

(c) S knows that P IFF (i) P is true,

(ii) S is sure that P is true, and

(iii) S has the right to be sure that P is true.[61]

Without delving into a detailed analysis of the Gettier problem, these three alternative formulations show that knowledge of a proposition depends on three criteria: (1) an epistemic criterion i.e. the proposition P itself being true, (2) a subjective criterion i.e. the subject S, “believing“, “accepting“ or “being sure“ that P is true and (3) a justification criterion i.e. S “being justified”, “having adequate evidence” or “having the right”. In addition to the fact that Gettier has pointed out that a person can be justified to hold a proposition as true owing to other elements of the situation that S does not know, this formulation and the criteria it establishes have many shortcomings. Moreover, when the belief that a person holds to be true is based on the testimony of another person who is deliberately lying, one remains justified to hold a belief as true but that belief does not constitute knowledge. My own view is that the traditional formulation of the epistemological problem fails to account for real processes of human knowing because it reduces knowing to “knowing that” i.e. knowing matters of fact. However, real processes of human knowing involve other aspects such as knowing how, knowing why, and knowing when and where. In other words, normative epistemology, reduces human knowing to following rules (such as the ones prescribes by Descartes in his Discourse on Method) but as Alasdair MacIntyre has noted: “[o]bjective rationality is therefore to be found not in rule-following, but rule-transcending, in knowing how and when to put rules and principles to work and when not.”[62]

b) The Justification Requirement

Looking at the justification criterion itself, it remains ambiguous. “Being justified”, “having the right”, and “having sufficient evidence” are not synonymous. According to Gettier “

> (a) is false in that the conditions stated therein do not constitute a *sufficient* condition for the truth of the proposition that S knows that P. The same argument will show that (b) and (c) fail if ‘has adequate evidence for' or ' has the right to be sure that ' is substituted for ' is justified in believing that ' throughout.

What should be questioned is not only the nature of epistemic justification itself but also the project of normative epistemology i.e. searching for necessary and sufficient conditions for the truth of propositions. Not only all matters of fact cannot be reduced to univocal propositions, but also, our assumption that in the process of eliminating the tyranny of authority and the arbitrariness of supernatural beliefs in both the description of reality and the articulation of knowledge should be characterized. The disintermediation of knowledge achieved through the elimination of the mediation by religious authority in the description of reality and the articulation of knowledge is really a point progress for both modern science and normative epistemology. However, it does not achieve direct knowledge. In other words, the form of disintermediation that modern science and normative epistemology brought seems rather to require other forms of mediation or justification. As Alston has noted:

> Where what justifies a belief includes the believer's having certain other justified beliefs, so related to the first belief as to embody reasons or grounds for it, we may speak of *indirectly (mediatly) justified belief.* And, where what justifies a belief does not constitute any such as constituent, we may speak of *directly (immediately) justified belief.* Correspondingly, a case of knowledge in which the justification requirement is satisfied by indirect (mediate) justification will be called *indirect (mediate) knowledge*; and a case in which the justification requirement is satisfied by direct (immediate) justification will be called *direct (immediate) knowledge.*[63]

The distinction between direct knowledge and indirect knowledge implies that in some cases not only knowledge or true belief has to be justified but also justification itself has to be justified *ad infinitum*. This can lead to an infinite regress because the doctrine that defines knowledge a true justified belief implies that:

> Our justified beliefs form a structure, in that some beliefs (the foundations) are justified by something other than their relation to other justified beliefs; beliefs that *are* justified by their relation to other beliefs all depend for their justification on the foundations.[64]

This doctrine called foundationalism is based on a certain conception of reality and knowledge that is Aristotelian. This model was borrowed from cosmology. It is a vestige of, as Carruthers has pointed out,

> one form of the medieval-Aristotelian conception of science. It was believed that the various natural sciences form deductive systems (Somewhat like geometry), the axioms of which are self evidently true as well as innately known.[65]

As an ideal, the Cartesian search for "new" and permanent foundations of knowledge is fascinating. No one would like to found anything on the shaky grounds of ignorance and doubt. However, Cartesian foundations remain themselves unfounded. In a scientific context, where techniques such as observation, reasoning and experimenting in contradistinction to revelation, tradition and reliance to authority are believed to lead to knowledge, it is paradoxical that the founder of modern rationalism himself bases his system of belief on intuition. Despite tremendous progress in both epistemology and philosophy of mind, intuition remains the most obscure concept in modern philosophy. On the one hand, it seems that intuition is handed to us by fundamental axiomatic propositions because the latter are self-evident! And on the other hand, intuition looks like a superior quality of humans that allow them to grasp basic concepts and axioms effortlessly. It is not clear whether intuition is based on the nature of propositional knowledge itself or whether it is based on the nature of the human mind itself. Despite this confusion, many scholars still uphold that intuition is real. For Simon, for instance, intuition:

> is an observable fact that people reach solutions to problems suddenly. They then have an "aha!" experience of varying degrees of intensity. There is no doubt of the genuineness of the phenomenon. Moreover, the problem solutions people reach when they have these experiences, when they make intuitive judgments, are frequently correct.[66]

However, that spontaneous act of understanding that emerges naturally and spontaneously seems to be much more of a myth rather than reality. This is so because it is not easy to determine in fine detail what factors enter what we should call the context of discovery. Many scientists and philosophers of genius have attempted to describe how they reached some great ideas – Descartes did it at length in his *Meditations* – but some scientists and philosophers of great reputation puzzled by the way they arrived at solutions to difficult scientific and philosophical problems outside their professional settings while attending to non-professional aspects of their lives. This phenomenon, that I shall call the triple B (Bus, Bed, Bath) i.e. the possibility of reaching great scientific and philosophical insights when one is travelling, sleeping or bathing points to a great weakness of Descartes' theory. By reducing knowledge to "clear and distinct" ideas, Descartes reduces human mental processes to those that humans are aware of. However, recent discoveries in cognitive science and experimental psychology have pointed out that there is a great part of our mental process that we are not aware. Clearly and distinctly structured thoughts as Descartes wishes are rather an exception to the rule. According to Lakoff and Nunez, there are three contribution of cognitive sciences to our understanding of mathematics (and of mental processes in general: (1) the embodiment of the mind, (2) the cognitive unconscious, and (3) metaphorical thought. Concerning the second contribution of cognitive science, Lakoff and Nunez point to the fact that:

> Most of thought is unconscious – not repressed in the Freudian sense but inaccessible to direct conscious inspection. We cannot look directly at our conceptual systems and at our low-level thought processes. This includes most mathematical thought.[67]

This aspect of human mental processes calls into question Descartes prescription of a method of conducting thought. This aspect not only undermines the possibility of monitoring one's thought step by step as Descartes but it has been documented by people from various disciplines and areas of academic interest. Penrose expresses this aspect, for instance, when he talks of the "non verbally of thought" and "the non-algorithmic nature of mathematical insight". Michael Polanyi focuses on this aspect in a whole book entitled for the purpose *The Tacit Dimension*.[68]

From another perspective, this aspect corresponds to what Rosalind Shaw calls, after Mudimbe[69], "implicit patterns of knowledge".[70]The latter are found "in symbolic action rather than in authorized written texts"[71] They escape not only codification but also formalization and systematization. According to Eboussi-Boulaga,

> They emerge from the habitus, the practical mastering of the symbolical significance of social relations. At every moment, they are capable of improvizations ordered in facts of perceptions, of representations, of appreciations and actions, in accordance with the context, the situation and the configuration of relations, and the balance of power.[72]

Insight is linked with other aspects that manifest the creative aspects of human knowing. These aspects defy the criteria of demarcation embedded in the realist and idealist traditions. They indicate that the idealist cannot clearly state which idea led to a particular insight. Similarly, the realist cannot sometimes express how a particular experience yields special meaning. Lonergan shows that despite the fact that insight occurs suddenly, it is preceded by the tension of inquiry. He describes the context of discovery as a context of tension where a problem seems to exhaust the resources of an existing context of description and definition or a paradigm as Kuhn would have said and indicated that understanding or insight:

(1) comes as a release to the tension of inquiry,
(2) comes suddenly and unexpectedly;
(3) is a function not of outer circumstances but of internal conditions,
(4) pivots between the concrete and the abstract, and
(5) passes through the actual texture of one's mind.[73]

This description of the context of discovery by Lonergan indicates that intuition is not an unfounded foundation as Descartes would make us believe. In addition to being a response to a tension of inquiry, intuition includes both implicit and explicit processes. Intuition is not based on the transparency of a mind that carefully monitors its processes but on previous experience and skill and on the tension embedded in the desire to know. Intuition as an unfounded foundation constitutes a sort of absolute beginning similar to Aristotle's unmovable mover but Descartes search for an absolute beginning of human knowledge into self-evident axioms that we intuit is misleading. Descartes himself stated philosophizing in adult age and after training had equipped him with a great deal of sensorimotor and logico-mathematical knowledge. He did not state with self-evident axioms or propositions but with doubting the system of scholasticism in which he had been originally trained and trying to find solutions in intellectual tools that his academic milieu offered especially mathematics and Newton's physics. It is worthy noting that in early modern time the distinction between science and philosophy that some of our contemporaries uphold was not that well delineated since what we call science now was called natural philosophy.

However, there are increasing challenges to the Cartesian reduction of knowledge to "clear and distinct" ideas that can be expressed in terms of univocal propositions. Moreover, the formulation of knowledge in terms of a-historical rational discourse that is founded on self-evident axioms and basic proposition that the human mind intuit led to an infinite regress as not only the beliefs on which other beliefs are founded have to be justified but also justification itself has to be justified. Moreover, the top-down approach to problems of knowledge that assume that knowing processes are deductive systems that are best exemplified by mathematical operations and logical inference excludes other aspects of human knowing such what Piaget calls sensorimotor knowledge or common sense knowledge. In fact, contemporary philosophers such as Hilary Putnam have called into question theories that are based on the Aristotelian model. According to Putnam:

> traditional accounts of meaning and reference fail in two different ways. On the one hand, they neglect the division of linguistic labor. On the other hand, they neglect the way in which the paradigms that are supplied by our environment contribute to the fixing of reference.[74]

Therefore, from the point of view of the division of the linguistic labour, a complete epistemology should not restrict human knowing to its logico-mathematiacal aspects. This approach leads to an emaciated highly abstract form of knowledge that is most of the time expressed in formal languages since they are the only ones which lend themselves to the fixation of meaning and reference into univocal propositions and follow invariable rules of inference. Most proponents of normative epistemology associate mathematical operations and logical inferences with immutable laws embedded in the order of the universe and the human mind. Therefore, there is, first, a need to recognize that science is a coded, specialised, formalized and systematized form of knowledge. Therefore, epistemology should take into account non-scientific aspects of processes of human knowing. Lonergan, for instance, calls for an integration of scientific and common sense knowledge not by putting them into a hierarchy or replacing one by the other. What is needed is to recognize the specificity of each form of knowledge and carefully control whether one from is not encroaching on the realms of the other. According to Lonergan, while "common sense is concerned with things as related to us, science is concerned with things as related among themselves."[75] Therefore, common sense, "never aspires to universally valid knowledge and it never attempts exhaustive communication."[76] Moreover, "it [common sense] has no use for a technical language and no tendency towards a formal mode of speech".[77] Moreover, common sense "has no theoretical inclinations".[78] In other words, science is a coded (use of technical language), formalized (fixing meaning and reference as a way of reaching unambiguous and univocal definitions), systematized (need for coherence of insights) and controlled (need of institutional, collegial validation, or at least peer review) type of knowledge. Science is in principle universal and objective while common sense knowledge deals mainly with highly context dependent problems. Science appeals to universal principles of rationality common sense appeals mainly to individual judgement and decision. Minsky has corroborated this view when he notes that:

> Common sense is not a simple thing. Instead, it is an immense society of hard-earned practical ideas – of multitudes of life-learned rules and exceptions, dispositions and tendencies, balances and checks.[79]

Therefore, if epistemology is to be complete, there is a need to overcome the neglect of the linguistic labor by dynamically integrating various form of human knowledge and not restricting the whole of human knowledge to logico-mathematical knowledge. As Lonergan has noted:

> The occurrence of insight is not restricted to the minds of mathematicians, when doing mathematics, and to the mind of physicists, when engaged in that department of science. On the contrary, one meets intelligence in every work of life. There are intelligent farmers and craftsmen, intelligent employers and workers, intelligent technicians and mechanics, intelligent doctors and lawyers, intelligent politicians and diplomats. There is intelligence in commerce and industry, in finance and taxation, in journalism and public relations. There is intelligence in the home and in friendship, in conversation and in sport, in the arts and in entertainment. In every case, the man or woman of intelligence is marked by greater readiness in catching on, in getting the point, in seeing the issue, in grasping the implications, in acquiring know-how.[80]

Moreover, following Putnam's suggestion, it is also important to take into account paradigms "that are supplied by our environment."[81] As normative epistemology found in modern science a great ally in eliminating the tyranny of authority and the arbitrariness of supernatural beliefs in both the description of reality and the articulation knowledge our environment supplies academically interesting paradigms such as the concept of information. Therefore, instead of reducing the scientific contribution to epistemology to 19th century physics, epistemology can be enriched by integrating in its areas of interests areas from other disciplines such as neurophysiology and cognitive science. These disciplines assist in overcoming some limits embedded in the Cartesian paradigm but also in solving puzzles associated with reducing reality to material, mechanistic and deterministic processes and taking into account the dynamic and integrative processes through which humans interact with their human and non-human environments. Therefore, instead of reducing knowledge to univocal propositions that lend themselves to invariant rules of logical inference there is a possibility of enriching the traditional view of knowledge as true-justified-beliefs by noting that processes of human knowing are not passive processes of a solitary thinker who is filling one's mind with representations no matter how accurate they are. In addition to being observers of reality, humans also act on reality. Therefore, epistemology should defines itself as a study of the nature, the possibility, the conditions, and the limit of human knowledge.

c) Truth and Differentiation in Levels of Consciousness

To count as knowledge beliefs have to be not only justified but also true. Truth remains a puzzle because it does not lend itself to the paradigms used to define reality. It is not a material substance or a mental representation but a relationship between the two. This elusive nature of truth has prompted some theorists to give to truth an absolute value. They actually talk of "The" truth rather than simply "truth." However, this absolutist notion of truth cannot be understood unless it is put in relation to other philosophical notions that define its contexts and determine its content. This absolutist conception of truth, according to Putnam is tributary to some metaphysical realism that upholds:

> the ideas that truth is a matter of Correspondence and that it exhibit Independence (of what humans do or could find out), Bivalence, and Uniqueness (there cannot be more than one complete and true description of Reality;[82]

These assumptions imply that "*to solve philosophical problems is to construct a better scientific picture of the world*."[83] However, this would amount to an inversion of roles. While traditionally, at least in the Aristotelian tradition, philosophy was considered as the foundation of all the sciences, in the modern context, philosophy is striving to be scientific. That is why normative epistemology should be understood as an attempt to elaborate a theory of knowledge that is modeled to modern science especially physics. This modeling of normative epistemology on modern physics is sometimes done in a way that does not takes into account internal dynamics the scientific enterprise itself and its various disciplines. This absolutist approach to truth "retains the ancient principle that Being is prior to Knowledge."[84] It implies that "all the philosopher has to do, in essence, is be a good "futurist" – anticipate for us how science will solve our philosophical problems."[85] In practice, "science should be understood without philosophic reinterpretation."[86]

However, this is a conception of philosophy that makes philosophy bite its own tail. It is a way of philosophizing that destroys philosophy itself by replacing it by modern science or by setting its targets into absolutist terms that reduce philosophizing to searching for certainty instead of maintaining the complexity and the dynamism embedded in loving wisdom. Real people involved in real processes of knowing are not looking for absolute truth or clear and distinct ideas that will wipe away their doubts once for all. They are involved into a process of inquiry that leads to accurate or non-accurate representations of the immediate data of experience but even when these representations are true-justified-beliefs or "clear and distinct" idea they are not sufficient to constitute a complete process of human knowing. In addition to representing the world, human knowing has a universal horizon that implies a process of integration and discrimination that classifies similar kinds as universals and separate them with elements from instances that do not fulfill the criteria of demarcation. This process of classification implies that in addition to representing the immediate data of experience (no matter whether the representations are accurate or not), human knowing implies making sense of these representations. In other words, these representations are compared and contrasted with pre-existing explanatory schemes that are acquired through early childhood learning for general knowledge and through training and life experience by domain specific knowledge. Therefore, understanding the immediate data of experience is a process of meaning creation that is both integrative and discriminatory. It takes data that fit is one explanatory scheme as true while it rejects those that do not fit in the explanatory scheme. However, data that does not fit in one explanatory scheme is not wasted because it prompts further inquiry and learning in way that leads to the questioning of the data themselves or sometimes in a dramatic way to the questioning of the explanatory scheme itself.

Therefore, empirical processes abide to correspondence theories of truth as they believe that, according to Crumley, "a sentence or proposition is true if it matches or corresponds to certain features of the world".[87] However, a real knower's objects of predications are not only material objects or features of the world. Sometimes, a real knower is involved in abstract reasoning and subject to logico-deductive processes as one does mathematical operations or is involved with univocal propositions and logical inferences. These processes lend themselves easily to coherence theories of truth because the knower is not longer interested in achieving accurate representations of material objects but in making sense of these representations themselves. This predicating on representations and not on features of the world creates a situation of abstraction where meaning and reference are fixed as a way of generating univocal propositions that are considered as embodiments of universality and truth. This process of abstraction is based on a metaphysical assumption that there are universals that are present in each instance but that cannot be isolated except by eliminating their changing aspects that are relegated to the level of appearance or accidents as contrasted to reality defined in terms of substance or essence. This essentialist metaphysical position implies that defining reality in terms of complexity and dynamism is going astray and missing the way to substance, essence and necessary truth.

This approach reduces the process of knowing to its outcome i.e. knowledge as contrasted with opinion and defined in terms of "clear and distinct" ideas or justified-true-belief. Moreover, it takes the various operations involved in the process of human knowing as one and the same thing. However, one can agree that empirical processes that may led to accurate representation of the world for some of its features are different for the intellectual processes that predicate not on material objects but in the presentations themselves as a way of fitting or excluding these representations into existing explanatory schemes. While empirical processes achieve representations, intellectual processes achieve meaning. Their role consists in understanding the immediate data of experience. Empirical and rational processes are most of the time put in opposition as different and opposing schools of thought. However, Lonergan indicates that focusing on the outcome of the process of knowing i.e. knowledge instead of the process itself leads to a situation where the various operations involved in the process of knowing are taken as wholes when they are only parts of one multidimensional, dynamic, integrative, iterative and cumulative process. Lonergan calls these dimensions levels of consciousness because when humans are involved in the process of human knowing they are not limited to achieving accurate or non-accurate representations or making sense of these representations. They are not passive contemplators of the world but they are involved in processes of generating resources that allow them to led a meaningful lives by satisfying their needs and maximizing their abilities. That is why the process of human knowing cannot be limited its empirical and intellectual dimensions because not only accurate or non-accurate representations are generated and understanding achieved through making sense of these representation, but also these representations themselves and the meaning generated by comparing and contrasting them with existing explanatory schemes are compared and contrasted with real situations as a way of determining the importance of these representations and their meaning and the way they can be aligned to purposes such as satisfying one's needs and maximizing one's capabilities. This process of comparing and contrasting representations and their meaning with concrete situation in an evaluative process that discriminate between important representations and meanings and those that are just accessory. This evaluative process is most of the time eliminated form the process of human knowing by normative epistemologists following the traditional contrasting of empiricism with rationalism, positivism with idealism, objects with ideas (concepts), facts and principles, practice and theory. This evaluative process can be elusive because it vacillates between the universal horizon of the terms at the right side of these binary opposites and the concrete, particular dimensions of their counterparts on the left side. This evaluative dimension does not led to the generation of accurate or non-accurate representation or the generation of meaning, it is not a process of experiencing or understanding but a process of judging that implies comparing real situation with principles and values that are idealizations based on either past experiences or expectations of the future. This evaluative process that is not necessarily to be associated adds to the process of knowing a dimension of value that eliminates from the processes of knowing representations and meanings that are not valuable. In other words, as the process of human knowing takes place, only representations that are meaningful and valuable constitute knowledge because as the knower is not a passive spectator of the world but an active generator of meaning and value, the knower uses meaningful and valuable representations as inputs into processes of decision-making and problem-solving. This means that meaningful and valuable representations emanating from comparing immediate data of experience with pre-existing explanatory schemes or with concrete situations are used to create desired situations as the knower strives to lead a meaningful life through satisfying needs and maximizing capabilities.

In addition to the evaluative process that is part and parcel of the process of human knowing alongside empirical processes that aim at achieving representations and intellectual processes that aim at achieving meaning, there is a pragmatic dimensions that aims at achieving concrete goals. In other world in addition to representational (empirical, perceptual), semantic (meaning), evaluative (value) dimensions of human knowing there is a teleological dimension that implies a pragmatic dimension of human knowing. All in all, the human mind operates at four levels of consciousness that aim at achieving representations, meaning, value and goals in a dynamic and integrative way. Therefore, truth should not be always defined in terms of a relationship between material objects and mental representations but it can also be a relationship between mental (or other) representations themselves as they are compared and contrasted with existing explanatory schemes in the process of meaning generation. Moreover, truth is not a fixed entity associated with immutable substance or eternal forms but a process that occurs either through achieving accurate representations of the world or its features (correspondence theory), or through reaching through deductive processes proposition that fit in already existing coherent systems of logically proven propositions (coherence theory). The two approaches to truth are not contradictory. They are different because they are not dealing with the same level of predication. Correspondence theories deal with empirical processes that aim at achieving accurate representations of the world or its features while coherence theories deal with these representations themselves as their accuracy (from previous empirical inquiries) is taken for granted and their truth depends on their fitting in an existing systems of true propositions and logically valid inferences. There is actually even a third theory of truth that is based in the process of using meaningful and valuable representations as inputs into the processes of decision-making and problem-solving. This theory, or the pragmatic theory implies that "a belief [or an idea] is true if it works or has certain kinds of consequences; the belief is cognitively useful".[88] This theory is different from the previous ones because as the correspondence theory is concerned with sense data i.e. the mental picturing or representing the material and the coherence theory with how propositions yields properties that make fit together in one system of true propositions, the pragmatic theory reverses these perspectives by creating a situation where truth is not an intrinsic quality of sense data or proposition but a quality to achieved through acting on real objects in the real world. This theory, called also verificationnism, would imply that there are not sense data or propositions that are intrinsically true. All of them have to be verified by their practicality. While correspondence theories would favor observation as a way of accessing knowledge and truth, coherences theory favor reasoning (logico-deductive methods) while pragmatic theories would favor experimental methods. The multiplicity of theories of truth calls for the natural questions of knowing whether there is one or many truth (s). The response can be found in the rejection of the outlook that upholds that:

> Independence, Uniqueness, Bivalence, and Correspondence are regulative ideas that the final scientific image is expected to live up to, as well as metaphysical assumptions that

> guarantee that such as final scientific resolution of all philosophical problems *must* be possible.[89]

This rejection leads to a much more modest approach whose aim would be "to find a picture that enables us to make sense of the phenomena from within our world and practice rather than to seek a God's-Eye view"[90] This modest approach would start by acknowledging that the first experience of the world that we have as humans is not the one of univocal and universal proposition or self-evident axioms but:

> We are "thrown" into the world as beings who understand and interpret – so if we are to understand what it is to be human beings, we must seek to understand understanding itself, in its rich, full and complex dimensions. Furthermore, understanding is not one type of activity, to be contrasted with other human activities. … Understanding is universal and may properly be said to underlie and pervade all activities.[91]

Paraphrasing Gadamer, Bernstein notes that "understanding is misconceived when it is thought of as an activity of a *subject*; it is a "happening," an "event," a *pathos*."[92] Therefore, paraphrasing the existentialists who uphold that we are "thrown" into existence, one can contend from an epistemological point of view that we are thrown into experience and that our first experience as human infants is a world where everything holds together. The world we experience as infants is a unified world and the challenge of intellectual growth and learning is our ability to separate the different pieces of the puzzle. In other words, reflection on the world and our knowledge of it is an ad hoc activity that appeals to our ability to apprehend the logical aspects of the universe. The word logic here is used in a broad sense linked with the Greek *logos* which is a principle of unity and intelligibility of reality that appeals to logico-mathematical processes in our minds. Therefore, the assumption by normative epistemologists that performing logico-mathematical inferences and operations is innate is erroneous. The performance of logico-mathematical inferences and operations is acquires as through training and life experience as one learns to untangle to puzzles of life experiences and to order then into a logical narrative or a series of equations or logical formulas.

In addition to neglecting changing paradigms, normative epistemology assumes a certain isomorphism between these universal laws embedded in the order of things and the laws of the mind because both types of laws are believed not only to be necessary but to be the object of mental representations. However, the error that normative epistemology makes is to consider all mental processes as one and the same thing. There is no differentiation of what we predicate on and what our aims in predicating are. As Putnam has pointed out, "Analytic philosophers have a preference for material objects and sense data."[93] Although this approach can be successful when one upholds an empirical approach, modern rationalism, for instance, claims do deal with concepts and not with sense data. Moreover, critical theory claims to tackle evaluative aspects and pragmatism claims to achieve concrete goals in the real world. The differences in approach from these four dominant schools show that actually all mental processes are not one and the same thing. There are empirical processes that deal with material objects and sense data in order to achieve representations. Empirical processes are not the only ones that takes place in the human mind. The logico-positivists were aware of these facts when they associated logic and positivism as way of getting the best from both logico-deductive forms of knowledge and empirical processes. However, logico-positivism itself as a concept is an oxymoron because the type forms of knowledge (logico-deductive and empirical/positive) that they are attempting to bring together show a dilemma of choice between the perfection of rationality associated with unambiguous formal systems of predication and inference such as mathematics and logics and the predilection for empirical methods a way of countering supernaturalism and psychologism.

However, taking into account of the paradigmatic nature of predication, one can acknowledge that empirical and logico-deductive approaches to knowledge are not antagonistic and much less contradictory. They are different levels of one multifarious process. When we are knowing we are not always doing one and the same thing. There are times where we are interested in acquiring sense data of material objects and this can be achieved through empirical processes that lead to representations. However, when logico-deductive knowledge is at stake, we have a universal horizon of meaning that aims at understanding the principles underlying empirical processes. The *telos* of logico-deductive knowledge is understanding while its achievement is meaning. Logico-deductive processes are intrinsically analytic. In addition to empirical processes and logico-deductive processes there are also evaluative processes where humans compare ends and means, principles and facts, theories and practices, rules and their application, ideas and objects, laws and procedures, ideals and experiences. This evaluative dimension is most of the time excluded from normative epistemology because the latter in search of universalistic discourses and a universal language sacrifices value by fixing meaning and reference. This implies that fixing meaning and reference eliminates value because the attribution of meaning in a potentially polysemic context implies not only interpretive acts but also evaluative processes. The attribution of meaning through evaluative processes determines which aspects of a material object is meaningful and valuable in a given context and which ones are not. It determines for instance whether a stone is a sitting place, a construction material, a weapon (in the case of an attack by a wild animal, for instance), a tourist attraction to be photographed, or a monument that will serve as an external human memory. This evaluative dimension of human knowing has been excluded from normative epistemology because of the association of value with morality, a dimension of human beings that has been considered by many modern philosophers as as arbitrary as supernatural beliefs. However, this evaluative dimension is at the basis of our abilities for criticism and choice and assists in determining our actions as we much means to ends. This evaluative dimension both precedes and succeeds our actions because it assists in choosing the best means to achieve our goals but also to assess whether our goals have been achieved using principles and values that are idealizations of real situations as yardsticks. In other words, reducing to the processes of human knowing to empirical and logico-deductive processes excludes evaluative and pragmatic processes. While empirical processes achieve representations and logico-deductive processes meaning, evaluative processes create value through a differential process of comparing ideals and realities while pragmatic processes achieve real goals in the real world.

Therefore, knowing involves many integrated and recurrent steps. In fact, different theories of knowledge such as empiricism, rationalism, naïve and representative realism and the different types of idealism have the mistake of taking themselves as wholes, whereas they are different and complementary parts of one process. From this point of view, it becomes clear that various theories and positions on the origin and the nature of truth and knowledge are not contradictory. Their claim to be absolutely true, total and definitive is rooted in a discriminatory either/or pattern of truth and falsity that deprives the intermediate position of incompleteness and limited truth. In fact, between truth and falsity there is a continuum of doubts, incomplete meanings and unfinished inquiries. The ignorance of this fact makes the dualisms identified above seem unresolvable.

However, following Lonergan's theory of levels of consciousness, it becomes clear that Hume's empiricism made the mistake of limiting the whole of knowledge to the empirical level. Similarly, Cartesian rationalism made a similar mistake by limiting knowledge to the intellectual level. The empirical view was echoed later by the early Wittgenstein's picture theory of language and led to a correspondence theory of truth. On the other hand, rationalism limited knowledge to the point of view of science, i.e. the abstract and general (or universal) level and led to a coherence theory of truth. Kant's attempt to reconcile empiricism and rationalism through the distinction of things as they are in time and space (the empirical level) and the categories of understanding in which those objects fit (the intellectual level) did not overcome the original dualism. Instead, it shifted it to the metaphysical real through the distinction between the phenomenological and the noumenal dimensions of reality. Hence, the phenomenal could be empirically apprehended and the noumenal could not be the object of empirical investigation. In brief, according to Lonergan, knowing is a dynamic and iterative process that integrates recurrent operations leading to the accumulation of insights. In other world, logico-positivism (although in practice there have been more logic than positivism and empiricism) reduces the process of human knowing to two types of operations when there are four. According to Bernard Lonergan, the process of human knowing includes four basic operations i.e experiencing, understanding, judging and acting. In Lonergan's own words:

> To apply these operations as intentional to the operations as conscious is a fourfold matter of (1) experiencing one's experiencing, understanding, judging, and deciding, (2) understanding the unity an relations of one's experienced experiencing, understanding, judging, deciding, (3) affirming the reality of one's experienced and understood experiencing, understanding, judging, and (4) deciding to operate in accord with the norms immanent in the spontaneous relatedness of one's experienced, understood, affirmed experiencing, understanding, judging, deciding.[94]

In fact, a throughout study of the nature of representation and epistemic justification shows that knowing is not just stocking accurate representations "in" the mind be they sensations or ideas. This spatial metaphor of the mind is linked to Cartesian reduction of knowledge to certainty (clear and distinct ideas) abandoning the traditional vocation of philosophy as love of wisdom. According to Rorty:

> The Cartesian change from mind-as-reason to mind as inner arena [consciousness] was not the triumph of the prideful individual subject freed from scholastic shackles so much as the triumph of the quest for certainty over the search for wisdom. [95]

However, returning to the traditional understanding of philosophy as love of wisdom shows that instead of a selective theory of knowledge that reduces wisdom to certainty and knowledge to univocal propositions that lend themselves easily to formalization and logical inference, there is a need to comprehend human knowing in its dynamism and complexity. This would imply a dynamic and integrative epistemology that not only takes into account of the "division of linguistic labor" as manifested by the interdisciplinary nature of the problems of human knowledge and the dynamic and integrative nature of human rationality. This idea of a dynamic and integrative human rationality is based on the fact that reason is not as autonomous as Descartes *Meditations* would make us believe. In real processes of human knowing, if we agree with Aristotle that the human person is a rational animal, the human person is not rational only intellectually but also physically, emotionally, morally and practically. Therefore, an integrative theory of rationality must include empirical, rational, critical, pragmatic dimensions of human knowing. This multifaceted nature of human rationality implies that, as Polanyi reminds us, knowing enhances the exercise of skills, the practice of connoisseurship, and commitment. It is commitment that gives personal knowledge a universal intent. In Polanyi's words:

> The arts of doing and knowing, the valuation and the understanding of meanings, are thus seen to be only different aspects of the act of extending our person into the subsidiary awareness of particulars which compose a whole. The inherent structure of this fundamental act of personal knowing makes us both necessarily participate in its shaping and knowledge its results with universal intent. This is the prototype of intellectual commitment[96]

Looking at the justification requirement one is puzzled by the permanent search for an absolute beginning, an unfounded foundation. Hence, one theory of justification that is called foundationalism implies that "knowledge constitutes a structure the foundations of which support all the rest but themselves need no support."[97] In other words, "the mode of support involved is justification, and what get supported is belief."[98] Foundationalism would imply for the case at hand that human knowledge is founded on fundamental propositions and axioms that we intuit. However, as shown in the previous section, intuition is not as unfounded as such. It is the result of the tension of inquiry and this tension of inquiry creates the context to spontaneous acts of discovery because some of the processes of inquiry are relegated to the subconscious level as we proceed with various cores of life. In other words, we are not inquiring only when we are aware that we are inquiring. Intuition actually is itself a dimension of rationality that can be assimilated to the trained observation that gives advantage of accuracy and speed to the expert over the novice. The expert not only can easily conduct processes of inquiry on subconscious levels but the expert can easily grab implicit patterns and meanings.

2. Beliefs and the Paradigmatic Nature of Predication

Even if we concede that human knowing implies knowing matters of fact i.e. "knowing that" it remains puzzling whether all matters of fact can be formulated into univocal propositions as proponents of the traditional formulation of the epistemological problem would want. In addition to reducing the whole of human knowing to propositional knowledge which lends itself easily to mathematical operations and logical inference, this traditional formulation ignores paradigmatic dimensions of the description of reality and the formulation of knowledge. It takes for granted the question of meaning and reference by assuming that all matters of facts can be reduced to univocal propositions that can translated into languages. This attempt of transforming human knowledge and human language into propositional statements that would lend themselves to the rigor of mathematical operations and logical inference was an attempt to introduce atomism and reductionism into epistemology by believing that as physical chemistry had found "fundamental" particles, it was also possible to find fundamental propositions and axioms. The first attempt to match every word with an object was attempted by Wittgenstein in the *Tractatus* and likewise many epistemologists believed that in the "language of thought" it is possible to attach an idea to every object or a proposition to every matter of fact. However, Hilary Putnam, after rejecting his previous views on knowledge and representation contends that:

> To interpret a language, one must, in general, have some idea of the theories and inference patterns which are common in the community that speaks that language. No one could determine what "spin" refers to in quantum mechanics, for example, without learning quantum mechanics, or what "negative charge" refers to without learning a

> certain amount of electrical theory, or what "inner product" refers to without learning a certain amount of mathematics.[99]

Therefore, even at the basic level of predication i.e. defining matters of fact following the propositional formulation of S is P there is a lot of background knowledge involved. Some of this background knowledge is acquired through experience and early education, but in some areas one has to go through specialist training. That is why there are differences across languages and cultures both in defining reality and articulating knowledge. Avoiding these differences implies imposing constraints to natural processes as a way of translating them into a universal language. Putnam again points out that:

> The predicate calculus if often treated by philosophers as a universal language; but to put beliefs expressed in a natural language into the predicate calculus format, one must *interpret* them – that is, one must deal with the very problem we wish to solve. A theory of interpretation which works only after the beliefs to be interpreted have been translated into some "regimented notation" begs the question.[100]

The problem of considering the predicate calculus as a universal language misses the fact that predicate calculus eliminates value by fixing meaning and reference. Working univocal symbols where each symbol has an invariant meaning and following necessary laws of inference, implies that one is dealing with the medium itself and not the objects it refers to. Actually, predicate calculus is very restrictive because it includes in the definition of a symbol or an object only one aspect that is considered as inalterable to changes in time or spatial location. As a medium, predicate calculus like mathematical operations works only in restricted domains of similar kinds. That is why after the interpretive process that lead to the fixation of meaning and reference as a way of translating matters of fact into a universal language, symbols and rules of inferences are considered as not having any reference at all. However,

> The predicate calculus format itself has problems. What should the variables range over? Analytic philosophers have a preference for material objects and sense data; but there is no guarantee that every human language and sublanguage, including the specialized sublanguages of various professions (psychoanalysis, theology, sociology,

> cognitive science, mathematics …), will employ these standard ontologies. In fact, we know that that the sublanguages just mentioned, at least, do not.[101]

Therefore, at the basic level of predication as we attempt to define reality or matters of fact following the propositional format of S is P, we are confronted with the problem of finding a universal language without simplifying complex systems and processes. Because, universal language is only possible when we find a permanent dimension of reality on which our predications refer to. Plato thought that permanence and necessity are embedded in universal and non-material forms while Aristotle was of the view that universals are embedded in substance and not in accidents. These metaphysical assumptions influence the modern attempts of finding permanent foundations of knowledge. But even in modern science the level of predication remains controversial because despite the modeling of many modern sciences on physics, physics itself as a scientific discipline is not homogenous. For instance,

> Space-time points are another choice popular with philosophers; but to tell whether someone is quantifying over points in Newtonian space, or in space-time, or in Hilbert space, or in the space of supergravitational theory … one has to *interpret* his or her discourse.[102]

In other words, predication itself is an interpretive act. It is not a neutral ground or a medium that defines the world as it is. What can or cannot be included in the predicate depends on metaphysical assumptions i.e. theories or beliefs defining what can be included in reality or not. For instance, in the European middle age, sneezing was believed to be a religiously beneficial act that would take out an evil spirit from a person. However, in the context of modern science as influenced by mechanics, sneezing is interpreted as a purely mechanical process that can be analyzed in terms of the movement of air from the lungs through the nose. Air itself has not been understood as a material "substance" in the history of European philosophy. The Greek concept of *pneuma* (air) has a lot of religious and supernatural connotation. A Christian appropriation of the concept of *pneuma* associates the spirit with air not in the act of creation where the demiurge creates life by inspiring air into matter but also in the act of dying interpreted with loosing one capacity to breath. These supernatural interpretations of air involve also contexts where the spirit is represented as thunder in religious texts or where and bad winds on the sea associated with the evil spirit. These beliefs can appear laughable in the context of modern since, but they point to the fact that the definition of reality and the articulation of knowledge are essentially paradigmatic. Therefore, a Newtonian modern meteorologist who defines reality in terms of material particles in motion would have a different view of a storm from a Jew of biblical time such as the fisher Peter. While the modern meteorologist is equipped with knowledge and instruments that allow him to measure and even predict storms in a reasonable way, Hebrews of the biblical times would not hesitate to throw Jonas in the sea on the ground that his behavior called for God's retribution and the ship was about to sink. Although, these examples are remote from modern science and normative epistemology, they point to the fact that metaphysical assumptions and epistemological positions are paradigm-dependent and the dominant paradigm influences human action in various ways. The paradigmatic nature of predication implies that:

> no human society is unsurpassable. For any human society, there is a possible other society that is more sophisticated, which has modes of conceptualizing and describing things which members of the first society cannot understand without years of specialized study. What is often said is true, that all human languages are intertranslable.; but that does not mean that one can translate a current book in philosophy or a paper in clinical psychology or a lecture on quantum mechanics into the language of a primitive tribe without first coining a host of new technical terms in that language. It does not mean that we could tell any "smart" native what the book in philosophy or the paper in clinical psychology or the lecture on quantum mechanics "says" and have him understand (without years of study). Often enough we cannot even tell members of our linguistic community what these discourses "say" so that they will understand them well enough to explain them to others.[103]

Therefore, the predicate calculus is not the universal language it claims to be but a medium that attempts to produce a form of knowledge based on modern physics belief in universal laws that can be formulated into simple mathematical relations. In fact, models of the universe influence conceptual frameworks and actions in a way that both the definition of reality and the articulation of knowledge are paradigm bound. Although physicalism as a form of materialism has dominated normative epistemology and modern science, it is worth noting that even within physicalism paradigms are not homogenous. Moreover, as humans made tools that assisted them is coping with reality they embedded in these tools beliefs about the universe and the possibilities if offers. This realization shows that Descartes belief in innate ideas and Kant's postulation of an a priori knowledge are questionable. Models of the universe provide models of social life and human action in a way that not only modes of thought but also patterns of action have been changing with changing paradigms. This creates a great risk of confusion as concepts used at different historical periods or in different societies can yield different meanings. This is a blow to normative epistemology's attempt to achieve universality by fixing meaning and reference. According to changes in paradigms one can note that scientists and philosophers have been shifting focus. For instance, although modern mechanics would agree with Newton's definition of reality in terms of material particles in motion, the concept of motion itself as it is used in Newtonianism is different from its Aristolelian use. Kuhn discovered this possible difference in reference and meaning as he found:

> rudiments of an alternative way of reading the texts with which I had been struggling. For the first time I gave due weight to the fact that Aristotle's subject was change-of-quality in general, including both the fall of a stone and the growth of a child to adulthood. In his physics, the subject that was to become mechanics was at best a still-not-quite isolable special case. More consequential to my recognition that the permanent ingredients of Aristotle's universe, its ontologically primary and indestructible elements, were not material bodies but rather qualities which, when imposed on some portion of omnipresent neutral matter, constituted an individual material body or substance.[104]

Therefore it is not easy to grab the full meaning of a proposition when one is not acquainted with the paradigm in which the proposition is uttered. The search for a universal language and permanent foundations itself is a paradigmatic change that aimed at eliminating the tyranny of authority and the arbitrariness of supernatural beliefs in both the definition of reality and the articulation of knowledge. However, this project is itself confronted to changing paradigms because even within the realm of physics concepts and paradigms are not homogenous. Moreover, in practice, the way physics is conceived and practices is also subject to changing paradigms as overall models of the universe influence human action and social life. Wiener points to this fact when he notes that:

> The thought of every age is reflected in its technique. The civil engineers of ancient days were land surveyors, astronomers and navigators; those of the seventeenth and early eighteenth centuries were clockmakers and grinders of lenses. As in ancient times, the craftsmen made their tools in the image of the heavens. A watch is nothing but a pocket orrery, moving by necessity as do the celestial spheres; and if friction and the dissipation of energy play a role in it, they are effects to be overcome, so that the resulting motion of the hands may be as periodic and regular as possible. The chief technical result of this engineering after the model of Huyghens and Newton was the age of navigation, in which for the first time it was possible to compute longitudes with a respectable precision, and to convert the commerce of the great oceans from a thing of chance and adventure to a regular understood business. It is the engineering of the mercantilists. **.**[105]

Wiener continuous his exemplification of how paradigms have been changing within the area of physics and engineering by noting that:

> To the merchant succeeded the manufacturer, and to the chronometer, the steam engine. From the Newcomen engine almost to the present time, the central field of engineering has been the study of prime movers. Heat has been converted into usable energy of rotation and translation, and the physics of Newton has been supplemented by that of Rumford, Carnot, and Joule. Thermodynamics makes its appearance, a science in which time is eminently irreversible; and although the earlier stages of this science seem to represent a region of thought almost without contact with the Newtonian dynamics, the theory of the conservation of energy and the later statistical explanation of the Carnot principle or second law of thermodynamics or principle of the degeneration of energy – that principle that makes the maximum efficiency obtainable by a steam engine depend on the working temperatures of the boiler and the condenser – all these have fused thermodynamics and the Newtonian dynamics into the statistical and the non-statistical aspects of the same science.[106]

As a conclusion Wiener sets as a contemporary challenge the fact that: "[i]f the seventeenth and the eighteenth centuries are the age of clocks, and the later eighteenth century the age of steam engines, the present age is the age of communication and control."[107] However, before I delve into a detailed description of an epistemology based on communication and control, it is worth noting that like Putnam:

> I am not thinking of the possibility that quantum mechanics may be best understood in terms of non-standard logic (although that illustrates the point in a different way), but of the problem of interpreting quantum mechanics in its standard ("Copenhagen") presentation. Copenhagen theorists claim that quantum mechanics does not treat the world as consisting of objects and observer-independent properties, but rather treats it as consisting of two realms: a realm of "measuring apparatus," described by one ontology and one theory (classical physics), and a realm of "statistical states," described by vectors in Hilbert space and projection operators on Hilbert space.[108]

The problem is that: "[t]he "cut" between these two realms is not fixed, but is itself observer-dependent – something the predicate calculus format has no way of representing."[109] Therefore, predication calculus fails to achieve its mandate i.e. providing a universal language through which material objects are described "as they are" because what is included in reality or excluded is paradigm dependent.

D. CONCLUSION

Therefore, instead of defining human knowledge through opposing knowledge (*episteme*) and opinion (*doxa*) in addition to reducing wisdom to certainty and knowing the logico-deductive processes there is a possibility of respecting "the division of linguistic labor"[110] and taking into account the "paradigms supplied by our environment" through the introduction of a dynamic and integrative model of epistemology based on the notion of information. This model is not a theory "in the sense that the scientific realist hopes that it will be possible to construct a theory of intentionality," but "a picture that enables us to make some sort of sense of a variety of different phenomena". Dynamic and integrative epistemology is not strictly speaking an epistemological position. It does not stand aside empiricism or rationalism for instance, either as their equal or their substitute. Dynamic and integrative epistemology suggests a series of paradigm shifts that allows the construction of a model of epistemology that takes into account various operations involved in the process of human knowing as it takes place at different levels of consciousness within an equally dynamic and integrative conceptual framework based on the notion of information. This conceptual framework upholds cybernetics as a metaphysical alternative to mechanics and suggests that the process of knowing in its dynamism should be viewed as information processing in contradistinction to representation which is an intrinsically static view. Moreover, dynamic and integrative epistemology suggests that instead of reducing matter of facts to univocal propositional statements through fixing meaning and reference, the complexity of the real should be handled as it is using complex methods such as "system thinking" in contradistinction to the simple, regular, and ordered patterns involved in the analysis/synthesis dichotomy. As a corollary to extending the process of human knowing beyond logico-deductive processes, dynamic and integrative epistemology suggests that philosophy should not restrict itself to handling concepts. As a way of becoming again the "love of wisdom" and not just a search for certainty, philosophy should complement its speculative tasks with practical issues pertaining to decision-making and problem-solving. Dynamic and integrative epistemology, therefore, is not a replication of computer algorithms by the human mind, but a philosophical framework based on a dynamic and integrative model of human rationality that acknowledges that at individual level the process of human knowing is multidimensional but also that sometimes individual rationality needs to be supported by institutional rationality.

END NOTES

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[3] Karl Popper, *Objective Knowledge: An Evolutionary Approach* (Oxford: Claredon Press, 1979). The emphasis is mine.

[4] Thomas Nagel, *The View from Nowhere* (New York: Oxford University Press, 1986).

[5] Jack S. Crumley II, *An Introduction to Epistemology* (London: Mayfield Publishing Company, 1999), p.3.

[6] Nicholas Rescher, *Objectivity: The Obligations of Impersonal Reason* (Notre Dame: University of Notre Dame Press, 1997), p.3

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[9] Ibid.

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[12] Richard I. Aaron, *Knowing and the Function of Reason* (Oxford: Oxford University Press, 1971), p. ix.

[13] John Cornwell, *Powers of Darkness, Powers of Light: Travels in Search of the Miraculous and the Demonic* (London: Penguin Books, 1991), p. 34.

[14] Alister, McGrath, *The Intellectual Origins of the Reformation* (Oxford: Basil Blackwell, 1987), pp. 27-8.

[15] Ibid., p.28.

[16]According to McGrath:

"The impact of the rising professional groups in cities throughout Europe in the late fifteenth century was considerable. No longer could a priest expect to satisfy his urban congregation by reading a Latin sermon as an adjunct to the reading of the mass – an intelligent and fresh sermon was required, if the priest was to be seen to justify his position within society. No longer could he expect to justify his privileged position in urban society merely by reference to his calling. At a time of economic depression, there was widespread criticisms of priests, who were both supported by the public, and exempt from their taxes. This increasing anticlericalism must not, however, be seen as a reaction against the Christian religion, but merely as a growing dissatisfaction with the role and the status of the clergy within an increasingly professional urbanized, yet still Christian, society. Similarly, the rising hostility towards scholasticism in theology must no be thought to imply a decline in popular interest in religion, but actually reflects both a growing theological competence on the part of some of the laity (and Erasmus may serve as an example), and increasing interest in non-academic forms of religion (often expressed in sentimental or external forms) on the part of others." .Ibid., p. 11.

[17] Ibid.

[18] Ibid., p. 129.

[19] Ibid., p. 128.

[20] As a precursor of the freedom of thought that characterized modern scientists and philosophers one can look at fascinating figures such as the character of Maître Pangloss in Voltaire's *Candide* or the lifestyle of Jean-Jacques Rousseau.

[21] Jonathan Dancy & Ernest Sosa (ed), *A Companion to Epistemology* (London: Blackwell, 1992).

[22] Ibid., p. vii.

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[25] Ibid.

[26] D. M. Armstrong, *What Is a Law of Nature ?* (Cambridge: Cambridge University Press, 1983), p. 3.

[27] Ibid.

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[30] Jean-Pierre Dupuy, *On the Origins of Cognitive Science: Mechanization of the Mind* transl. M. B. DeBevoise (Cambridge, Mass: The MIT Press, 2009).

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[49] Lakoff and Nunez, p. 8.
[50] Ibid., p. 4.
[51] Ibid. Emphasis in the original.
[52] Pandit, Ibid.
[53] Crumely, p. xii. Emphasis in the original.
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[56] Ibid.
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[58] Ibid., p. 121
[59] According to Gettier, „Plato seems to be considering some such definition at *T heaetetus 201* and perhaps accepting one at *Meno* 98." (Ibid.)
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[64] Ibid., p. 19.
[65] Peter Carruthers, *Human Knowledge and Human Nature: An New Introduction to an Ancient Debate* (Oxford: Oxford University Press, 1992), p. 17.
[66] Ibid., p. 26.
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[68] Michael Polanyi, *The Tacit Dimension* (New York: Double Day, 1966).
[69] V.Y. Mudimbe, *The Invention of Africa: Gnosis, Philosophy and the Order of Knowledge* (Bloomington: Indiana University Press, 1994).
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[79] Marvin Minsky, *The Society of Mind* (New York: Simon & Schuster, 1986), p. 22.
[80] Lonergan, *Insight* p.173
[81] Putnam, ibid.
[82] Ibid., p. 107
[83] Ibid., emphasis in the original-
[84] Ibid.
[85] Ibid.
[86] Ibid.
[87] Crumely, p. 4.
[88] Crumely, ibid.
[89] Putnam, p. 107.
[90] Ibid., p. 109.
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[92] Ibid. p. 113.
[93] Ibid., p. 88.
[94] Bernard J. F. Lonergan, . *Method in Theology* , pp.14-15.
[95] Richard Rorty, *Philosophy and the Mirror of Nature* (Princeton University Press, 1979), p.61.
[96] Polanyi, *Personal Knowledge*, p.65.
[97] Alston, Ibid., p. 19.
[98] Ibid.
[99] Ibid. ,p. 86
[100] Ibid., p. 88.
[101] Ibid.
[102] Ibid. Emphasis in the original.
[103] Ibid., p. 89.
[104] Thomas S. Kuhn, *The Essential Tension*, pp.xi-xii.
[105] Norbert Wiener, *Cybernetics or Control and Communication in The Animal and The Machine* 2nd ed. (New York: The MIT Press, 1961), p. 38-9.
[106] Ibid.
[107] Ibid.
[108] Putnam, pp. 88-9.
[109] Ibid.
[110] Ibid., pp. 37-8.

CHAPTER TWO

FROM REPRESENTATION TO INFORMATION PROCESSING

A. INTRODUCTION

Normative epistemology has been challenged from two main perspectives. On the one hand, its dissociation of physical and mental processes has been challenged by studies in neurophysiology. These studies have in various ways associated processes that lead to sensations and ideas with physiological processes in the human brain. On the other hand, scientific psychology, in describing in detail phenomena such as sensation and perception, has proved that the knower is not a passive spectator, but an active participant in the process of human knowing. Moreover, in contradistinction to normative epistemology's reduction of knowing to thinking, recent theories such as emotional intelligence, virtue epistemology, and social epistemology point to a need to integrate affective, ethical, and social dimensions of the human person in the process of knowing. However, this task may remain an uphill climb if one does not first question the metaphysical assumptions that have given rise to normative epistemology. This chapter will first question mechanical models of the universe. It will suggest, at the metaphysical level, a shift from mechanical models, i.e. understanding reality in terms of matter, motion, and immutable mechanical laws, to cybernetic models, i.e. understanding reality in terms of information, control, and feedback. This paradigm change is based on the parallelism between mechanical models of the universe, modern science, and normative epistemology, and analytic methods. Mechanical models not only assume that reality is constituted by material particles in motion (atoms), but also that the motion of these particles follow immutable universal mechanical laws that are embedded in the universe itself and that are manifested in the universe's simple, orderly, and regular aspects. However, this description of the universe is more and more challenged and complexity is more and more perceived as an important aspect of natural systems and processes. If the complexity of the real is taken into account, the mechanical models' portrayal of a universe that is simple, ordered, and regular seems to be more ideal than reality. As an alternative to mechanical models, a cybernetic model will be assessed not only because cybernetics is an information-based model that is part of the "paradigms supplied by our environment"[1], but also as it follows the inventor of the concept's contention that "[t]he thought of every age is reflected in its technique"[2] and our age is "the age of communication and control"[3]. In other words, the development and diffusion of electronic computers, related information, and communication technologies (ICTs) can inspire a new model of reality (cybernetics) that is different from the one modelled on mechanics. The invention of the steam engine and other material sources of energy and motion (water or wind) moved us from an era of animation, where motion and action were described in terms of a spiritual power, the soul, or "*anima*" in Latin, to an era of automation where motion and action are described in terms of material bodies self-moving through the effects of energy (a derivative of matter and motion). Likewise, we can postulate that the computer revolution introduced the era of programming and cybernetics where motion and action can be understood in terms of information, control, and feedback. In other words, our metaphysical outlook is shifting from mechanics (matter + motion) to cybernetics (matter + motion + logic + symbolism) or from energy to information as a defining characteristic of reality.

A cybernetic model of reality is itself an information-based metaphysical position, but also an important background for an info-computational model of knowledge. A cybernetic model of reality provides the necessary metaphysical assumptions for a paradigm shift from conceiving knowing as representing (a static model) to conceiving knowing as information processing, i.e. a dynamic and integrative model that implies processes of information, control, and feedback as the knower enriches the immediate data of experience with meaning and value for the purpose of decision-making and problem-solving. Instead of reducing rationality to the principles of logic and mathematics, which are based on mechanical assumptions such as the continuity of substance, the permanence of reality, and the actuality of only regular and linear efficient causality, a cybernetic model completes its two predecessors, namely mechanical and electromagnetic models. An electromagnetic model accepts discontinuity (such as the succession of discrete signals in digital systems) and alternation (such as the regular succession of charges of opposite signs in alternating current) as being part of reality. However, electromagnetic models can still be reduced to mechanical models on the grounds that electricity can be defined as motion of electrons or ions. Therefore, a cybernetic model implies that reality should not be defined exclusively in terms of substances (that imply permanence), but also in terms of dynamic patterns and relations. A cybernetic model does not reject mechanical and electromagnetic models. It completes them by elevating to the metaphysical level logical and symbolic aspects that are generated by our relations to the universe. Therefore, in addition to the natural laws that physics has identified in the universe, one should include within the scope of reality artificial laws that humans have made for their interaction with nature and between themselves. The most popular of these artificial laws for our time are computer programs or software. In other words, a cybernetic model of the universe recognises the existence of both a material and mechanical component (hardware) and a logical and symbolic component (software) of reality. After this metaphysical ground clearing, this chapter will introduce a dynamic and integrative model of human knowing that is based on the concept of information and is meant to complete normative epistemology. This model associates the concept of information with the degree of order, i.e. the negative entropy, as, according to a cybernetic model of reality, any organized system or process conveys a certain amount of information. The definition of information as negative entropy by Norbert Wiener[4], the founder of cybernetics, implies that a totally disorganized system or process yields the highest levels of entropy (disorder) and conveys the lowest amount of information. Conveying the lowest amount of information or no information at all makes these systems and processes unintelligible and meaningless. At the other end of the continuum, a system or a process that is organized by following simple, ordered, and regular patterns (mechanical systems and processes, for instance) conveys the highest levels of information due to its minimal or non-existent degree of entropy. These systems and processes are fully intelligible because they operate by following linear patterns of causality and they lend themselves to analytical methods and univocal representations. They can be assessed with high levels of accuracy in a way that fulfills Descartes' dream of "clear and distinct" ideas since their simplicity, regularity, and orderliness implies possibilities of fixing reference, meaning, and rules of transformation. Between these two extremes, there are systems and processes that are more or less intelligible according to their degree of organization, i.e. the amount of information they convey or in Wiener's terms their "negative entropy"[5]. An info-computationalist model of human knowing, therefore, defines knowledge not as true justified belief. It does not aim at infallible, indubitable, incorrigible knowledge, but assesses real processes of knowing as they occur in concrete human beings in concrete situations. Instead of looking for perfect knowledge with the highest levels of accuracy, an info-computationalist model of human knowing defines knowing as accumulating insights through information processing. Information processing implies enriching immediate data of experience with meaning and value for the purpose of decision-making and problem-solving. Insight, therefore, is not restricted to principles of logical inference or mathematical operations. It has experiential, intellectual, evaluative, and pragmatic dimensions. In other words, accumulating insights through information processing is, in Lonergan's terms, a fourfold process of experiencing, understanding, judging (evaluating, choosing, deciding), and acting.[6] These operations attest to the fact that knowing is not a single level activity, i.e. the accumulation of sensations by empirical means or of ideas by intellectual means, but human knowing is a multilevel activity because, in Lonergan' terms, the human mind operates at four levels of consciousness, namely the empirical, the intellectual, the rational, and the responsible.[7] Each level of consciousness contributes to the overall outcome of the process of human knowing by achieving representations at the empirical level, meaning at the intellectual level, value at the rational (evaluative) level, and goals at the responsible (practical) level. In other words, the process of human knowing as the accumulation of insights through information processing has representational, semantic, evaluative, and pragmatic aspects that are linked with the fact that information processing implies enriching immediate data of experience with value and meaning for the purpose of decision-making and problem-solving.

B. FROM MECHANICS TO CYBERNETICS

1. Mechanics: Matter, Motion, Automation, and Instrumental Rationality

What Newton called "rational mechanics" and Leibniz "dynamics" is different from the branch of physics that contemporary scientists call "mechanics". In some contemporary physics textbooks, mechanics is presented as a series of equations that are assumed to be self-evident to the teachers and students of that discipline.[8] This approach to mechanics follows idealizations of bodies as mass points in order to facilitate mathematical calculations.[9] In other physics texts, first, principles are formulated by the physicist in general statements given their assumed universality, and then, graphic representations and mathematical formulations follow.[10] However, for the philosopher in general and the epistemologist in particular, mechanics in its original sense is a body of theories and practices that are linked to materialist, mechanical, and deterministic models of the universe. These models present the universe as constituted of material bodies in motion. Hence, scientists, as natural philosophers, have not only devoted time and energy to the study of matter and motion, but have also limited their study to aspects of reality that fit into these models. These aspects match criteria such as order, simplicity, and regularity. In contradistinction to the divine-organic model that mechanics replaced, the mechanical model does not assume the superposition of a natural and a supernatural order. For the mechanical model, the universe is an autonomous and automatic system that does not require any explanation and justification outside itself. Therefore, one does not need revelation, tradition, or the mediation of religious authority to access knowledge and truth. The "universal" laws that regulate the universe are accessible to immediate human experience and they can be formulated in simple mathematical relations. The social, technological, intellectual context of early modernity gave to the scientists, who were also called natural philosophers, a new subject matter and new methods. In an unpublished preface to his *Principia*, Newton explains the subject matter of mechanics as follows:

> The aim of the Book of Principles was not to give detailed explanations of the mathematical methods, nor to provide exhaustive solutions to all difficulties therein relating to magnitudes, motions, and forces, but to deal only with those things which relate to natural philosophy and especially to the motions of the heavens [...].[11]

In other words, mechanics was the study of matter, motion, and the cause of motion, i.e. force. Although mechanics has been now reduced to a branch of physics that studies the mathematical characteristics of bodies in motion, mechanics in its original sense was a general understanding of the world: a cosmology. Mechanics was a theory of the universe that meant to be a foundation of a natural philosophy. The idea of a natural philosophy itself has emerged as an opposition to scholasticism that includes the supernatural in its philosophical framework. Natural philosophy, therefore, can be defined as a conceptual framework that eliminates any role played by supernatural powers, such as God, angels, and so forth. In contradistinction to the scholastic divine-organic order, which assumes that reality as an unchanging substance is hidden beyond the veil of appearance that is essentially accidental and transient, mechanics upholds that reality, knowledge, and truth are accessible by natural processes. For this reason, mechanics, as natural philosophy, does not rely on revelation, tradition, and religious authority as methods of accessing knowledge and truth. Instead, it relies on observation, reasoning, and experimenting.

Natural philosophy upholds that as an automatic and autonomous system, the universe is regulated solely by universal laws. These laws are universal in the sense that they are embedded in the universe itself. They are custodians of the simplicity, order, and regularity that mechanical models of the universe display. By following these patterns, one can explain various natural phenomena, such as the regularity of the seasons, the succession of day and night, and the periodical occurrence of phenomena, such as eclipses. Therefore, universal laws are not only descriptive, but also predictive. They allow the description of natural phenomena in naturalistic terms, but also make possible the anticipation of the final conditions of a natural process when one knows the initial conditions and the rules of transformation. The predictive dimension of natural laws sets the boundaries between natural phenomena and claims to supernatural phenomena in some religious contexts. For instance, when a person claims to have contacts with supernatural beings, such as God, spirits, the devil, Jesus, the Virgin Mary, and so forth, scientific examinations check whether there is anything in the physiological functioning or the behavior of the "visionaries" that natural laws of biological and psychological sciences cannot explain. The predictive role of natural laws is much more evident when these laws are applied to various technological processes. At the end of a process they indicate that "something" went wrong as the outcome of the process is different to what following natural laws would imply.

The mechanical model of the universe has served as an inspiration to scientists and engineers. They have carefully studied matter and motion, and, managed to embed the mechanical laws in a huge variety of machines. Therefore, one can agree with Wiener that "[t]he thought of every age is reflected in its technique"[12] In the beginning, machines like clocks assisted in the navigation and measurement of time, and later the invention of the steam engine led to the Industrial Revolution. As Weizenbaum states:

> The word "machine" calls up images of complex and yet somehow regular motion. The back-and-forward movement of the needle of a sewing machine, so analogous to both the hustle of the gyrating, thrusting connecting rods that drive the locomotive's wheels and the tremor of the pulsating escapement mechanism of the most delicate watch, such images almost sum up what we mean by "machine". Almost. Sufficiently so that we need ask no further what a machine is. Regularity, complexity, motion, power.[13]

The machine that is often associated with the Industrial Revolution is the steam engine. Before the invention of the steam engine motion, in fact, had always been linked to supernatural powers, especially the soul. The invention of the steam engine provided a material source for motion. Hence, it was not just a technical achievement, but a revolution in metaphysics as well. It brought a change in the understanding of reality. During the era that preceded the steam engine, only *animated* beings (animals and human beings that were believed to have a soul – *anima* in Latin) were believed to be capable of generating motion. Even at the level of the planets, before Newton, Galileo, and Copernicus came up with their theories, planets had been believed to have a life of their own and to be able to influence human destiny in many respects. However, the generation of motion from material substances such as water and steam was proof to the possibility of a system of explanation that would explain motion and force in naturalistic terms according to a mechanical model by which everything could be expressed mathematically and represented geometrically in terms of matter (mass) and motion (force and velocity). In other words, the replacement of supernaturalism by mechanical models moved humanity from an era of animation, in which motion and action were described in terms of a spiritual power, the soul or "*anima*" in Latin, to an era of automation, in which motion and action are described in terms of material bodies self-moving through the transformation of energy. With mass defined as quantity of matter and motion as change in spatial position over time, the modern physicists created a new system of explanation that led to the naturalization of force. Within this change of framework, a philosophical revolution took place: philosophers and scientists moved from supernatural animation (relying on supernatural powers, such as the soul, which generate and explain motion) to automation (relying on material and mechanical forces, which need no explanation and justification outside themselves).

An important notion that has emerged with the definition of reality in terms of matter and motion is the concept of energy. Energy as a derivative of matter and motion became a driving force of the modern/industrial society. Daniel Bell, in his seminal book *The Coming of the Post-Industrial Society*[14] describes in great detail changes that have led to the modern/industrial society. According to Bell, whereas the main mode of production in the pre-industrial society was extractive and mainly focused on the primary economic sector, i.e. agriculture, mining, fishing, timber, oil, and gas, the industrial society mainly produced by means of fabrication, which was focused on the secondary economic sector, i.e. goods producing, manufacturing, and heavy construction. In other words, extractive modes of production consisted in supporting nature and getting the best of natural processes while fabrication implied the domination of nature by human labor. However, as we look at the modern/industrial society as a *weltanschauung* where energy, a derivative of matter and motion, is a driving force, Bell shows that the pre-industrial society mainly relied on natural powers, such as wind, water, draft, animal and human muscle. The industrial society, on the other hand, used created energy, such as oil, gas, or nuclear power.[15]

From a social point of view, in the pre-industrial society the artisan, the manual worker, and the farmer occupied the center stage at least in Europe. In the Middle Ages, the feudal system was well entrenched and land tenure was a major source and sign of wealth. The industrial society, on the other hand, was dominated by the engineer and the semi-skilled worker. This situation has changed radically since the post-industrial society is dominated by scientists and experts holding technical and professional positions. Peter Drucker notes that the “knowledge worker”, an expert, is replacing the semi-skilled worker of the massive production of the industrial society. The semi-skilled worker is, in fact, the fruit of Cartesianism, i.e. the habit to "break apart problems, to fragment the world"[16]. The semi-skilled worker was precious in the industrial society because, at that time, the industrialist "analyzed tasks and broke them down into individual, unskilled tasks that could be learned quickly"[17].

Last but not least, the modern/industrial society, as the fruit of defining reality according to a mechanical model, brought a new "state of mind." In Bell's view, the pre-industrial society was past-oriented; its axial principle is traditionalism. In practice, it tended to transmit tradition from one generation to another and it played games against the natural course of events through practices such as divination. The industrial society experimented, and the findings from experiments were incorporated into existing bodies of knowledge through ad-hoc adaptiveness. It created technology, and yet, struggled to put into places political structures, social systems, and cultural patterns that limit its excesses and abuses. Through invention and regulation, the industrial society played a game against fabricated nature, and its axial principle is productivity.[18] That is why the modern/industrial society witnessed the emergence of a wide range of artifacts. Herbert A. Simon claims that artifacts attest a paradigm shift from the traditional vocation of science, i.e. exploring the secrets of nature, to acting on nature. Simon's merit is in distinguishing natural things from artificial things without opposing them. He ascertains that nature is the preferred domain of science while the artificial is the realm of engineering. Moreover, Simon notes that while the method of science is analytical, the method of engineering is synthetic. For Simon:

> The thesis is that certain phenomena are "artificial" in a very specific sense: they are as they are only because of a system's being molded, by goals or purposes, to the environment in which it lives. If natural phenomena have an air of "necessity" about them in their subservience to natural law, artificial phenomena have an air of "contingency" in their malleability by environment.[19]

Artifacts, in addition to being distinguished by contingency, have four main characteristics.

1. Artificial things are synthetized (though not always or usually with forethought) by human beings.
2. Artificial things may imitate the appearance of natural things while lacking, in one or many respects, the reality of the latter.
3. Artificial things can be characterized in terms of functions, goals, and adaptation.
4. Artificial things are often discussed, particularly when they are being designed, in terms of imperatives as well as descriptives.[20]

In modern times, where a materialistic, mechanistic, and deterministic outlook based on the success of classic physics dominated, reality was identified with immutable and universal laws of nature. The same laws were believed to apply simple, regular, and ordered patterns, which are similar to invariable patterns in the movements of planets and particles, to human behavior and social interaction. These patterns themselves became the focus of scientific inquiry and philosophic reflection in a way that natural processes and systems were more and more studied from the point of view of their spatial and temporal characteristics. There was a shift from metaphysical or ontological themes related to 'principles and first causes' to the study of observable physical characteristics. According to J. Christiaan Boudri, with the development of modern science the study of matter has shifted from inquiring about its nature to inquiring about its structure.[21]

The focus on observable physical characteristics has reinforced a mechanical approach to people and societies. Both individuals and societies have been believed to be characterized by order, regularity, and predictability. Science, through the identification of the regular patterns of natural phenomena and human behavior, has been able to design means of controlling the course of nature and human interaction. This control was to be achieved through the establishment of simple relationships between cause and effect, means and ends, inputs and outputs. This way of reasoning has been called "instrumental rationality". According to the principle of instrumental rationality, "if you intend that a situation, X, occurs and you believe, in agreement with your evidence, that another situation, Y, is the most effective means to X, then you rationally should have Y occur"[22]. Therefore, there is a possibility of establishing a parallelism between mechanical models and instrumental rationality because the two approaches are based on assumptions of simplicity, order, and regularity. Mechanical models assume that natural processes in the universe are simple, ordered, and regular, and hence, follow linear patterns of causality while the principle of instrumental rationality also follows linear patterns of causality with the assumption that, as in natural processes, complex systems and processes in the universe can be explained in terms of simple atoms, complex knowledge patterns can also be explained in terms of simple axioms or simple univocal propositions.

2. Platonic and Neo-Aristotelian Alternatives to the Mechanical Model

a) Platonic Reactions

Paradoxically, mechanical models have prevailed even among those who have found them unsatisfying. Many philosophers writing about science or philosophy of science have reduced the scientific understanding of reality to mechanical models. They call their position "materialism", physicalism, and sometimes simply naturalism. This reduction is based on the belief in the explanatory adequacy of physics. According to Lewis, the explanatory adequacy of physics would imply:

> The plausible hypothesis that there is some unified body of scientific theories, of the sort we now accept, which together provide a true and exhaustive account of all physical phenomena (i.e. all phenomena describable in physical terms). They are unified in the sense that they are cumulative: the theory governing any physical phenomenon is explained by theories governing phenomena out of which that phenomenon is composed and by the way it is composed out of them. The same is true of the latter phenomena, and so down to the fundamental particles or fields governed by a few simple laws, more or less as conceived in the present-day theoretical physics.[23]

The explanatory adequacy of physics leads inevitably to a materialist theory of the mind. The background of this theory is the elimination of any reference to supernatural entities or vital powers from the modern mode of explanation. The natural universe as a physical universe only operates through physical processes. Even phenomena that do not belong to the discipline of physics can still be explained in terms of physical entities and processes. According to Armstrong:

> It is now very probable, even if not certain, that life is a purely physico-chemical phenomenon. We do not need to postulate 'vegetative souls' or 'vital entelechies' to explain life. [...] More and more psychologists and neurophysiologists explicitly or implicitly accept the view that, so far as mental processes are concerned, that there is no need to postulate anything but purely physical processes in man's central nervous system. If we take the word 'mind' to mean 'that in which mental processes occur' or 'that which has mental states', then we can put this view briefly and not too misleadingly as: the mind is nothing but the brain. If scientific progress sustains this view, it seems that man is nothing but a material object having none but physical properties.[24]

Opponents to the mechanical model adopt a strategy of separating material objects from their representations. They uphold a metaphysical dualism different from the medieval one. Wheareas the medieval dualism opposed the natural to the supernatural, opponents of the mechanical model oppose the material to the mental. Modern science, based on the mechanical model easily rejects supernaturalism on empirical grounds. The scientific position is that, since supernatural entities can be observed, logically deduced, or experimented on, either they do not exist, or at least they are subject to methodological doubt. Systematic Platonic and neo-Aristotelian responses to the mechanical model adopt different strategies. Instead of defining reality in terms of substance and accidents (since the existence of metaphysical essences, which acquires the existence of individual kinds, would be difficult to prove scientifically), one strategy is reducing the substance/accidents dichotomy to the material/form dichotomy. This strategy allows the elimination of supernatural entities, but maintains that not all is matter or that matter is not everything. It opposes individual objects, which are material, to their representations, which are mental or formal. Therefore, material objects and processes can be confined within the boundaries of the mechanical model while their representations cannot. The proponents of this strategy attribute an independent existence to representation systems. Roger Penrose, for instance, has set this question clearly: "How "real" are the objects of the mathematician's world?"[25] He notes that:

> From one point of view it seems that there can be nothing real about them at all. Mathematical objects are just concepts; they are mental idealizations that mathematicians make, often stimulated by appearance and seeming order of aspects of the world about us, but mental idealizations nevertheless. Can they be other than mere arbitrary constructions of the human mind? At the same time there often does appear to be some profound reality about these mathematical concepts, going quite beyond the mental deliberations of any particular mathematician. It is as though human thought is, instead, being guided towards some external truth – a truth which has reality of its own, and which is revealed only partially to any one of us.[26]

The positions that Penrose brings out, highlight two dominant views both in the philosophy of science and the philosophy of mind: the formalists and the realists. Penrose is a realist. He is faced with the question of whether mathematics is invention or discovery.[27] He elaborates his position as follows:

> When mathematicians come upon their results, are they just producing elaborate mental constructions which have no actual reality, but whose elegance is sufficient simply to fool even the inventors into believing that these mere mental constructions are 'real'? Or are mathematicians really uncovering truths which are, in fact, already "there" - truths whose existence is quite independent of the mathematicians activities? I think that, by now, it must be quite clear to the reader that I am adherent to the second, rather than the first view, at least with regard to such structures such as complex numbers and the Mandelbrot set.[28]

Despite the unquestioned dominance of the mathematical model, people still disagree over the reasons for its triumph. There are two dominant positions. One position, represented by Penrose for instance, attributes an independent existence to representational systems. This position, called realism, implies that representation systems, such as mathematics, are not products of the human mind. They are embedded in the order of things, and what the human mind does, is simply to discover them. Realism, therefore, attributes a metaphysical character to mathematics. In Penrose's view, mathematics exemplifies the coherent, conceptual representation of reality that science seeks. In his own words:

> The appropriateness of the real number system is not often questioned, in fact. This confidence - perhaps misplaced - must rest (although this fact is not often recognized) on the logical elegance, consistency and mathematical power of the real number system, together with a belief in the profound mathematical harmony of nature.[29]

The usefulness of mathematics seems to be embedded in its quality as a reasoning tool. However, throughout the history of philosophy, mathematics has often been understood from a metaphysical point of view. The Greek mathematician and philosopher Pythagoras was the first one to postulate that number is the underlying principle of reality. The importance of mathematics has emerged again with the search for a universal language. This search was based on the belief in a natural harmony embedded in the system of the universe and a unique descent of humankind. Those who believed in a unique descent of humankind mixed the biblical narrative of Adam and Eve with pseudo-scientific speculations. They literally searched for an Adamic language that could be understood by all people. Other thinkers postulate that that kind of language must be constructed artificially. As Donald Rutherford has noted:

> Most early proponents of artificial language schemes stressed the practical value of their inventions as instruments of communication. Their works were primarily attempts to devise systems of writing, modelled variously on Chinese characters, cryptographic codes or shorthand notation, where synonymous words in different languages would be represented by a common sign.[30]

For most modern scientists and philosophers universal language was neither to be reconstructed nor to be invented. It was inscribed in nature. According to Pythagoras's intuition, mathematics was what Heinz Pagels calls "The Building Code of the Demiurge"[31].

The other strategy consists in upholding the principles of the mechanical model, but restricting the model's domain of applicability. According to this strategy, the mechanical model is a wonderful tool for describing natural processes, but it is inadequate as far as human behavior is concerned. Human behavioral processes are considered as acts of will that involve non-mechanical aspects such as volition and intentionality. Whereas mechanical processes are mainly autonomic, human behavioral processes are relational, and hence intentional. This strategy suggests that the mechanical model should only be applied to material processes as opposed to mental or spiritual processes. However, the concept of the mental or the spiritual remains ambiguous. It is often wrapped into veils of metaphors borrowed from physical processes. For instance, the Greek concept of *pneuma* (air) has been associated with non-material processes for a long time. Biblical narratives indicate that the act of creation consists in infusing air into inanimate matter. This creates confusion between non-material processes and breathing. However, according to the mechanical model, breathing is a physical process because, on the one hand, air is constituted by material particles, and on the other hand, the laws regulating the motion of air in the human body are mechanical laws. There is, therefore, nothing non-physical in the process of breathing. The metaphor of air as a non-physical process is so well entrenched that even modern medicine techniques of reanimation (giving back the *anima*, the soul) consist of infusing air in someone's lungs to allow the patient to breath properly. The mechanical model does not add any supernatural dimension to air. The laws of thermodynamics are natural laws like the laws of motion.

The mechanical model, therefore, accounts for material bodies in motion, but has the function of naturalizing some processes and aspects that were previously considered as supernatural. Actually, breathing is not the only metaphor used to describe non-material processes. John Locke, for instance, borrowed from painting when he thought of the mind as a *"tabula rasa"*. In our photography-dominated culture, we believe that we have mental "pictures" of material objects while those familiar with information and communication technologies, such as Churchland, uphold computational models. This view that attributes independent existence to systems of representation is called realism. It is opposed to formalism that upholds that systems of representations are constructions of the human mind. According to this distinction, Penrose can be classified as a realist while Dretske, for instance, is a formalist.

What these two alternatives to the mechanical model have in common is their essentialist position. They reject the mechanical position that the universe is one and that other aspects such as motion, duration, and modality are dimensions of the physical universe. This difference in the description of reality implies that the concepts of naturalism, physicalism, and materialism are not univocal. It is easy to reject supernaturalism, but it is not clear by what it can be replaced. The neo-Platonist and neo-Aristotelian alternatives to the mechanical model are metaphysically dualistic. However, the type of dualism they bring about is not the opposition of the natural to the supernatural, but the material to the mental. There are two dominant positions on this issue. Realism contends that representation systems have an existence of their own. They are independent of the objects they represent. Formalism, on the other hand, upholds that representation systems are mental constructions. They are abstracted from characteristics of the objects they represent. Ernst Cassirer notes:

> Physical reality seems to recede in proportion as man's symbolic activity advances. Instead of dealing with things themselves man is in a sense constantly conversing with himself. He has so enveloped himself in linguistic forms, in artistic images, in mythical symbols or religious rites that he cannot see or know anything except by the interposition of [an] artificial medium.[32]

b) Neo-Aristotelian Reactions

Whereas the mechanical model has been efficient in tackling the impasses of scholasticism, it also has its own impasses. One of its criticisms is that it cannot account for religious beliefs. Authors, like Charles Hartshorne, who have tried to salvage religious beliefs in the context of fast scientific and technological development, have adopted the strategy of separating the domain of science from the domain of philosophy. According to Hartshorne, for instance:

> The scientist asks, what ideas will fit and explain the facts? The philosopher asks, what ideas will explain the ideas that fit the facts, and in addition, will explain the ideas which do not fit the facts? The philosopher is seeking principles so general, so basic, that they are no longer special cases to be explained by more general principles, but are themselves the most general of ideas, true not only of the actual world but of any conceivable one. Since there is nothing beyond them, nothing more fundamental, those ideas must, taken together be self-explanatory.[33]

This understanding of philosophy and its role by Hartshorne is in accord with the tenets of scholasticism. It defines philosophy in an Aristotelian way as "the knowledge of first causes and first principles". It makes philosophy a second order activity. The type of principles it seeks are so encompassing that, in the end, they are ultimate. According to Hartshorne:

> They form a system which sets forth the ultimate what? How? And Why? (in whatever sense there be such ultimates). Because this system (if only we can find it) is completely general, it can deal with values as well as facts, with God as well as man, with the everlasting as well as the temporary, with the possible as well as the actual.[34]

For him:

> The philosophical system would not be a complete version of science, for it can contain only general principles, not specific facts. Thus philosophy does not compete with science. Nor can science take the place of philosophy, as can be seen from this alone, that scientific knowledge by itself gives no satisfaction to the man who reflects intelligently upon death.[35]

In other words, for Hartshorne science and philosophy are different both in their purposes and in their methods. Despite the popularity and the widespread use of science in human affairs, science does not occupy the whole terrain. There are aspects of human existence that cannot be handled scientifically. Those aspects pertain not only to issues of religious beliefs and morality, but also to an understanding of reality as a whole. Hartshorne further articulates the role of science and, at the same time, questions it as follows:

> Science explains facts by such ideas as "matter", "law", and "experience" or "observation". But are these ideas as used by the scientists, fully generalized, or are they special cases? Is *all* reality matter in motion, or can there be "immaterial" spirits? Can there be lawless matter or experience; what are the most general relations between matter, experience, and law? These are some of the questions that a scientist would hardly wish to consider, but which philosophy takes as its own.[36]

Secondly, the authors who try to salvage religious beliefs adopt a radical anti-Cartesianism. In an ambiguous characterization of science in his foreword to Hartshorne's *Reality as Social Process,* William Ernest Hocking points out that:

> One feature, however, of Cartesian thinking we are not discarding, and I am not sure it isn't the chief mark of the modern era. I venture to say we shall never discard it. It is the inseparability of science and philosophy, of physics and metaphysics. Every future

> philosophic era will be, like our era, for better or worse, "scientific" in the sense that whatever science reveals belongs integrally to the philosophical world picture. But the era now opening has the specific task of **putting science at its place**.[37]

Hocking characterizes his and Hartshorne's thought as follows:

> This implies that science is not the whole of truth or scientific method the whole of human thinking. As laboring to weld together the sciences with philosophy, our pragmatists, naturalists, realists and positivists have labored well. But to put science into its place requires a *pou sto* beyond science: that is the task of metaphysics. The era on which we are entering is marked by nothing so much as by a revival of metaphysical courage – the will not only to describe but to understand.[38]

The book Hocking is introducing characterizes itself by a struggle to build an alternative metaphysical model that would replace the materialist, mechanistic, and deterministic model of Newton's physics. This new type of metaphysics would then support religious belief and a conceptualization of God in categories that appeal to the modern intellectual mind. Right from the beginning Hartshorne points out a categorical confusion that expresses itself in radical antinomies. In his view:

> Nearly all the questions that are important for our time are begged or confused by such crude or equivocal alternatives as – fascism versus communism (or even, capitalism versus socialism), naturalism versus supernaturalism, idealism versus realism. If we have made basic advances in intellectual method, and I think we have, in the last century or so, this should affect not merely our answers but our questions, to such an extent that the old dichotomies should be viewed with suspicion.[39]

Hartshorne's rejection of a conceptual framework that locks philosophical discourse into irreconcilable dichotomies and hermetically closed schools of thought may be historically important. Although his motives for questioning Cartesianism develop within a religious perspective, the new philosophical categories he is looking for would overcome the denounced dichotomies just as they would fit well with religious belief. They are a way of siding with metaphysics as opposed to mere physics, an affirmation of some reality beyond what physics considers. Hence, Hartshorne calls for a separation between philosophy and science, claiming that these activities have different modes of questioning and that the principles they seek are at different levels of generality.

Hartshorne's questioning of the vocation and the role of science is legitimate; although by opposing matter to mind, nature to "supernature", science to philosophy, he is still partially bound by the dichotomies of the Cartesian system that he sensed to transcend. He can be credited for pointing out the ambiguities linked with radical dichotomous oppositions and hermetically closed schools of thought. Hartshorne's situation where he struggles to transcend a system of categories and, at the same time, falls into its tangles is symptomatic of an age where a conceptual framework can no longer accommodate the available elements of human experience and another more comprehensive conceptual framework has not yet been crafted or well articulated. This declining conceptual framework seems to create unsolvable problems and irreconcilable ways of thinking. Nevertheless, Hartshorne, in consistency with his search for a fully generalized system of ideas, describes the philosophical landscape that has been generated by the scientific challenge to scholasticism:

> It [philosophy] seeks a set of ideas of which any scientific or common-sense notions, true or false, can be viewed as special cases. For example, materialism is the philosophy which regards "matter in motion" as the general principle, and experience, mind, purpose, as special cases. Idealism, on the other hand, makes mind the general principle, and matter the special case. Similarly, the philosophical doctrine of determinism views law or causal order as completely universal, and treats freedom as the special case where the laws happen to govern motives and acts of will; whereas libertarianism makes freedom the rule, and treats law as the special case where freedom is slight, resulting in approximate or statistical uniformities.[40]

Hartshorne then claims that a "higher synthesis" is taking place in philosophy, and asserts that "[p]erhaps all reality is both physical and psychical, and perhaps everywhere there is law and freedom. In that case, the extremes of doctrine might cease to exist as extremes"[41]. Hartshorne tries to overcome the shortcomings of the conceptual frameworks he criticizes by introducing another paradigm, namely the "social". In his view:

> There is a conception in which motion and mind, law and freedom are inextricably blended. It is the conception of the "social", or rather it is what this conception becomes when fully generalized.[42]

He introduces this concept by describing various aspects of social processes and interactions. For him:

> Critics of the social philosophy who complain that we cannot detect definite social character in all portions of nature are missing the point, which is that an idea actually known to be true in some cases, but not even potentially known to be false in any *conceivable* case, is for all purposes an ultimate idea.[43]

However, Hartshorne falls short in his description of his new paradigm. He begins with the attempt to give a social account of scientific theories, such as atomism and the fact that "living matter" is multi-celled. However, his use of political metaphors, such as his contrasting of "monarchical" and "democratic" societies, seems farfetched. They can only be accepted, in my view, as analogies and not as accurate descriptions, and perhaps that is how they were intended. In addition to this contrast, Hartshorne upholds the existence of a certain hierarchy in nature. This hierarchy allows him to establish the supremacy of God by claiming that "[d]emocratic cooperation is possible only within an all-inclusive monarchy"[44]. In addition to the idea of a hierarchy, Hartshorne attempts to transcend mechanics with his claim that reality is governed by aesthetic principles. These aesthetic principles are an expression of his concept of harmony. His approach now introduces the concept of value to the description of reality, unlike the predominance of mathematical representation in mechanics that was mainly concerned with facts. For Hartshorne:

> If experience is the source of meanings, then the basic traits of experience must somehow correspond to the basic possible meanings, and these to the basic structure of any world that can be meant. Now all experience is concerned with value.[45]

Hence, for him, aesthetic experience is the foundation of all abstract descriptions of reality. In his own terms:

> Aesthetic experience is intuitive, concrete; aesthetics is the science of the laws of direct awareness or intuition as such. But all abstract knowledge presupposes intuitive

> awareness. Hence, aesthetics establishes data that all abstract knowledge must take into account if its basis in immediacy is to be understood. And unless this basis is understood, we cannot know what the abstractness of the knowledge consists in, what it is of concrete reality that? is omitted.[46]

In other words, the diversity of positions in philosophy is based on the harmony in nature, a complementary uniting of opposites, which introduces the aesthetic value of contrast both to nature and its description. Hence, Hartshorne defines harmony as:

> a kind of relation between things such that though they are felt to be different from each other, they are yet felt to be not merely different. Otherness is not the only relation between them. In fact, it seems that the very opposite of otherness is also involved.[47]

3. An Electromagnetic Model: Taking into Account Discontinuities and Alternatives

Hartshorne tries to illustrate his "social model of the universe" and its harmonious patterns where difference and opposition should be understood as manifestations of the aesthetic value of contrast. For example, he finds that:

> there are only two ways of failing to achieve harmony – by too little contrast ("insipidity," "monotony"), and too little similarity ("discord," "incoherence," and "chaos").[48]

Moreover:

> The importance of contrast is not confined to art. All through life run the great contrasts of man and woman, child and adult, joy and sorrow, lively and calm temperaments or moods etc.[49]

Hartshorne's concept of contrast that generates harmonies finds echoes in Heraclitus' doctrine of the "uniting of opposites" and recently in Chinese Confucianism, where the contrast between the masculine principle of Yang and the female principle of Yin creates harmony in the universe. Applied to science, this concept brings useful insights into the paradigm shifts that have been taking place within science itself. First, Hartshorne affirms that "[c]ontrast is not found only throughout life but throughout nature as disclosed by science"[50]. He illustrates his view by the fact that:

> There is the shift of the electron between energy levels. This shift is sharp, and has a fixed minimal value which measures the least unit of radiant energy emitted by the

> electron, e.g. a photon of light. The electron does not relieve the monotony of its existence, we might say, merely by shifting its path a little, but rather by shifting it enough to achieve a deep contrast between its two successive states.[51]

Another phenomenon that illustrates contrast in nature is the wave pattern:

> Again, nature avoids monotony by flowing in waves. A calm lake surface is not so far lacking in contrast, but when the wind ruffles this surface, sharply contrasting planes are introduced. We know now that nature carries all her fundamental operations, not in the manner of an unruffled stream, or an arrow cleaving the air without deviation from its almost rigid trajectory, but in the manner of a stream simultaneously flowing and ruffling in waves. The wave pattern, which is a simple scheme of repetitive contrast, is all pervasive in nature.

Even matter at particle level is not as compact as the common sense view makes us believe. In fact, regarding "this wave pattern or 'wave-pocket, waves are, it seems, collected in pellets. Matter is both continuous and discontinuous, a vital harmony, apparently, of those two contrasting aspects. This unity in duality is called in physics 'complementarity'."[52]

After noting that there are other contrasts in nature, such as the contrast between "living matter" and "dead matter" and between "efficient" and "final causes", Hartshorne notes that:

> It is interesting to note that, beginning with Heraclitus twenty-five centuries ago, a number of philosophers have held that the world is a "unity of opposites". But opposite does not mean simply unlike, but rather: emphatically unlike and - in some respect – emphatically alike. For instance, particles and waves are alike in that both involve sharp contrast; the particle with its surrounding "empty" space, and the waves in their divergent planes.[53]

Hence:

> To decide whether the world as disclosed by the new physics is really beautiful apart from man, it would be necessary to discuss the question with reference to the categories of quality and meaning as well as the category of harmony, which is here alone for consideration. But in as far as the new physics pictures nature as a system of complementarities or vital harmonies, it is immeasurably more satisfying esthetically than the old physics, which was full of monotonous continuities, and of unlikeness not unified by equally pronounced likeness, while it was poor in strong and well-unified contrasts.[54]

In my view, Hartshorne's insights, although they have the main purpose of creating a conceptual framework that supports religious belief, are useful for other philosophers. They dismantle a conceptual framework that is based on assumptions that have been challenged too little and that have largely been taken for granted. The most important of these assumptions are exaggerations of a continuity of substance and of a permanence of reality. These assumptions are at the origin of rejecting change as part of reality in previously dominant metaphysical schools. That is why pre-Socratic philosophers looked for a permanent element of reality (that was believed to be material) and science looks for immutable universal laws, relegating change to the realm of appearance. In contrast, Hartshorne's principle of harmony points to the fact that some aspects of reality are not explained by the continuity of their permanent features, but by the succession of opposing aspects in a regular pattern. This characteristic, for instance, differentiates digital communication systems, which function by transmitting discrete signals at regular intervals, and analog communication systems, which transmit continuous signals. Therefore, instead of reducing reality to permanent and continuous features, there is a possibility of shifting from a "metaphysics of substance" (understood as a permanent and continuous substratum) to a "metaphysics of relation and process". Hartshorne is not the one to suggest an elevation of change and process to the metaphysical level.

Mechanical models were not limited to the study of the movement of planets. Modern chemistry tried to study the structure of matter at the microscopic level, i.e. the atomic level. Rutherford established the similarity between the structure of atoms and the solar system. Despite the success of mechanics, Newton himself remained puzzled by another phenomenon: electricity and magnetism. He contends that:

> He who investigates the laws and effects of electric forces with the same success and certainty will promote philosophy [i.e., natural philosophy] even if perhaps he does not know the cause of these forces. First, the phenomena should be observed, then their proximate causes – and afterwards the causes of the causes – should be investigated, and finally it will be possible to come down from the causes of causes (established by phenomena) to their effects, by arguing a priori.[55]

Although electricity and magnetism have not attracted special attention from philosophers, these phenomena created a new metaphysical puzzle. Not only was reality made of material particles in motion, but also these particles were charged with electric power. The motion of a charged particle created magnetic fields. These phenomena introduced, in addition to mechanics, a new field in physics: electromagnetism. According to Frederic E. Brasch:

> various other physical concepts of the nature of force at attraction and inertia were developed by William Gilbert (1544-1603). He assumed that motion and attraction were due to magnetic-electrical phenomena.[56]

An electromagnetic model, although it was not considered as a revolution in itself, brought a new understanding of matter. It somehow complemented Newton's mechanical understanding of reality in terms of "matter in motion". The charged particle did not only explain the puzzling phenomenon of action at distance, but also brought a new understanding of phenomena such as light and heat. Charged particles could not only attract or repel each other, but moving these particles could create electromagnetic fields. An electromagnetic model created a redefinition of the notion of force no longer only in terms of matter and motion, but in terms of electric charges, electromagnetic fields and new phenomena such as radiation. Although electromagnetic phenomena have been widely used in engineering and in the manufacturing of various tools in modern society, they have received relatively little attention from philosophy.

4. Cybernetics: Complexity, Dynamism, Control, and Integration

An electromagnetic model has, to the best of my knowledge, never been proposed as a *weltanschauung* very explicitly before. The revolutionary character of its development has remained unnoticed by philosophers to the extent that even some contemporary philosophers continue to think in terms of objects (material bodies) and ideas (their representation). One possible explanation of this neglect is that electromagnetism can be integrated into mechanics by arguing that electricity can be defined as motion of electrons or ions. However, there is an emerging paradigm shift, to which various academic disciplines have pointed. For instance, Prigogine and Stengers have pointed out that "today interest is shifting from substance to relation, to communication, to time"[57]. At the same time, Drucker has postulated a multidimensional change characterized by *The New Realities in Government and Politics, in Economics and Business, in Society and World View*.[58] Another voice that has begged for a paradigm change is Richard Bernstein, who has called for a *New Constellation.*[59] However, it is Henry C. Mishkoff who has given the concept of cybernetics its status as a new *weltanschauung* in the tribute of his book on artificial intelligence. According to Mishkoff:

> Norbert Wiener is best known for developing a new approach to understanding the workings of the universe. Since the time of Newton, scientists have concentrated on an energy model, explaining events and processes in terms of the transfer of energy. Wiener suggested a model that has proven to be extremely valuable in understanding computers as well as people – he suggested that the transfer of information rather than energy is the best way to model different kinds of scientific phenomena. Cybernetics was the name Wiener used both to describe his informational approach and to entitle his 1948 book on the subject.[60]

The concept of cybernetics may be new, but the phenomenon it describes is not. Before Wiener, Whitehead stressed "organism", Hartshorne "social", and Progogine and Stengers stressed both "relation" and "process". These are implicit ways, in my view, of expressing the complexity and dynamism that are at the heart of the cybernetic model. Cybernetics has not been accepted immediately in the scientific community. In the beginning, it has been considered as belonging to the esoteric jargon of highly skilled mathematicians given its origins at the Massachusetts Institute of Technology.[61] As K. M. Syre warns us, the concept of cybernetics has come a long way. Before its general acceptance, it had competing or substituting concepts that, instead of overcrowding it, revealed its intrinsic link with information science and its richness. In his 1967 article "Philosophy and Cybernetics", Syre notes that:

> The term 'cybernetics' has not been universally accepted by mathematicians and engineers in this country, who often prefer to speak instead of information theory or of the theory of feedback and control. The use of the term here does not reflect a decision one way or another regarding those issues which incline many specialists from adopting 'cybernetics' as a technical term.[62]

The concept of cybernetics, like any other encompassing concept, refers to such wide and different areas of reality that it is not easy to define. For example, its mechanical counterpart defines reality as "matter in motion" and hence, insists on the transmission of energy. We can also describe how mechanical principles apply to machinery, in body functions, such as the understanding of speech as the movement of the tongue in the mouth, dying as the impossibility of motions including the motion of blood in vessels, the motion of air in the lungs, or economics as the motion of goods and services between sellers and buyers (the notion of "financial flow" attests to this). The same wide areas of application are available for the concept of cybernetics. According to the inventor of the concept himself:

> Since the end of World War II, I have been working on the many ramifications of the theory of messages. Besides the electrical engineering theory of transmission of messages, there is a larger field which includes not only the study of language but the study of messages as a means of controlling machinery and society, the development of computing machines and other such automata, certain reflections upon psychology and the nervous system, and a tentative theory of scientific method. This larger theory is a probabilistic theory … Until recently, there was no existing word for this complex of ideas, and in order to embrace the whole field by a single term, I felt constrained to invent one. Hence "Cybernetics", which I derived from the Greek word *kubernetes*, for "steersman", the same Greek word from which we eventually derive our word "governor".[63]

Hence, from the subtitle of the book where the founder of cybernetics has systematically exposed this concept, we can define cybernetics as the science of "control and communication, in the machine and the animal"[64]. The encompassing character of the concept of cybernetics creates a situation where, as Syre warns us, "there is no recognized philosophic theory or school that could properly be termed cybernetics"[65]. The reason for this is that "cybernetics stands to the real machine – electronic, mechanical, neural, or economic – much as geometry stands to a real object in our terrestrial space"[66]. In other words, cybernetics is not a form of description or a separate theory, but a framework through which the functioning of both natural and artificial machines can be understood. According to Ashby:

> it (cybernetics) treats, not things, but *ways of behaving*. It does not ask "what *is* this thing" but *"what does it do?"* Thus it is very interested in such a statement as "this variable is undergoing simple harmonic oscillation", and is much less concerned with whether the variable is the position of a point on a wheel, or a potential in an electric circuit. It is thus essentially functional and behaviouristic.[67]

This clarification by Ashby confirms Neville Moray's definition of cybernetics as the study of the behavior of systems of all kinds. It is the science of "input" and "output".[68] This shift introduces a double dynamism. On the one hand, it requires us to study and understand not the invariant characteristics associated with structure, but the variable ones that are associated with behavior. Therefore, while modern science has shifted our focus from the study of nature (ontology) to the study of structure, cybernetics invites us to shift from the study of structure to the study of behavior, and behavior implies change or difference. For this reason Ashby points out that:

> the most fundamental concept in cybernetics is that of "difference", either that two things are recognizably different or that one thing has changed with time … All the changes that may occur with time are naturally included, for when plants grow and planets age and machines move, some change from one state to another is implicit. So our first task will be to develop this concept of "change", not only making it more precise but making it richer, converting it to a form that experience has shown to be necessary if significant developments are to be made.[69]

On the other hand, change effected at one end of the behaving system is transmitted to other parts of the system or to its environment. Therefore, change does not occur merely within the system, but the system is both an object and an agent of change. In other words, cybernetics is not only interested in the way both internal and external factors change a given system, but also in how this system transmits the change to its environment. This double dynamism points to another aspect of cybernetics, namely the study of "input" and "output".[70] Not only is the system acted upon by its environment, but it also acts itself on its environment. This capacity to be acted on or to receive inputs and the capacity to generate an output create a situation where the system loses its invariant character and is subject to complex processes of change that are triggered by both internal and external factors. Hence, “a system is a set of attributes and the history of the changes of that set of attributes”[71].

Being a set of attributes and the history of that set of attributes, any system basically presupposes some complexity. This complexity is brought by the fact that, on the one hand, in order to make a system one must bring several entities or attributes together, and on the other hand, not only these entities, but also their various relations are subject to change over time. Hence, adopting cybernetics as a *weltanschauung* implies what Nicholas Rescher calls “the complexity of the real”[72]. Acknowledging the complexity of the real invites our proceeding in a way opposed to that of traditional metaphysics and philosophy of science, which attempted to understand reality by reducing it to its fundamental constituents. Hence, both traditional metaphysics and the philosophy of science subscribed implicitly to the simplicity of the principles underlying reality, whether they were considered as simple particles (atoms or monads), elements (water, fire) or principles (change, permanence, contrast, or the indeterminate). The complexity of the real then requires the acknowledgement that the world is complex at the various levels of our understanding both in its constituents and in its processes. The number of chemical elements that modern chemistry has identified and presented in the periodical table, for instance, attests to this fact. Moreover, advances in science have proved that both non-living and living beings are complex both at the atomic and the genetic levels although these levels used to be considered as fundamental keys to the of understanding reality.

The complexity of the real becomes more evident with the various patterns of organization and interaction of elements and entities that can be aggregated to form complex beings or are involved in various relations, be they spatio-temporal, exchanges of various forms of energy, or various possibilities of transformation given both external and internal factors.The degree of complexity can be so high to the extent that some philosophers and scientists have started to question the ideas of simplicity, order, and regularity, which found modern physics. There is increasing literature that claims that reality, at least in some of its aspects, is chaotic. This chaotic aspect has been studied to the extent that some scientists have attempted to find its mathematical formulation especially by pushing the variables of functions, which are otherwise simple when their computation is kept in 'normal' limits, beyond certain limits. The distinction Alvin Toffler makes when he assesses Progogine and Stengers' ways of thinking is worth noting. In their view:

> Summed and amplified, they hold that while some parts of the universe may operate like machines, these are closed systems, at best form only a small part of the physical universe. Most phenomena of interest to us are, in fact, open systems, exchanging energy or matter [one may add information] with their environment. Surely biological and social systems are open, which means that the attempt to understand them in mechanistic terms is doomed to failure.
>
> This suggests, moreover, that most of reality instead of being orderly, stable, and equilibrial, is seething and bubbling with change, disorder, process.[73]

The link between cybernetics and the info-computational model of knowledge, which we are developing in this thesi is based on the possibility that if we consider reality as behaving systems, we can acknowledge the basic principle of reality as information. At this level, the notion of information can be defined by opposing it to its contrary, namely entropy. According to Wiener, the founder of cybernetics:

> The notion of the amount of information attaches itself very naturally to a classical notion in statistical mechanics: that of *entropy*. Just as the amount of information in a system is a measure of its degree of organization, so is the entropy of a system is a measure of its degree of disorganization; and the one is simply the opposite of the other.[74]

One implication of this description of information is that the absence of information would lead to infinite entropy and hence, to total chaos and meaninglessness. Thus, simple, regular, and orderly systems like those based on mechanics can be understood as having a bigger "amount of information" than their complex, irregular, and somehow chaotic counterparts.

This notion of information leads to "a statistical theory of the *amount of information*, in which the unit amount of information was transmitted as a single decision between equally probable alternatives"[75]. Associated with this concept of information is the notion of message. Wiener, narrating how he has managed to identify cybernetics as a new model of reality, notes that:

> the problems of control engineering and of communication engineering were inseparable, and that they centered not around the technique of electrical engineering but around the much more fundamental notion of the message, whether this should be transmitted by electrical, mechanical, or nervous means. The message is a **discrete** or **continuous** sequence of measurable events distributed in time – precisely what is called time series in statistical mechanics.[76]

The notion of information understood as negative entropy introduces an understanding of reality not only as complex, but also dynamic. Many systems, be they natural or artificial, are embedded in these two principles that determine their "degree of organization". However, systems remain organized as long as their complexity and their dynamism are limited. The limiting factor is a certain feedback that does not allow certain parameters of the system to go beyond certain limits without destroying the system itself. According to Syre, for instance:

> A star at midlife is balanced thermally by negative feedback between forces of gravity and of radiation. On earth, life is an energy exchange between environment and organism, regulated by processes of negative feedback. With respect to reproductive groups, these processes are known as natural selection. In the individual organism they are known as learning, and in the organism's nervous system as perception and consciousness. [77]

In other words:

> Feedback is basic to all life processes. But feedback is a form of information exchange. The fundamental category of life is information, in the technical sense of communication theory. The task of this book is to exhibit man in his organic and mental functions as a natural outcome of these informational processes.[78]

Although Wiener had applied the notion of feedback to mechanical systems he realized that this notion has wide areas of application both in human action and in social organization. In his view, "an extremely important factor in voluntary action is what the control engineers term *feedback*"[79] given the fact that:

> when we desire a motion to follow a given pattern the difference between this pattern and the actually performed motion is used as input to cause the part regulated to move in such a way as to bring its motion closer to that given pattern.[80]

Wiener himself observed the phenomenon of feedback in the nervous system during an experiment he performed on a cat[81] and found other examples as well, such as the thermostat, which regulates the temperature in a house[82], the governor of a steam engine[83], the way we drive a car on an icy road, animal and human reflex action[84], and the recognition of patterns by human senses, such as vision.[85] Concerning the way we drive a car on an icy road, for instance, Wiener notes that:

> Our entire conduct depends on knowledge of the slipperiness of the road surface, that is, on a knowledge of the performance of the system car-road. If we wait to find this by the ordinary performance of the system, we shall discover ourselves in a skid before we know it. We thus give to the steering wheel a succession of small, fast impulses, not enough to throw the car into a major skid but quite enough to report to our kinesthetic sense whether the car is in danger of skidding, and we regulate our method of steering accordingly.[86]

He generalizes this process as follows:

> This method of control, which we may call control by informative feedback, is not difficult to schematize into a mechanical form and may well be worth while employing in practice. We have a compensator to our effector, and this compensator has a characteristic which may be varied from outside. We superimpose on the incoming message a weak high-frequency input and take off the output of the effector a partial output of the same high frequency, separated from the rest of the output by an appropriate filter. We explore the amplitude-phase relations of the high-frequency output to the input in order to obtain the performance characteristics of the effector. On the basis of this, we modify in the appropriate sense the characteristics of the compensator.[87]

The generalization of the information model of reality as embedded in cybernetics is not far fetched. Cybernetics not only has found a wide audience in various academic disciplines, but its applications have also been wide-ranging. The theory of cybernetics has been accepted in disciplines such as systems sciences, control sciences, information sciences, psychology, linguistics, and biology. As a new paradigm, cybernetics has been applied in biology, psychology and education, social sciences, health care, management and organization, engineering, linguistics, artificial intelligence, global planning, and the forecasting of the future.[88] In the ongoing studies of human brains motivated both by the application of theories of measurement of intelligence at the workplace and research in artificial intelligence, Wiener, J. P. Schade and other collaborators have studied in detail the “cybernetics of the nervous system”[89] while Vladimir H. Brix has elevated this concept to a “metaphysical” level by contending that “all is cybernetics”[90]. Wiener has also generalized this notion beyond his original area of academic interest, namely from mathematics and engineering to the social sciences. According to Wiener:

> It is certainly true that the social system is an organization like the individual, that it is bound together by a system of communication, and that it has a dynamics in which circular processes of a feedback nature play an important part. This is true, both in the general fields of anthropology and sociology and in the more specific field of economics; and in the very important work … of von Neumann and Morgenstern the theory of games enters into this range of ideas.[91]

C. KNOWING AS INFORMATION PROCESSING

1. Knowledge as a Factor of Information

In the tradition dominated by normative epistemology, both epistemologists and philosophers of science have, at least implicitly, assumed an invariant element. For the philosopher of science, this invariant element is the universal laws embedded in the order of things and can be identified by science and then represented mathematically through formulations and relations that are universally (always and everywhere) valid. For the epistemologist, this invariant element is the human mind, which, by following proper methods, can access truth and is then capable of formulating knowledge as opposed to mere opinion. The first assumption is implicit in the increasing mathematization of every discipline that claims the status of science. As Philip J. Davis and Reuben Hersh remind us:

> Mathematization is upheld as the only way for a field of study to attain the rank of a science. Mathematization means formalization, casting the field of study into axiomatic mode and thereby, it is supposed, purging it of the taint of rhetoric, of the lawyery tricks used by those who are unable to let the facts and logic speak for themselves.[92]

In other instances, this search for an invariant element is manifested in the control of elements that are not examined according to the principle of *caeteris paribus* (or all other things kept equal). The second principle is found in texts by authors who oppose some aspects of normative epistemology, but who are not radical enough to question its foundations or to provide alternatives. They remain entrapped by the search for a fixed frame of reference which they do not find in the order of things, but in the knower. This is also the case for Pandit, for example, who assumes that the knowing subject is the fixed frame of reference. In Pandit's words:

> Thus in the subjective context, I took 'I know that *p*' as (expressing) a K-claim in its own right as much as "S knows that *q*'; each invariably involving the presumption of the knowing subject as a fixed frame of reference.[93]

The informational model of epistemology is a logical consequence of the cybernetic model that we have introduced previously as its metaphysical ground. This approach recognizes a double dynamism that occurs both in the knower and in the object of knowledge. Its basis is the acknowledgement of the complexity and the dynamism of both the knower (the subject) and the known (the object). Hence, the information model of knowledge recognizes that both the knower and the object known are "behaving systems" and then shifts from the study of knowledge understood as an end product to the study of the process of knowing understood as an activity of the knower. Philosophers of knowledge now investigate what is human knowing in this context of dynamism and complexity, and what is the role of an information-based framework in this process. From the definition of "the amount of information" as an organizing principle by Wiener, the founder of cybernetics, and its unit of measurement as what is transmitted as a single decision between equally probable alternatives[94], we are introduced to a metaphysics of alternatives where the invariant element assumed by normative epistemology is replaced by a probabilistic element. This probabilistic element creates a situation where the process of knowing does not aim at certainty, but at wisdom according to the etymological definition of philosophy as “the love of wisdom”. Although the links between this shift from an invariant to a probabilistic element may not be directly evident, this element creates a situation where the knower is not a passive contemplator of reality, but an active participant in the creation of value and meaning. Hence, the metaphysics of alternatives, which is postulated at the elementary level of the measurement of the amount of information, can be elevated to the cognitive level by considering the knower not only as an information processor, but also an information provider, and an information evaluator. Hence, whereas normative epistemology aims at establishing “clear and distinct” representations of objects in terms of sensations (empiricism) or ideas (rationalism), the information model of knowledge aims at capturing the dynamism embedded both in the knower and in the object of knowledge and ordering them into a valuable and meaningful process. Therefore, instead of defining knowledge as true justified beliefs or the acquisition of accurate representations that lead to certainty, we can define knowledge as a factor of information. According to Peter Drucker:

> Knowledge is information that changes something or somebody – either by becoming grounds for action, or by making an individual (or an institution) capable of different and more effective actions.[95]

This definition remains unclear as, in the common parlance, the concept of information is often overclouded or even replaced by another related concept, namely the concept of data. However, Robert Schultheis and Mary Sumner have pointed out:

> data and information differ. *Data* are the individual elements of a transaction, such as item number, item quality, and price on a sales order transaction. Information, on the other hand, is data with meaning for decision-making.[96]

In other words, from a cognitive point of view, information is data enriched with value and meaning for the purpose of decision-making and problem-solving. This definition of knowledge then transcends the model suggested by normative epistemology that reduces knowing to perceiving or thinking, which is only accessing data. It acknowledges that the knower receives a wide variety of data with different senses, but the process of knowing does not take place unless these data is processed. Processing, then, is enriching data with value and meaning and organizing it according to purposes. Hence, in addition to accessing data through immediate experience, by understanding data the knower enriches it with meaning and by judging data the knower enriches it with value. By experiencing data, the knower codes it in various forms of representations and patterns, but this does not yet make data meaningful. Meaning is created when new data is integrated into an already existing conceptual framework that links the new data with past experiences, challenges, and opportunities of the present and expectations of the future. Only when accessing and understanding data leads to what Lonergan calls insight, then meaning is created. According to Lonergan:

> By insight…is meant not any act of attention or advertence or memory but the supervening act of understanding. It is not any recondite intuition but the familiar event that occurs easily and frequently in the moderately intelligent, rarely and with difficulty only in the very stupid. In itself it is so simple and obvious that it seems to merit the little attention that commonly it receives. At the same time, its function in cognitional activity is so central that to grasp it in its conditions, its workings, and its results, is to confer a basic yet startling unity on the whole field of human inquiry and human opinion.[97]

In other words, according to the analogy of the detective with which the preface to *Insight* begins, insight does not solve problems through "the mere apprehension of any clue"[98] or "the mere memory of all", but through "a quite distinct activity of organizing intelligence that places the full set of clues in a unique explanatory perspective"[99].

However, the process of human knowing does not limit itself to enriching data with meaning. This process leads to a second stage where the knower enriches data with value. It is at this stage that the knower distinguishes between what is relevant and what is irrelevant, what is important and what is trivial. At this stage, the knower uses both implicit and explicit principles and values as yardsticks to select what is meaningful and to notice what may require inquiry. Hence, the process of knowing is intrinsically selective as not all the data that presents itself to the knower is meaningful or valuable.

2. Knowing as a Dynamic and Integrative Process

Lonergan is of the view that the human mind acts at four differentiated, but integrated levels of consciousness. The idea of knowing as thinking defended by normative epistemology reduces the whole process of knowing to its second level, that of understanding. This polymorphic character of human knowing, according to Lonergan, is linked to the very nature of human consciousness. Whereas normative epistemology has presented consciousness as a "container" and knowledge as "contents of consciousness", Lonergan presents consciousness as a multidimensional and a multilevel activity. According to Lonergan:

> Different levels of consciousness and intentionality have to be distinguished. In our dream states consciousness and intentionality commonly are fragmentary and incoherent. When we awake, they take on a different hue to expand on four successive, related, but qualitatively different levels. There is the *empirical* level on which we sense, perceive, imagine, feel, speak, move. There is an *intellectual* level on which we inquire, come to understand, express what we have understood, work out the presuppositions and implications of our expression. There is the *rational* level on which we reflect, marshal the evidence, pass judgment on the truth or falsity, certainty or probability, of a statement. There is the *responsible* level on which we are concerned with ourselves, our own operations, our goals, and so deliberate about possible courses of action, evaluate them, decide, and carry out our decisions.[100]

In brief, our information-based model of human knowing can be summarized as follows:

Operation/ Activity	Greek Equivalent	Level of Consciousness	Achievement	Proponent School of Thought	Method
Experiencing	*Pathos*	Empirical	Representations (data)	Empiricism	Phenomenology
Understanding	*Logos*	Intellectual	Meaning	Rationalism	Analytic
Judging Evaluating	*Ethos*	Rational	Value	Critical Realism	Critical
Deciding Acting	*Praxis*	Responsible	Purpose	Pragmatism	Experimental

According to the informational model, knowledge is oriented towards action. Therefore, this model corrects the modern reduction of knowledge to thought and rationality to intellectual activity. It calls for the recognition that knowing is multifaceted and occurs at different levels of consciousness. Hugo Meynell points out rightly that:

> [n]ow empiricism and materialism both presuppose, in their different ways, that it is only experience, and not the whole process of experience, understanding, and judgment, which actually puts us in touch with the real world; real knowledge of the real world, for these philosophies, is fundamentally a matter of taking a look at what is open for inspection rather than inquiring intelligently and reflecting reasonably.[101]

Meynell's remark brings to our attention the central Lonerganian idea that knowing is not a single and separate event, but an integrative and iterative process of experiencing, understanding, judging [and I will add acting].[102] This implies that knowing cannot be reduced to a simple, static, invariable, or universal relation between the knower and the known. It is a complex process that integrates operations such as seeing, hearing, touching, smelling, tasting, inquiring, imagining, understanding, conceiving, formulating, reflecting, marshalling and weighing evidence, judging, deliberating, evaluating, deciding, speaking, writing [and reading].[103] The appreciation of this complexity corroborates the previous view that knowing is essentially an activity of the knower and that the knower is not a *tabula rasa*, but a creator of meaning given the knower's situation as an embodiment of past memories, challenges, and opportunities in the present and expectations of the future (both real and imaginary or illusory). Moreover, the knower is not isolated, but is involved in intricate and complex networks of relationships, which not only define the knower as a person, but also provide a substratum for the knower's activity through the creation of different systems of valuation where an economy of meanings occurs. In this respect knowing is contextual and intersubjective.

The recognition that knowing is not a single-level activity is full of consequences. It demonstrates that different epistemological schools, such as empiricism and rationalism, are not to be opposed since they focus on two different stages on one continuum. Whereas empiricism reduces knowing to experiencing, rationalism makes the same mistake by reducing knowing to its intellectual dimension, namely understanding. It becomes clear that various theories and positions that have been opposed make the mistake of considering themselves as wholes, whereas they are different and complementary parts of one process. Their claim to be absolutely true, total, and definitive is rooted in a discriminatory either/or pattern of truth and falsity, which deprives the intermediate positions of incomplete truth. This leads consciously or unconsciously to the ignorance or the neglect of the fact that there is a continuum of doubts, incomplete meanings, and unfinished inquiries between truth and falsity.

The same reduction is found in various schools that have dominated contemporary philosophy – namely phenomenology, analytic philosophy, critical theory, and pragmatism. The remedy to this neglect or ignorance is the recognition that knowing is a multidimensional activity that occurs at different levels of consciousness.These four operations show that the great limitation of phenomenology, analytic philosophy, critical theory, and pragmatism is that they consider themselves as wholes although they are parts of one, but multifaceted process. All these philosophic disciplines reduce knowing to a single-level activity, which creates a fragmented philosophical landscape with irreconcilable dualisms. For instance, phenomenology reduces knowing to experiencing and discards important intellectual activities, such as abstraction, calculation, classification, and formalization; analytic philosophy reduces knowing to understanding and creates a contempt for some important sources of immediate data, such as senses and emotions, while it marginalizes ethical principles and aesthetic values as epistemologically unworthy since they do not meet the canons of rationality established by modern science. Critical theory reduces knowing to judging according to one of society's definitions of the good life. It reintroduces ethical concerns, as for instance, conforming of the individual to social norms and institutions. However, it does not leave enough room for the possibility of social change based on a redefinition of what good life is by rebels who are capable of turning the existing social order upside down, reformers who call for timed and progressive change, and charismatic leaders who create new ideals and draw society to a new way of understanding itself. Moreover, critical theory does not account for mutual communication of information between societies through different patterns of exchange including material goods, artefacts, movements of people, and different processes of cultural influence. Pragmatism, by reducing knowing to acting, creates a sort of social engineering that may reduce persons to entities that are malleable and that can be moulded in one's understanding of what an ideal human community is thought to be. In this way, pragmatism does not account for aspects that are recognized as uniquely human, such as freedom and autonomy. Not only can people act on the world, but the world also acts on them. There is a process of mutual influence in a give and take fashion that amounts to a two-way information cycle. Understanding knowing as a fourfold process that integrates experiencing, understanding, judging, and acting puts the four schools together and calls for a dynamic and integrative theory of human knowing that emphasizes different levels of consciousness and that bridges the opposition bred by the search for fixity and its concomitant discontent. This search for a permanent foundation of what is valid and valuable knowledge has been conceptualized by Bernstein as objectivism. This school of thought seems to proclaim, in an apodictic fashion, the impossibility of knowledge and value outside its own horizon. As Bernstein notes, objectivism involves:

> an underlying belief that in the final analysis the only viable alternatives open to us are *either* some form of objectivism, foundationalism, ultimate grounding of knowledge, science, philosophy, and language, *or* that we are ineluctably led to relativism, skepticism, historicism, and nihilism.[104]

The information model of knowledge can be an antidote to the fragmentation of the philosophical landscape by acknowledging that human knowing is a multilevel process and by highlighting each operation at its proper place in the whole process. This new synthesis of knowledge demands an integration of the conceptual and the analytical model that dominated classical science with an experiential and synthetic model. In my view, this model based on information will lead to a more complete and comprehensive understanding of reality, which integrates elements of our experiencing, understanding, judging, and deciding. On the one hand, this model of the process of knowing integrates various forms of knowledge, namely emotional, intellectual, ethical, and practical or behavioral knowledge; and on the other hand, it overcomes some deep embedded dichotomies linked with the opposition of operations and framework. This model, instead of opposing reason to emotion, ideas to sensations, theory to practice, and perception to thought, can locate these activities on one continuum. In other words, instead of being an epistemology of oppositions, the information-based model of knowing creates an epistemology of successions.

The information-based model of human knowing that we are suggesting implies then that knowing is polymorphic.[105] This acknowledgement is an antidote to a certain reductionism that limits human rationality to its intellectual dimension, thus reducing knowing to thinking. Knowing has experiential, intellectual, judgmental, and pragmatic dimensions. In fact, even scientists do not always appeal to scientific principles when they do not practise their profession. Lonergan is right to point out that "[t]he occurrence of insight is not restricted to the minds of mathematicians, when doing mathematics, and to the minds of physicists, when engaged in that department of science"[106]. The reason for this is that since scientists carry on the cores of daily life, they appeal to a level of consciousness that is different from the intellectual level, which is essentially logico-deductive.[107] In fact, Lonergan points out again that "one meets intelligence in every walk of life" and various professions such as farming, technical work and mechanics, medicine and law practice, politics and diplomacy are not devoid of insight merely because they are not mathematical and logico-deductive.[108] Professions that are remote from physics (which is presented as “the” model of modern science), appeal to a great degree of intelligence. As there is insight in mathematics and physics, there is also insight in industry and commerce, finance and taxation, journalism and public relations. This is the case even in the sphere of private life, the home and friendship, conversation and sports, arts and entertainment. One may wonder, for instance, whether living together with a person of the opposite sex (a woman in my case), scoring a goal, or raising children requires less intelligence than solving equations and making logical inferences. For Lonergan, “[i]n every case, the man or woman of intelligence is marked by greater readiness in catching on, in getting the point, in seeing the issue, in grasping implications, in acquiring know-how”[109].

Thinking is only one aspect of the process of human knowing. It has to be complemented by other human operations, such as making accurate observations when perceiving objects or events, integrating new data in a pre-existing conceptual scheme, making inferences, and establishing meaningful and valuable connections within and between wide and various sets of data, making reasonable decisions, and carrying on effective actions. The information-based model of human knowing requires a dynamic and integrative model of rationality. This idea of a dynamic and integrative model of rationality is based not only on the fact that knowing is polymorphic and that the process of knowing is multidimensional, but also on the fact that reason is not as autonomous as normative epistemology postulates. In a real process of knowing, objectivity and universality can be hindered by both internal and external elements. If the human person is a rational animal, he or she is not rational only intellectually, but also physically, emotionally, morally, and practically. Therefore, a dynamic and integrative model of rationality gives credit to various theories of multiple intelligence and must at least include the visual, the auditory, the gustatory, the olfactory, and the tactile aspects, as well as the kinesthetic, the interactive, the rational, and the artistic aspects. A multifaceted model of rationality implies that the idea of knowing as an activity of the mind as propagated by normative epistemology should be replaced by a more encompassing idea of knowing as an activity of the whole organism.

3. Knowing as an Activity of the Knower

The scientific model of knowing requires objectivity. Therefore, the knower and his or her context must be detached from the process of knowing. Knowledge must occur on a neutral ground. However, the appreciation of the complexity identified in the previous subsection shows that knowing is an activity of the knower. The knower cannot be detached as he or she is not a *tabula rasa*. The knower is an embodiment of past memories, challenges, and opportunities in the present and expectations of the future (both real and imaginary or illusory). Moreover, the knower is involved in intricate and complex networks of relationships. These relationships not only define him or her as a person, but also provide a substratum for his or her knowing activity. As a member of a human community, the knower is committed to various systems of values and meanings. These systems constitute a conceptual framework where an economy of meanings constitutes the lieu where the production, the supply, and the demand of knowledge occur. In this respect, knowing is contextual and intersubjective.

Therefore, the idea that knowledge is "the possession of accurate representations of an object"[110] is too limited. This view is based on a particular understanding of philosophy that emerged in the seventeenth century, according to which "[p]hilosophy should provide a permanent matrix of categories into which every possible empirical discovery and cultural development can be fitted"[111]. This search for a permanent matrix was emphasized by the scientific quest for objectivity and universality. Therefore, it relegated the role of the knower to the periphery. The historicity of this approach needs to be acknowledged. As Rorty notes again:

> To think of knowledge which presents a "problem" and about which we ought to have a "theory", is a product of viewing knowledge as assemblage of representations [...] as a product of the seventeenth century.[112]

This approach to philosophy in general and epistemology in particular has created difficult problems, such as the problem of other minds, and the problem of the existence of the external world. Moreover, the idea of knowing as having representations has reduced knowledge to factual knowledge. In the long run, it created the image that intellectual knowledge is more perfect than common sense and feeling. Later, the belief in the autonomy of reason made abstraction a criterion of purity and perfection of knowledge. This reductionist approach was based on the belief that knowledge can be a simple, static, invariable, or universal relation between consciousness and reality. In fact:

> The notion of knowledge as the assemblage of representations is optional [...] it may be replaced by a pragmatist conception of knowledge which eliminates the Greek contrast between contemplation and action, between representing the world and coping with it.[113]

Therefore, Lonergan's identification of different levels of consciousness posits an active and dynamic subject. This subject integrates the external data brought by his or her empirical capacities into the inner dimensions of his or her inquiring, understanding, abstracting, and generalizing capacities. Michael Polanyi has corroborated this view when he notes that:

> Knowing is an active comprehension of things known, an action that requires skills. Skilful knowing and doing is achieved by subordinating a set of particulars, as clues or tools, to the shaping of a skilful achievement whether practical or theoretical.[114]

In other words, knowing is not done by brains in a vat, as Putnam hypothetically assumes. It is done by a dynamic subject endowed with judgement capabilities, not in a passive contemplation of truth, but in an active search for truth. This search occurs in the context of complex realities where the knower struggles to lead a meaningful life by satisfying a wide range of needs (both material and non material) against the background of moral values and changing patterns of culture, economics, society, politics, and religion. In brief, Lonergan's dynamic and integrative theory of knowing not only takes into account the changes that occur in the known, but also those that occur in the knower. In Lonergan's words:

> The operations then not only intend objects. There is to them a further psychological dimension. They occur consciously and by them the operating subject is conscious. Just as operations by their intentionality make objects present to the subject, so also by consciousness they make the operating subject present to himself.[115]

This double presence is an additional feature of Lonergan's understanding of knowledge as self-appropriation through the active self-affirmation of the knower, which is, in fact, a prerequisite condition for "the possibility of judgements of facts"[116].

4. Knowing as Self-Appropriation

The scientific model, in search of objectivity and universality, excludes the knower. Knowledge is meant to be universal, impersonal, and absolute. This approach ignores that knowing does not only change the known, but also the knower. The knower, in fact, is capable of learning and creativity. In other words, the knower is not a *tabula rasa*, as Locke has assumed. Moreover, there is no detached universality awaiting to be unveiled. The kind of universality the inquiring subject can attain is a generalization of particulars. This cannot be done through repeated similar experiments looking for elements of invariance that can be established into universal laws, but through an accumulation of insights. This accumulation of insights is achieved through a dynamic, integrative, and recurrent process of experiencing, understanding, and judging. This pattern overcomes the dualisms that have plagued the various attempts to establish a definite, permanent, and universal relationship between the knower and the known.

In fact, knowing is not merely apprehending the way things relate to one another. It is inquiring the way they relate to us. This raises a need to understand the difference between "nominal definitions"[117] and "explanatory definitions"[118]. Whereas nominal definitions "merely tell us about the correct usage of names"[119], explanatory definitions "include something further that, were it not in the definition, would have to be added as a postulate"[120]. These views should not be opposed or contrasted in antagonistic fashion, for they are not fundamentally different, but rather attest to the fact that "knowing is not a single-level activity"[121]. According to Flanagan:

> [It] involves three different but functionally related sets of activities. This discovery not only explains why knowing ourselves as knowers is so difficult to achieve, but it also suggests why so many different accounts of knowing can be interpreted as part of a developing, dialectical process leading to the goal of knowing our own knowing. Once this goal is achieved we proceed to identify the different forms and objectives of specialized patterns of knowing and to integrate them into a search of a unifying objective.[122]

Hence, every knower is the fruit of a creative integration of his or her external environment and an inner disposition to know. Therefore, Lonergan's approach constitutes a change in paradigm from "classical to historical consciousness"[123]. This creative integration of the external environment and the knower's internal disposition is reflected both in the elements of insight and in the understanding of knowledge as self-appropriation.

In other words, knowing is not just establishing a simple relation between an abstract and isolated knower and an atomistic and static object. Knowing cannot be compared to a simple pattern such as the early Wittgenstein's picture theory of language since knowledge understood as self-appropriation leads inevitably to:

> The effort to give an account of the invariant dynamic structure of conscious intentionality with immanent criteria of objectivity, truth, reality, and value. But, still more importantly, it is taking reflective possession of oneself as constituted fundamentally by operative, preconceptual, prelinguistic criteria of knowledge, objectivity, truth, reality and value.[124]

In other words:

> Self-appropriation is radically different from the Cartesian strategy of cutting oneself off from external objects in order to find oneself in the internal remainder. Self-appropriation is not disengagement from the world of subjects but development of an understanding of oneself in the widest possible range of cognitive and moral engagements. The criteria immanent in interior operations cannot be discovered unless the interior operations occur. Accordingly, Lonergan deliberately provides opportunities in *Insight* for his readers to catch themselves in the act of performing cognitional operations – experience themselves questioning, imagining, having insights, reflecting on the correctness of their insights, and making judgements.[125]

The demands for objectivity and universality embedded in the project of normative epistemology require a hypostatized knower. This knower is the contemplator of "pure forms" and merely uses one faculty, "pure reason". However, the double dynamism found in the cybernetic model of reality and in the information-based model of human knowing that we are advocating postulates a more modest idea of the knower. The knower, like any ordinary person, is not a passive spectator of an unfolding reality, which meets his or her rationality to reveal its true nature. The role of the knower then is not merely to observe the universe, to understand the intricacies of the laws of its workings, and to formulate them in necessary propositions. The knower is, like any other human being, confronted with a wide range of data, with both its clarity and ambiguities in a world where the knower struggles to satisfy his or her needs and to maximize his or her capabilities. In other words, the knower is an "incarnate subject". In Lonergan's words:

> That dimension is the constitutive role of meaning in human living. It is the fact that acts of meaning inform human living, that such acts proceed from a free and responsible subject incarnate, that meanings differ from nation to nation, from culture to culture, and that, over time, they develop and go astray. Besides the meanings by which man apprehends nature and the meanings by which he transforms it, there are the meanings by which he thinks out the possibilities of his own living and makes his choice among them. In this realm of freedom and creativity, of solidarity and responsibility, of dazzling achievement and pitiable madness, there ever occurs man's making of man.[126]

The informational model, by bringing back the knower to the center of the knowing processes, recognizes that knowing is a multifaceted activity. By inquiring intelligently and reflecting reasonably, the knower is paradoxically involved in processes of integration and discrimination that identify similarities and differences and establish criteria not only for truth, but also for valid and valuable knowledge. This permanent tension requires vigilance, but also integration. The attempt to reduce knowing to a single level leads to a conflict between different binary opposites, such as objects and ideas, practice and theory, the particular and the universal, the concrete and the abstract, facts and principles, rules and values, the accidental and the essential, the dynamic and the static, the contingent and the necessary, the emotional and the intellectual, the analytic and the synthetic, the real and the ideal, and the perceptual and the conceptual. These oppositions are due to the fact that various schools of thought consider themselves as wholes while they are only parts of one, but multifaceted process. For instance, whereas empiricism reduces knowing to experience, rationalism, in its crude version, reduces knowing to thought. The explicit idea that knowledge is aimed at action reintroduces the concept of finality or final cause or purpose into epistemology. This is a challenge to normative epistemology's predilection for knowledge for its own sake and also to the idea that knowledge is value-free.

Hence, the information-based model of human knowing, instead of isolating the knower, makes the knower the center of the epistemological process. There cannot be any process of information processing without an information processor. Likewise, there cannot be any process of knowing without a knower. Therefore, the process we have defined above only takes place if we acknowledge that knowing is, first and most of all, an activity of the knower. This appreciation of intentionality that was, at least, present in Aquinas, in some Neo-Scholastic thinkers, such as Joseph Maréchal, who influenced Lonergan and Karl Rahner, and in some pragmatists, process thinkers, and phenomenologists, brings together not only the complexity of the knower and the complexity of the object of knowledge, but also the complexity of the process of knowing itself. Therefore, in order to bring together these multilevel complexities, epistemology should not start by investigating the representation of objects in the mind, but the subject-centered process that leads to self-appropriation. In Lonergan's words:

> The beginning, then, not only is self-knowledge and self-appropriation but also a criterion for the real. If to convince oneself that knowing is understanding, one ascertains that knowing mathematics is understanding and knowing science is understanding and the knowledge of common sense is understanding, one ends up not only with a detailed account of understanding but also with a plan of what there is to be known. The many sciences lose their isolation from one another; the chasm between science and common sense is bridged; the structure of the universe proportionate to man's intellect is revealed; and as that revealed structure provides an object for a metaphysics, so the initial self-criticism provides a method for explaining how metaphysical and anti-metaphysical affirmations arise, for selecting those that are correct, and for eliminating those that patently spring from a lack of accurate self-knowledge. Further, as a metaphysics is derived from the known structure of one's knowing, so an ethics results from knowledge of the compound structure of one's knowing and doing: and as the metaphysics, so too the ethics prolongs the initial self-criticism into an explanation of the origin of ethical positions and into a criterion for passing judgment on each of them.[127]

5. The Role of Information

a) Information as an Inviting Final Cause: the Role of Purpose, Value, and Meaning

The limitations the scientific model faces when it is applied to human affairs are similar to those it faces when applied to natural phenomena. As Prigogine and Stengers have noted:

> Today we are beginning to see more clearly the limits of Newtonian rationality. A more consistent conception of science and of nature seems to be emerging. This new conception paves the way for a new unity of knowledge and culture.[128]

In fact, the application of the scientific method to human affairs is based on an important misgiving. Human interaction and social organizations cannot be reduced to materialist entities that interact mechanically. In addition to being systems and structures, they are embodiments of meaning and value. This dimension is manifested in the ability to create and communicate signs and symbols. Therefore, various areas of human interactions and different social organizations are not just material and mechanical systems. They integrate material and mechanical aspects with logical and symbolic aspects. If we call **information** the meaning and the value, then human interaction and social organization are not only mechanical processes, but also flows of information. This informational aspect of human knowing is not a random process, but it is purposeful. In this respect, information is an inviting final cause. Efficient causality as emphasized by the scientific model confines us to the question of how to attain truth. It excludes purpose and makes the question of why we aspire to attain truth irrelevant.

b) Information as a Meaningful Interaction with a Context

With the flow of information within and outside systems, the ordered and simple universe of classical science is more and more challenged. We are more and more aware that science is a specialized type of knowledge that cannot embody the whole of knowledge. The special conditions in which it occurs are different from the ordinary conditions of daily life. Moreover, the scientific dream of an objective and universal knowledge is increasingly challenged. Both the knower and the context play an active role in the process of knowing. Rescher recognizes that:

> objectivity will have to take context into account, seeing that different individuals and groups confront very different objective situations. Rationality is universal, but it is **circumstantially** universal - and objectivity with it.[129]

The recognition of the importance of the context and the knower challenges the scientific predilection for abstraction. As I noted earlier, abstraction distorts reality. This view is emphasized by Prigogine and Stengers, when they point out that:

> The progress of science has often been described in terms of rupture, as a shift from concrete experience towards a level of abstraction that is increasingly difficult to grasp. We believe that this kind of interpretation is only a reflection, at the epistemological level, of the historical situation in which classical science found itself, a consequence of its inability to include in its theoretical frame vast areas of the relationship between man and his environment.[130]

Among these “vast areas of the relationship between man and his environment” is the informational component of reality. We live in a world where natural phenomena, human behavior, organizational styles, cultural values, social structures, various living and non-living organisms can be considered as huge information processors. The universe, for instance, can be portrayed as a huge analog (not digital) computer while the human person can be more and more perceived as "being digital"[131].

c) Information as a Meaningful Interaction with Others

The kind of objectivity and universality that the scientific model stipulates violently relegates some aspects of human experience to the periphery of knowledge. For instance, that kind of objectivity and universality excludes elements of culture, context, value, and meaning. However:

> By admitting only a subjective meaning for a set of experiences men believe to be significant, science runs the risk of transforming these into the realm of the irrational, bestowing upon them formidable power.[132]

In fact, in both human interaction and social organization non-intellectual elements sometimes play a great role. In fact, the influences that stratify and structure society are not a stable equilibrium because the development of social order is not a linear process. As Lonergan has noted, "in the dialectic of community there is the operation not only of practical common sense but also of human inter-subjectivity"[133]. However, the structured narratives of the origins and the development of a given social order create the impression that "the course of social change [is]… a succession of insights, courses of action, changed situations, and fresh insights"[134]. The construction of these narratives misses the fact that "truly practical insights have to be divided into operative and inoperative"[135] ones. In fact, "the operative insights alone go into effect, for they alone either meet with no group resistance or else find favour with groups powerful enough to overcome what resistance there is"[136]. Therefore:

> [t]he social order that has been realized does not correspond to any coherently developed set of ideas. It represents the fraction of practical ideas that were made operative by their conjunction with power, the mutilated remnants of once excellent schemes that issued from the mill of compromise, the otiose structures that equip groups for their offensive and defensive activities[137].

Having these facts in mind, it becomes clear that a mathematical model of a social order is implausible. It is impossible to be established with simple rules of efficient causality and formal systems of explanation as some aspects of human interaction cannot be quantified or formalized. Moreover, social causality is so complex that, in my view, it cannot be reduced to simple mathematical relations or physical laws. Therefore, a study of human affairs that yields to the characteristics of Newton's physics or Darwin's evolution is limited. In fact, that kind of study would be inaccurate if elements of value and meaning are not taken into account.

d) Information as a Dynamic and Irregular Process

The world displays elements of instability and randomness that make the Cartesian search for "a permanent foundation for the sciences"[138] fruitless. The new understanding of reality identified above and the new types of knowledge it requires are at the heart of the paradigm shift we are investigating. Although Pagels' penchant for Darwinism is obvious, he seems to share Drucker's view that we are experiencing a "shifting knowledge base"[139]. Other philosophers, such as Gaston Bachelard, talk of the rise of a "non-Cartesian epistemology"[140], while Weizenbaum reacts against "the imperialism of instrumental reason"[141]. These views highlight an epistemological shift that will not only change our patterns of thought, but also our worldview. This worldview will lay new foundations for knowledge, value, and meaning through an integration of materialistic, mechanistic, logical, and symbolic aspects of reality.

Drucker suggests a shift from "analysis" to "perception". Although this suggestion is, in my view, limited, it unveils the limits of Cartesianism, Newtoniasm, and Darwinism. As an overall worldview, Drucker suggests the incorporation of the informational aspect in reality through the replacement of a Newtonian physical model by a biological model. In his own words:

> While it is the triumph of the analytical and conceptual model […] the computer also forces us to transcend that model. "Information" itself is indeed analytical and conceptual. But information is the organizing principle of every biological process. Life, modern biology teaches, is embodied in a "genetic code" that is, in programmed information. Indeed, the sole definition of that mysterious reality "life" that does not invoke the supernatural is that it is matter organized by information. And biological process is not analytical. In a mechanical phenomenon the whole is equal to the sum of its parts and therefore capable of being understood by analysis. Biological phenomena are however "wholes." They are different from the parts of their parts. Information is indeed conceptual but meaning is not [...].[142]

D. CONCLUSION

Normative epistemology is based on the modeling of philosophy on modern science. Therefore, normative epistemology and modern science share a certain search for truth and knowledge as expressed by "clear and distinct" ideas. However, this program, which is based on Cartesian rationalism and influenced analytic philosophy in a great way, falls short of accounting for the whole process of human knowing as it reduces knowing to merely one of its aspects, i.e. thinking. This problem is not solely epistemological, but metaphysical as well. It involves a certain conception of reality in terms of substance or universals, which imply necessity and permanence. This metaphysical model is assumed to be expressible into simple mathematical relations or rules of logical inference and conforms to the mechanical model, which defines reality in terms of matter, motion, and mechanical laws. However, this view of reality is mistaken since it reduces reality and natural laws to their invariant aspects. There is a possibility of formulating a modest dynamic and integrative epistemology, which is based on how real processes of knowing occur instead of setting an agenda of disambiguation and certainty that reduces knowledge to univocal propositions and knowing matters of fact. Taking into account the dynamic and integrative nature of human knowing implies respecting the division of linguistic labor emanating from the diversity of areas of knowledge, but also recognizing that even at the individual level knowledge is polymorph. It integrates emotional (*pathos*), intellectual (*logos*), evaluative (*ethos*), and pragmatic (*praxis*) dimensions. It includes basically four operations, i.e. experiencing, understanding, judging, and acting as the human mind operates at four levels of consciousness, namely the empirical, the intellectual, the reasonable, and the responsible. According to this dynamic and integrative model of epistemology, knowing is defined not in terms of formulating true justified beliefs, but in terms of accumulating insights by enriching the immediate data of experience with value and meaning for the purpose of decision-making and problem-solving. This definition of knowing replaces a well-entrenched conception of knowledge as representation by an alternative conception of knowledge as information processing. Knowing as information processing means that the knower is not a passive spectator of reality, but an actor, who is involved in various acts and processes of meaning generation and value creation, as the knower achieves various purposes linked with satisfying one's needs and maximizing one's abilities. This dynamic and integrative model of human knowing, therefore, requires a conceptual framework that takes into account the turbulent aspects of reality instead of trying to fix meaning and reference as a way of translating dynamic and integrative processes into a medium that led itself to univocal predication, mathematical operations, and logical inferences. This model, in my view, requires as a prerequisite a change of worldview from mechanics to cybernetics. Mechanics needs not to be eliminated, but it needs to be acknowledged that systems and processes that are as simple, ordered, and regular as mechanical systems and processes are rather special cases of cybernetic models, which are generated through fixing structure and purpose. It is fixing structure and purpose that allow the introduction of an invariant element in both natural processes and human behavior. This invariant element makes human behavior simple, ordered, and regular as fixing structure and purpose does not only involve stabilizing internal processes of change, but also isolating the system or the process from possible changes induced by the environment. In other words, by emphasizing invariant aspects as a way of looking for substance or universals, constraints are imposed on natural processes either by singling out invariant aspects or by fixing meaning or reference. There is no need to postulate a separate world of necessity made of Platonic forms, mathematical symbols and rules, or predicates and the logical calculus, but a need to acknowledge the dynamic and integrative nature of human knowing based on the *pathos* of being thrown into experience and the accumulation of insights through our interaction with our human and non-human environment. Humans are not passive spectators of reality, but active generators of meaning and value as they integrate material, mechanical, logical, and symbolic aspects into dynamic and integrative processes of human knowing. These processes appeal to substantive, structural, behavioral, and functional dimensions of the human organism, which are the custodians of empirical, intellectual, rational, and pragmatic abilities. Nor is there a need to reject the achievement of modern science or to separate science and philosophy as a way of accommodating aesthetic values and religious beliefs. Science should be understood as what it is, i.e. a coded, formalized, systematized body of knowledge, which aims at defining reality in terms of invariant aspects (universals or substance) and formulating universal laws. The risk of a scientific approach is to reduce philosophy and knowledge to certainty while philosophy as love of wisdom includes non-scientific aspects of knowledge as well. Reality can still be tackled in its complexity and dynamism using appropriate methods such as “systems thinking”.

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CHAPTER THREE

FROM THE ANALYSIS/SYNTHESIS DICHOTOMY TO SYSTEMS THINKING

A. INTRODUCTION

The paradigm shift from normative epistemology based on mechanics to a dynamic and integrative epistemology based on cybernetics calls for other paradigm shifts. These shifts do not only affect the description of reality and the articulation of knowledge, but also the methods used in the process of knowing. A mechanical model describes reality in terms of matter and/in motion, while cybernetics upholds a four dimension paradigm that includes material, mechanical, logical, and symbolic aspects. Therefore, a mechanical model looks for immutable laws that are believed to be universal and objective while a cybernetic model looks for differential laws due to the interactive nature of cybernetic systems and processes. The immutable laws that mechanics seeks are linked to the nature of causality in mechanical systems. In mechanical systems and processes the same causes lead to the same effects. However, in cybernetic systems and processes there are no causes or effects proper, but inputs and outputs. On the one hand, the level of inputs influences the level of outputs, but on the other hand, the level of outputs influences the level of inputs as in cybernetic systems and processes, when the value of outputs reaches certain thresholds, the behavior of the system and process is reversed as the threshold values activate a feedback process. Therefore, in terms of the epistemological method, there is a need to shift from the analysis/synthesis dichotomy to systems thinking. This paradigm shift is based on the fact that we can only analyze systems and processes that are analyzable. Analycity does not depend solely on the prowess of the analyst, but also on the contents (substance), the structure, the behavior, and the function (goal) of the system/process being analyzed. Analycity depends on the level of interaction of the various components of the system/process being analyzed and on its pattern of causality. Indeed, only systems and processes that follow a linear pattern of causality are analyzable because as the level of complexity of systems and processes increases through their integration with other systems and processes, they can only remain analyzable when their patterns of causality are additive; and these patterns can be additive only when they are linear, which is not the case for cybernetic systems that operate according to a differential pattern of causality. This is the case for natural cybernetic processes, such as homeostatic processes in animals or the functioning of endocrinal organs, or for non-natural cybernetic systems, such as thermostat. There have been sketches of this paradigm shift from various areas of academic interest. Whereas Drucker, for instance, suggests a shift from "analysis" to "perception", Prigogine and Stengers point out that "today interest is shifting from substance to relation, to communication, to time"[1]. Cybernetics as a metaphysical framework is a metaphysics of "organized complexity". Therefore, a worldview that has complexity at its heart implies devising means and methods that can handle complex processes and systems. The mechanical model is a special case of the cybernetic model, emanating from fixing not only inputs and outputs (the principle that the same causes generate the same effects), but also the rules of interaction. This chapter aims at suggesting a paradigm shift from the analysis/synthesis dichotomy to systems thinking. In the first section, it will present some salient aspects of the origin and the claims of the analytic method, i.e. "cutting complex systems and processes into pieces", and anti-metaphysicalism. Then, it will assess the synthetic method, especially as it is used in artifacts. The limitations of the analytic method will be pointed out, not from the points of view of its practice, but of its universal pretensions. We can only analyze systems and processes that are analyzable, i.e. mechanical systems and processes. Systems thinking will be introduced from the points of view of complexity as a major characteristic of cybernetic systems and processes. Various aspects that affect the level of complexity of a system or a process, i.e. contents (substance), structure, behavior, and goal/function will be pointed out, and salient aspects of systems thinking as a method suitable for a dynamic and integrative epistemology will be presented.

B. ANALYTIC MODELS AND METHODS

1. Cutting Systems and Processes into Pieces

The basic characteristic of an analytic method amounts to understanding complex systems and processes in terms of their components. The analytic method implies that a whole is nothing but the sum of its parts. The assumption of the analytic method is that complex systems and processes are better understood when reduced to their simpler components, until one reaches a fundamental level of basic components, such as material atoms or simple propositions. For instance, complex phenomena and processes, such as floods and earthquakes, could be understood in terms of fundamental particles, such as atoms and their rules of interaction; and the whole of human knowledge could be understood in terms of simple propositions. Although the academic divide between analytic philosophy and continental philosophy would hardly associate Descartes with the analytic method, Descartes advocated an analytic approach to thought when he stipulated in Rule 5 of his “Rules for Conducting the Mind” that:

> The whole method consists entirely in the ordering and arranging of the objects on which we must concentrate our mind’s eye if we are to discover some truth. We shall be following this method exactly if we first reduce complicated and obscure propositions step by step to simpler ones, and then, starting with the intuition of the simplest ones of all, try to ascend through the same steps to a knowledge of all the rest.[2]

The analytic method is so well-entrenched in our culture, which is dominated by modern science, that very few contemporary philosophers or scientists question its assumptions. Very few even take the trouble to examine its origin and the philosophical questions the proponents of this method tried to solve. A universalistic pretension in philosophy would want to eliminate any reference to history, but the analytic method cannot be better understood unless one puts its assumptions in a historical context. Not only can this method be linked to the Newtonian mechanical worldview, but also to the epistemological ambitions of modern science. Newton's mechanical model defines reality in terms of simple, regular, and ordered material and mechanical processes. In other words, Newton's world is a world of material bodies, be they particles or planets that move according to simple, regular, and ordered patterns. What guarantees this simplicity, regularity, and order is not an external divine power, but universal laws embedded in the universe itself. Therefore, according to mechanical models the laws that regulate the universe are as simple and as clear as the rules of mathematics. They do not only imply fixed quantities, but also qualities can be represented by univocal symbols that imply the fixation of meaning. The fixation of meaning renders symbols universal. On the one hand, the fixation of quantities has led to unprecedented inventions of measuring instruments, and on the other hand, the fixation of meaning has led to the elimination of ambiguity in the process of human knowing. In other words, Descartes' predilection for "clear and distinct ideas" is the logical outcome of his methodological doubt, but it is also the consequence of the creation of a world of fixity where not only the meaning of symbols and propositions is fixed, but also the rules of inference. This world of fixity is well-represented by modern mathematical and logical systems. From an epistemological point of view, fixity, as a criterion for universality, implies fixing the outcome of the process of human knowing, i.e. knowledge itself. Knowledge defined as true justified beliefs implies that in order to qualify as knowledge, beliefs have to be infallible, indubitable, and incorrigible.[3]

Reaching the level of accuracy required by the Cartesian search for "clear and distinct ideas", i.e. infallible, indubitable, and incorrigible knowledge defined as true justified beliefs implies not only fixing meanings, rules of inference, and the outcomes of the processes of human knowing, but also quantifying qualities. Christiaan Boudri has discussed this phenomenon extensively:

> Clearly, where the possibility and range of quantification are concerned, we cannot simply lump all the qualities together. We could define a complete quantification (based on Aristotle's definition of quantity) as one in which the *parts* of the quantity bear the same relationship to the quality in question as the *whole* quantity. In those cases can one posit an absolute linear scale in which values can be added and subtracted without losing the relation to the original quality? Duration would then be a 'completely quantified' quality: a time scale can be divided into parts, each of which also represents a duration. The sum of two parts of the time scale is equal to the total of the corresponding durations. The success of this quantification explains why, in modern physics, the duration of time is identified with its quantification.[4]

Another illustration of the practice of quantifying qualities, according to Boudri, is the measurement of temperature. For him:

> One example of a less far-reaching quantification is Celsius' temperature scale. Heat and cold – or as we say now, 'temperature' – is converted into a linear scale by measuring the expansion of the volume of a material such as mercury. The freezing point and boiling point of water at the pressure of one atmosphere serve as the calibration points.[5]

Quantifying qualities creates a possibility of handling qualities as spatial entities since quantified quantities can be represented graphically. This process of translating qualities into a medium that allows them to be apprehended according to geometrical rules and mathematical principles implies that geometry and mathematics can be considered as universal media. Moreover, in addition to their role as media, mathematical principles and geometrical rules are sometimes assigned a metaphysical role that would confer them a separate existence as essences. However, the possibility of quantifying qualities and representing quantities graphically leads to a process of mediation that allows apprehending qualities and quantities as spatial entities. This occurs as qualities that are essentially and substantially different can be handled through their quantities and the spatial representations. This aspect of scientific practice, both ancient and contemporary, reinforces *logocentrism* as by allowing the establishment of fixed points of calibration that allow the measurement of qualities as linear functions of fixed quantities of qualities considered as units of measurement. Mathematical principles and geometrical rules are considered as expressions of the *logos*, a principle that, as the ancients believed, was at the core of the unity and the intelligibility of reality. The association of mathematical principles and geometrical rules with logocentrism is based on the fact that any inquiry of a scientific nature can, in principle, be put into a quantitative or geometrical medium as by fixing some quantities of qualities or their geometrical representations as units of measurement, any inquiry of a scientific nature can be expressed as an inquiry about quantity and space. Quantifying qualities and representing quantities graphically, therefore, provides a universal medium where qualities cannot be compared with each other as metaphysically different substances, but rather by their quantified and graphically represented aspects. In this context, the subject matter of scientific inquiry does not become the material objects or qualities themselves, but the quantified measurements and graphic representations of aspects that are under consideration. By following this double possibility, i.e. quantifying qualities and representing qualities graphically, ancient geometry and mechanics find themselves dealing with the same subject matter. Newton pointed to this fact when he noted that:

> The geometry of ancients was indeed concerned with magnitudes, but propositions concerning magnitudes were sometimes demonstrated by means of local motion, as when the equality of two triangles in prop. 4 of book 1 of Euclid's *Elements* was demonstrated by transferring either triangle into the place of the other. But also the generation of magnitudes by continual motion was accepted in geometry, as when a straight line was multiplied by a straight line to generate an area, and an area is multiplied by a straight line to generate a solid. If a straight line which is multiplied by another one is of a given length, a parallelogram area will be generated. If its length is continually changed according to the same fixed law, a curvilinear area will be generated. If the magnitude of an area which is multiplied by a straight line is continually changed, a solid terminated by a curved surface will be generated. If the times, forces, motions and velocities of motions are represented by lines, areas, solids and angles, these quantities can also be dealt with in geometry.[6]

The possibility of quantifying qualities and representing quantities geometrically implies that various quantities of matter or positions of bodies in motion can be apprehended as spatial entities through their geometrical representations. It would, therefore, not be surprising that graphic representation is an important tool in both ancient and modern. Graphic representation allows the scientist or the natural philosopher to give spatial dimensions to qualities and phenomena such as matter and motion, which were previously understood in metaphysical terms. What its quantity is represented graphically, matter is no longer conceived as a metaphysical substance. Its metaphysical (ontological) dimension becomes less important for scientific inquiry than its extension in space. Hence, characteristics such as the quantity of matter itself (mass) or the size of the space it occupies (volume) became sufficient criteria for understanding the behavior of material, be they as huge as planets or as small as atoms or other elementary particles. Graphic representation confines intangible qualities and dimensions within the realm of physical space. In fact, representing these qualities and dimensions graphically provides them with one important characteristic of material objects, i.e. physical extension in space. In this way, graphical representation is not only a tool of analysis and calculation, but it also assists in quantifying qualities and naturalizing modality and duration. The capacity to represent natural processes and various aspects of human behavior graphically is very useful for the practice of modern science as it introduces an element of fixity into dynamic and integrative processes, which cannot lend themselves to analytic methods otherwise.

In other words, the success in the quantification of qualities through graphic representation gives physical significance to some notions that remained elusive due to the fact that they evade direct observation. One such notion is the notion of force. There was agreement among physicists that the cause of motion was force. However, the nature of force remained elusive. In early modern times, some scientists returned to the idea of ether from alchemy while others still searched for religious causes. However, mechanical models of the universe understood the universe as constituted by material bodies in motion. These bodies could be as huge as planets, or of the size of billiards balls, which were used for experimental purposes, or as small as particles. In the study of the notion of force, scientists have developed various methods, such as adding and subtracting forces, by using the rule of the parallelogram. The innovation at this stage is that, in addition to scalar quantities that are measured in one dimension, the qualification and quantification in terms of their point of application, their direction, their orientation, and their magnitude allows the representation of force or directs motion using vectors. Representation of force through vectors then allows measurement in two and three dimensions in a context where various dimensions of physical bodies are understood as quantities of qualities with fixed quantities of the same qualities used as standard units of measurement.

In a context where reality is understood in terms of permanent characteristics (substance as opposed to accidents) and immutable laws of inference (for the sake of universality), graphic representation provides a second-order, level form of abstraction where relationships between material objects or mechanical processes can be analyzed by analyzing their respective representations. This is where Newton's admiration for ancient geometry comes from. There is some (assumed) isomorphism between the relationships between the objects and processes themselves, on the one hand, and the relationships between their respective representations, on the other hand. This is the reason why representing material objects, natural processes, and some aspects of human behavior graphically translates these objects, processes, and aspects into a medium that renders them suitable for analysis. On the one hand, graphic representation eliminates ambiguity and, on the other hand, it fixes meaning, inputs, outputs, and rules of inference. This process of fixation leads to the *paribus ceteribus* (everything kept equal), which is a condition *sine qua none* for any scientific enterprise. However, in real situations, be they natural or man-made, there are very few occasions where everything is kept equal. Graphic representation, therefore, creates a situation where initial conditions, rules of transformation, and results are fixed, as modern science assumes to operate in a wonderful world as simple, ordered, and regular as the one Newton assumed. These aspects of simplicity, order, and regularity are not confined to the structuring of the universe, but they can also be found, as Descartes assumed, in the structuring and the functioning of the human mind leading to a perfect form of knowledge (clear and distinct ideas) and clearly defined steps of conducting thought.

Graphic representation, in other words, translates dynamic and integrative systems and processes into a medium that reduces them to their immutable characteristics and relations in a way that they become univocal, with the possibility of separating and reassembling their components at will, and hence, creating the possibility for linear patterns of causation. In brief, graphic representation renders complex systems and processes analyzable by fixing their components spatially, which allows the analyst to separate the components and put them together at will (as Euclid did with triangles). Moreover, graphic representation fits well the anti-metaphysical stance of modern science emanating from its rejection of scholasticism and reference to supernatural entities. Graphic representation does not present matter in terms of metaphysical essences, which are hidden behind the veil of appearance, but matter itself and other natural processes, such as motion, duration, force, and modality, are understood as characteristics of physical bodies within the boundaries of space and time.

Graphic representation, thus, provides a medium to express immutable characteristics conceived not as metaphysical essences, but as permanent relations that attest to the universal character of natural processes and their rules of transformation. Graphic representation does not only succeed in quantifying qualities, but, in addition to fixing inputs, rules of inferences and outcomes, graphic representations also, paradoxically, fix motion itself. The success in the quantification of qualities through graphic representation confines notions that would have otherwise remained elusive to the realm of time and space. One such notion is the notion of force. Force would have remained elusive due to the fact that it evades direct observation. However, by giving force fixed physical characteristics, such as its point of application, its direction, its sense, and its intensity (measured as the magnitude of a vector), force entirely becomes a physical notion, which does not lend itself to the idea of either so dear to alchemy or to its association with supernatural entities, such as the soul (*anima* in Latin), as it was done before the steam engine became a material proof that motion (a derivative of force) can be generated exclusively from purely material entities and processes.

In metaphysical terms, graphic representation confines various qualities that would be considered as metaphysical essences in an Aristotelian framework to the realm of the *physis.* For instance, when modality and duration are represented graphically, their metaphysical aspects, i.e. their ontology, are not relevant any longer; they are not only considered as they are in themselves, but as they relate to other physical systems and processes spatially. Graphic representation contributes to the success of the mechanical model by showing that material objects and processes can be better understood when their representations and their spatial relations are understood. Graphic representation, in other words, renders natural processes analyzable, as Bertalanffy has pointed out:

> Application of the analytical procedure depends on two conditions. The first is that interactions between "parts" be non-existent or weak enough to be neglected for certain research purposes. Only under this condition, can parts be "worked out", actually, logically, mathematically, and then be "put together". The second condition is that the relations describing the behavior of parts be linear; only then is the condition of summativity given, i.e., an equation describing the behavior of the parts; partial processes can be superimposed to obtain the total process, etc.[7]

Therefore, quantifying qualities through graphic representation does not only make fixing inputs, outputs, and rules of transformation possible, but also by providing a spatial dimension to qualities that naturally lacks tangible physical extension. Graphic representation as a medium renders qualities such as duration and modality analyzable and maintains linear causal patterns since by fixing meaning, it maintains an invariant relation between initial conditions, rules of transformation, and outcomes.

2. Anti-Metaphysicalism

Quantifying qualities is not the only way of putting reality into an analyzable medium. Modern scientists, as natural philosophers, have adopted an anti-metaphysicalist attitude. They have avoided or simply rejected metaphysical (ontological) questions and focused on epistemological questions. The position that I will call anti-metaphysicalism implies that modern scientists, as natural philosophers, have eliminated any reference to supernatural entities in the description of reality and the articulation of knowledge. Moreover, they would not consider important aspects of the objective and universal knowledge they have intended to achieve as based on metaphysical essences, but as based on universal laws embedded in the structuring and the functioning of the universe itself. In other words, the type of universality sought by modern scientists is not ontological, but nomological. This understanding of universality assumes a certain isomorphism between the structuring and the functioning of the universe and the structuring and the functioning of the human mind. Therefore, the anti-metaphysicalist position, paradoxically, is to some extent a metaphysical position in its own right. It postulates a materialistic, mechanistic, and deterministic universe, in which there is no other substance except for material substance. Natural processes and human behavior take place according to deterministic, mechanical laws that underlie all physical processes. This model is reductionist as it assumes that complex biological and behavioral processes can be reduced to their physical counterparts in terms of particles (atoms) in motion. This approach, according to Boudri, shifts the focus of scientists or natural philosophers from inquiring about the nature of material objects (things-in-themselves) to inquiring about their structure.[8]

Structure certainly lends itself to the analytic method as structure implies looking at the ways how various components fit together in order to form a complex whole. However, structure remains within the framework of fixity because as a subset of the mechanical model, focusing on structure suggests that components of complex systems, such as societies, languages, markets, floods, and earthquakes can be analyzed as results of material particles in motion. It is in this context that, for instance, societies are understood as the sum of individual actions, which are conceived as movements of limbs, languages, and movements of air between the lungs and the mouth following simple, regular, and ordered movements of the tongue in the mouth. Whereas markets as well as societies are mechanical as actions of economic agents are movements of limbs influenced by the mechanical laws of supply and demand (movements of goods and services), floods and other natural phenomena, in fact, fit the mechanical model better than the social counterparts. For instance, the movement called structuralism in social sciences is an attempt to apply the mechanical model to social phenomena. This school of thought has been identified with Lévi-Strauss. Moreover, many prominent French intellectuals, such as Roland Barthes, Michel Foucault, and Jacques Lacan have also been called structuralists. Structuralism has been applied to many areas of study, such as linguistics, mathematics, psychology, and biblical interpretation. As John Sturrock has pointed out, "[s]tructuralism holds to this vital assumption, that it studies relations between mutually conditioned elements of a system and not self-contained essences"[9]. Jean Piaget explains this shift from essences to structures when he contends that what is common to all the types of structuralism is:

> first, an ideal (perhaps a hope) of intrinsic intelligibility supported by the postulate that structures are self-sufficient and that, to grasp them, we do not have to make reference to all sorts of extraneous elements; second, certain insights to the extent that one has succeeded in actually making out certain structures, their theoretical employment has shown that structures in general have, despite their diversity, certain common and perhaps necessary properties.[10]

In addition to the understanding of structures as self-contained and autonomous, structuralism also ascertains that “a structure is a system of transformations”[11]. In other words:

> Inasmuch as it is a system and not a mere collection of elements and their properties, these transformations involve **laws**; the structure is preserved or enriched by the interplay of its transformation laws, which never yield results external to it. In short, the notion of structure is comprised of three key ideas: the idea of **wholeness**, the idea of **transformation**, and the idea of **self-regulation**.[12]

The idea of structure yields characteristics of the universe understood as a self-contained, autonomous whole without any influence from a supernatural realm. Moreover, the understanding of reality in terms of structures and systems leads to the possibility of formalization of both the elements of the structure and their laws of their interaction. Formalization then leads to a type of knowledge that yields the coherence of Newton’s physics and the consistency of mathematics. Structuralism embodies the principles of the mechanical model as the characteristics that structuralists attempt to find in their object of study are similar to those that Weizenbaum finds in mechanical machines. Weizenbaum reminds us that although machines exemplify the way a complex system and process occur, machines of the modern times are mainly characterized by **regular motion**.[13] This can be seen, for instance, in the back-and-forth movement of the needle of a sewing machine, or in the hustle of the gyrating, thrusting connecting rods that drive the locomotive’s wheels, or in the pulsating escapement mechanism of the most delicate watch.[14] Mechanical machines, in other words, are characterized by “[r]egularity, complexity, motion, power”[15].

In other words, the mechanical model, by emphasizing the existence of an invariant order of nature, considers the universe as a machine. This universe operates in the context of fixity of inputs, outputs, and rules of transformation since this context of fixity yields analycity, which implies low or inexistent levels of interaction and requires linear causality. The same causes lead to the same effects and the immutable laws of transformation act as a black box where inputs yield outputs without being affected by the process itself. Linear causality creates a symmetry of inputs and outputs in such a way that mechanical processes can be reversed materially or formally. On the one hand, knowing the inputs and the rules of transformation would render one capable of predicting the outcome. On the other hand, knowing the outcome and the rules of transformation would enable one to determine or calculate the inputs. Approaching reality mechanically and analytically also suggests that knowing the inputs and the outputs would make possible deducing the rules of transformation, which are believed to be simple mathematical relations emanating from the fact that mechanical laws are themselves simple, given the simplicity, the regularity, and the orderliness of mechanical processes.

Mechanical instruments are based on implicit assumptions, such as the permanence of reality (material substance) and the immutability of rules of transformation. These assumptions have influenced the way mechanical machines have been designed. Mechanical machines are meant to embody the characteristics of simplicity, regularity, and orderliness, which Newton and his successors assumed to be embedded in the order of the universe. Very few philosophers and historians of modern sciences have realized the fact that the design and the construction of mechanical machines have imposed constraints to natural systems and processes. There is no mechanical system or process that does not embody an invariant element. These instruments have served to quantify qualities and fix the frame of reference. The quantification of qualities mainly implies a comparison between similar kinds following an arbitrary designation of a certain quantity as the unit of measurement. This is true for the Celsius temperature scale as it is applied to various measuring units of the metric system. In other words, in addition to the fact that the Scientific Revolution did not only bring new methods of scrutinizing nature, but also created new instruments for that purpose, instruments are also embodiments of metaphysical and epistemological assumptions and principles. These assumptions and principles determine why some instruments and techniques are used and others not. For instance, we would not expect a twenty-first century philosopher to consult the Oracle of Delphi to seek wisdom. Nor would we rely on revelation, tradition, and religious authority as warrants for knowledge and truth. The reason for this is that, as Wiener has pointed out, "[t]he thought of every age is reflected in its technique." Techniques, methods, and instruments are not only embedded in a paradigm, but they are also embodiments of that paradigm. Domenico Bertoloni Meli has noted that:

> Several accounts of the so-called Scientific Revolution focus on instruments and their practitioners. Most of them emphasize the new instruments that emerged in the seventeenth century, such as the telescope, the microscope, the barometer, the thermometer, and the air pump. At the time these were called "philosophical" instruments, in contrast to "mathematical instruments" such as surveying equipment, quadrants, sectors, and other measuring tools.[16]

This separation between mathematical tools and philosophical tools in the context of modern science is far-fetched. In addition to being embodiments of a paradigm, instruments are built to display the characteristics of the universe of their makers and users. Therefore, mechanical instruments are built on the model of Newton's universe, and if they work properly, they display the characteristics of this universe, i.e. simplicity, regularity, and order. In other words, instruments are paradigm-bound. They embody processes and phenomena that are used to measure other phenomena. Measurement, as a comparison of similar kinds, implies that the simple phenomena in the measuring instruments would differ from the phenomena that are only measured with respect to their magnitude. This difference in magnitude suggests that the unit of measurement will also be a faction of the quantity that is measured as instruments are expected to play the role of "neutral" witnesses. They measure objects, processes, and phenomena as the latter are, without adding or subtracting parameters or qualities. Mechanical instruments, therefore, can only be designed according to the model of mechanics, i.e. matter in motion. Moreover, they must display characteristics of a mechanical universe, i.e simplicity, orderliness, and regularity. They cannot fulfill their roles thoroughly, unless the invariant relation between inputs, outputs, and rules of transformation is maintained and checked regularly.

Wiener maintains a strong connection between thought and technique as a paradigm is also reflected in the technique of the time. In fact, as Wiener has indicated, the civil engineers of the ancient times and those of the seventeenth and eighteenth centuries modeled their instruments after their own model of the universe. They considered the movements of the planets in, what they conceived as, "the heavens"[17] as operating according to the mechanical model. Although detailed studies of Wiener's assessment would require more time and space, Wiener states that "[i]f the seventeenth and the eighteenth centuries are the age of clocks, and the later eighteenth century the age of steam engines, the present age is the age of communication and control"[18]. In other words, instruments embody epistemological and metaphysical principles. It is important to know that the making and the use of these instruments have implicit epistemological assumptions that determine the way the instruments are made and used. At the actual level of the development of science, for instance, it is also important to know that not only the composition of the chemicals used in a laboratory, but also different tools of conservation, manipulation, measure, and record are able to reach a level of knowledge that meets the expectations and the standards established by the scientific community. The mastering of the instruments has both epistemological and social importance. On the epistemological level, correct manipulation of instruments helps to avoid errors that may falsify the results, and on the social level, wrong manipulation of instruments may lead to accidents that are detrimental to human health. Although the instruments of knowledge have not been considered as a domain of interest in epistemology before, one needs to be aware that these instruments are part of the technological developments that assist in testing new paradigms. They embed in themselves the principles and laws that allow the researcher to observe phenomena that escape human senses with more precision. Domenici notes that:

> Despite their apparent simplicity and availability, objects were not always easy to handle, either conceptually or practically. They required training – for example, in dropping balls at the same time or in counting pendular oscillations over several hours – and ingenuity. At times they required intellectual tools developed only much later, but often it was not necessary to have a complete understanding to start dealing with them in a variety of ways.[19]

However, instruments should not only be understood as material objects. They can be symbolic artifacts as well. For instance, whereas ancient geometry has been a great instrument for understanding spatial relationships, differential equations have provided a very useful mathematical model for studying change. Intellectual instruments, be they material objects or symbolic artefacts, play the role of intermediaries (media) between the objects that are studied and their representations. Therefore, humans can analyze relations between dimensions of material objects by computing relations between their representations. This isomorphism between the relations of dimensions of material objects and the relations between their representations spare the analyst from direct observation as an initial stage in the process of knowing. It takes the human mind from the first level of consciousness, which is empirical, to the second level, which is intellectual. Therefore, huge magnitudes, such as dimensions of the universe, do not need to be observed directly, but can be computed according to a mode of representation that brings these dimensions in a system of representation and rules of inference, which maintains the invariant relationship between initial conditions, rules of transformation, and outcomes.

The reflection of thought in technique implies that there is no technical revolution that is not in itself a philosophical revolution. From an understanding of reality as matter in motion in a materialistic, mechanistic, and deterministic universe follows that everything can be understood and explained in mechanical terms. As qualities such as duration and modality are quantified and fixated through graphic representation, it becomes clear that there is no need to oppose time to eternity. Time, like other puzzles such as force, duration, and modality, becomes either an absolute continuum, in which physical processes take place irreversibly, or an additional dimension of the physical universe. Instruments, as embodiments of metaphysical and epistemological assumptions and principles, have the effect of linking objects and their representations in such a way that one can deduce truth about the objects by acting on representations. As a matter of fact, this is what occurs in mathematics or formal logic. Mathematics and formal logic are systems of representations with an invariant relation between initial conditions, rules of transformation, and outcomes. This invariant relation attests to the fact that the systems and processes represented are subject to a linear pattern of causality. The consequence of a linear pattern of causality is a transparent universe. When one knows the initial conditions and the rules of transformation, one can infallibly compute the outcomes. Likewise, when one knows the outcomes and the rules of transformation, one can also compute the initial conditions. The rules of transformation themselves can be computed as a mathematical relation between the outcomes and the initial conditions. In a mechanical universe, this mathematical relation takes the form of a linear function. Abstraction, therefore, is the best way to render objects, systems, and processes analyzable. It does not suggest extracting university from the diversity of individual kinds, but finding a medium of representation that lends itself to a closed system of representations with an invariant relation between initial conditions, rules of transformation, and outcomes. For instance, the mechanical model, by reducing reality to matter and motion, automatically eliminates any reference to supernatural entities or vital entelechies. Moreover, the rules of transformation are universal laws (embedded in the universe itself) and not acts of the will of a divinity or a "homunculus". The mechanical model implies then that natural processes and human behavior are material, mechanistic, and deterministic processes since they can be reduced to material particles in motion in the final analysis. The universality that the mechanical model implies is not inscribed in the order of things, but in the rules of transformation that the mechanical model assumes, i.e. universal laws. In other words, the universality that the mechanical model targets and advocates is not ontological, but nomological. That is why, despite its efficacy in technological developments and the structuring of modern society, the mechanical model is not the only system of representation that assists humans in making sense of the complexity of the world.

The mechanical model, therefore, by defining reality in terms of matter and motion, understands rules of transformations as changes of spatial location in a three-dimensional universe. One should keep in mind that the materialistic, mechanistic, and deterministic framework that the mechanical model upholds that spatial extension is the defining characteristic of material objects. There is no matter except for spatially extended matter. The contemporary confusion that leads to the concepts of materialism and physicalism being used interchangeably emanates from the radical assumption that physical objects are spatially extended while mental "facts" are not! However, motion, understood as change of position in a space with three dimensions, cannot be dissociated with duration. Duration implies temporality and the role of time in the mechanical model cannot only be understood as a rejection of eternity as a frame of reference, but also as the consequence of the extension of the physical realm beyond material objects.

3. The Limits of Analytic Methods

The limits of analytic methods do not lie in its inefficacy. The analytic method is very efficient and, therefore, capable of being understood by analysis. However, not all systems and processes in the universe are analyzable. Biological phenomena, for instance, are "wholes".[20] They are different from the parts of their parts.[21] Analytic methods are, therefore, only applicable to mechanical systems/processes. Mechanical systems and processes fulfill the criteria of analycity on the one hand they operate according to assumingly immutable universal laws that can be formulated into simple mathematical relations. This simplicity makes the relationships between parts of mechanical systems summative. Moreover, mechanical systems/processes follow a linear mode of causality, where the same causes lead to the same effects. However, a cybernetic model does not allow the philosopher or the natural scientist to operate in a framework or a metaphysics of substance that assumes or aims at fixity. Cybernetic systems and processes operate within the framework of a metaphysics of relations. Prigogine and Stengers repeatedly point out that "today interest is shifting from substance to relation, to communication, to time."[22]

Analytical philosophy was born from the belief that analysis is the only method that is adequate for philosophical inquiry. According to Thomas Baldwin:

> [p]hilosophical analysis is a method of inquiry in which one seeks to assess complex systems of thought by 'analysing' them into simpler elements whose relationships are thereby brought into focus.[23]

The analytic method is not concerned with the nature (ontology) of its object of study, but with the way simpler components fit together to form a complex whole. Unlike the philosophical tradition known as "analytic philosophy", the analytic method finds its ancestry in practices as old as Aristotle's habit to dissect animals or his formulation of complex arguments into syllogistic formats, which are at the origin of contemporary formal logic. Whereas this aspect of dividing complex systems and processes into simpler components is a salient aspect of an analytic method, in recent philosophical traditions, analytic philosophy was vehemently anti-metaphysical. This anti-metaphysicalism helped in asserting the authority of modern science over previous conceptual frameworks, namely the divine-organic model that dominated the Middle Ages and the dualism inherent to scholasticism. However, there has been a metamorphosis of the dualism of the truth of substance (permanence) and the falsity of transience (change) to a dualism of the material and the mental. In other words, it is not accurate to characterize analytic philosophers as anti-metaphysical. Instead, one may characterize their position as an ambiguous one since they uphold materialism as a metaphysical framework and, yet, fail to explain mental processes, rationality, and behavior. The anti-metaphysicalism that characterizes analytic philosophers is reductive as it reduces materialism to physicalism and physicalism to mechanics. Materialism and physicalism are often used interchangeably and the reduction of physicalism to mechanics is often simply ignored or eliminated. However, this double reduction generates philosophical impasses since by reducing all natural processes to physical processes and all physical processes to mechanical processes, two important aspects of the structuring and the behavior of natural systems and processes are eliminated, i.e. order and purpose. Mechanics, by reducing physical processes to matter and motion, provides a framework of simple, ordered, and regular processes and linear patterns of causation, which lend themselves to analysis.

A critique of the analytic method, therefore, is not an advocacy for a return to an ontological dualism, but a quest for more rigor and precision in the articulation of the way natural processes and human behavior occur. This quest implies that looking at reality in terms of matter and motion is right, but it cannot account for all aspects of natural phenomena, human individuals and collective behavior. The analytic method requires to fix meaning by way of the design of methods that only cater for symbols that are univocal, or to reduce dynamic and integrative processes to their unchanging aspects that are conceived as embodiments of universality. However, the initial conditions of fundamental particles or univocal propositions that are prerequisite to any analytic endeavor are not found anywhere in nature. The first experience of reality that we have as humans is an experience of complex, dynamic, and integrative systems, aspects which we can analyze as the result of a higher level of our mental development. In other words, the type of universal knowledge that modern science intends to achieve is nomological and not ontological. It is not embedded in the order of things and in the natural functioning of the human mind. It is the fruit of a long process of development of attaching fixed meanings to objects and processes and an ability to create a mediated world in which one can understand the relations between material objects and processes by analyzing the relations between their representations. This process of development may be attributed to evolutionary and ecological factors, but even within the life span of an individual human being, it is clear that analytic skills are acquired only at a later age in life and naturally assumed to improve through practice. In other words, in addition to the fact that all systems and processes that we come across are not analyzable, i.e. (1) are not made of components whose interactions are sufficiently weak or inexistent for us to separate them; (2) their modes of interaction do not always follow a linear pattern; analytic skills occur at a high level of human intellectual development.

Without reverting to a pre-scientific metaphysical dualism, there is, on the one hand, a possibility of understanding natural processes without necessarily reducing them to the simple, regular, and ordered patterns that Newton postulated. On the other hand, there is also a possibility of putting logico-deductive knowledge (to which analytic skills belong) on a continuum of human mental development, where later stages build on previous stages without suppressing them. Jean Piaget shows in his classical book entitled *Knowledge and Biology* that Moreover, it should be acknowledged that human knowing is polymorph. As Piaget has pointed out:

> The essential starting point here is the fact that no form of knowledge, not even perceptual knowledge, constitutes a simple copy of reality, because it includes a process of assimilation of previous structures.[24]

Piaget distinguishes between three stages in the process of the intellectual development of a child, namely a sensorimotor period, a period of preoperative representation, and a period of propositional operations. According to Piaget, the sensorimotor stage is:

> a period during which sensorimotor schemata ranging up to acts of practical intelligence by means of immediate comprehension (using a stick or a piece of string, etc.) are

> established as well as practical substructures of future notions (permanent object schemata, spatial displacement "group," sensorimotor causality, etc.)[25]

The preoperative stage "begins with the semiotic function (language, game symbols, picture making) manifests itself"[26] and ends with "the setting up of operations that are called "concrete" because they still have a bearing on objects (classifying things, putting them in series, noting connections, understanding numbers)"[27]. The whole process culminates in the period or stage of:

> propositional operations (implications, etc) with their combinatorial quality and their possible transformation made by relation to a quaternary group – a combination of two elementary reversibility forms (inversion or negation and reciprocity).[28]

Although Piaget's theory focuses on children and the stages he sets for the establishment of these stages have been challenged on empirical grounds, his theory shows that the assimilation of the previous stages in the process of intellectual development points to a dynamic and integrative pattern in adult life. This dynamic and integrative pattern allows the development of new patterns without suppressing the previous ones, and a possibility of using the skills of early stages when they are needed. Thus, as persons involved in the process of knowing we do not always do one and the same thing. We are subject to processes that take place at various levels of consciousness, namely the empirical, the intellectual, the rational, and the responsible. The process of human knowing includes operations such as experiencing, understanding, judging, choosing, deciding, and acting. It does not solely aim at describing reality, but at acting on it as well. Therefore, in addition to the search for objective and universal knowledge *(episteme)*, the process of human knowing involves skills that help the knower not only to achieve accurate descriptions and to formulate "universal" laws, but also to make sound judgements, which lead to responsible decisions, and effective solutions to problems. These aspects of decision making and problem solving can involve the description of reality and its laws, but they also appeal to other forms of rationality that are evaluative (*phronesis*) and practical (*praxis*). In fact, as Bernstein has noted:

> There is a deep irony in the tradition that Aristotle helped to initiate. Aristotle is at once one of the noblest defenders of the autonomy and integrity of *praxis* and *phronesis* and also the philosopher who sowed the seeds for the denigration of practical philosophy. The expression "practical philosophy" is virtually self-contradictory, because philosophy as the love of *sophia* is something higher and more divine than *phronesis*.[29]

However:

> [i]t has become a dogma of modern thought that only after we resolve the "hard" issues of epistemology and come to grips with scientific knowledge can we turn to the "softer" and "fuzzier" concerns of moral, social, and political philosophy. This is a prejudice that is being questioned in the new conversation about human rationality.[30]

Human rationality, like human knowing, is polymorph. Human rationality can lead to descriptions, formulations of laws, evaluations of situations with reference to idealisations, such as principles and values, and realisations of goals. Rationality, in other words, can be descriptive, normative, evaluative, or teleological, but also prescriptive and predictive. Analytic methods reduce human knowing and human rationality to logic. This reduction is due to the fact that the classic concept of the *logos*, a principle of unity and intelligibility of reality, has been adopted by modern scientific, academic disciplines as an epithet; hence, today there are sciences such as biology, sociology, psychology, etc. This concept, as adopted in modern science, assumes truth, objectivity, and universality embedded in scientific discourse. The *logos* in Greek philosophy is not only a principle of unity of diverse processes that render the universe as one, but it is also a principle of intelligibility. In other words, not only does the *logos* organize natural processes, but also human intellectual processes. The *logos*, translated – wrongly in my view – as *ratio* in Latin, accounts for specific aspects in the universe, such as order, simplicity, regularity, hierarchy, proportion, and symmetry, which are indeed characteristics of an intelligible universe. At the same time, the *logos* is associated with aspects of the human mind, such as the power of human reason itself, rationality, logic, objectivity, universality, quantification, inference, and formalization. In other words, the universe is intelligible since it is organized according to "logical" principles that are similar to those of the organization of the human mind. This explains why an intelligible universe lends itself to the intelligent activities of an intelligent mind since there are two aspects of reality that are organized according to similar principles. Therefore, in human reasoning processes there is a superposition of the logical principles within the universe and the logical principles in the human mind.

However, the first experience of reality we have as humans is rather a *pathos* and not a *logos*. A logical approach to reality is developed as we make generalizations from our early experiences in the sensori-motor, the pre-operative, and the operative stages. Before, we reach the analytic stage by which we can fix meanings, inputs, outputs, and rules of inferences, we first act on objects before we reach the stage by which we act on their representations. We do not operate in two worlds, one material and another mental, but we are involved in processes of dynamism and integration where matter is not only in motion (as Newton postulated), but where matter organizes itself following various patterns of order through which physical organisms achieve goals and solve problems. While Piaget is of the opinion that these dynamic and integrative processes operate according to a cybernetic model of information, control, and regulation through feedback, it is important to note that when a dynamic and complex process is represented graphically, it is not reproduced as it is. Only the salient aspects that are the subject of the analysis are taken out since abstraction, in this sense, does not mean abstracting universal (immutable) characteristics from individual kinds, but confining the process of analysis only to aspects and characteristics that are relevant to the object under study. On account of this, the mechanical model, despite its success in natural sciences and its unprecedented contribution to modern technological development, is essentially reductive. Not only does it reduce all natural processes to physical processes, but it also reduces all physical processes to mechanical processes. In other words, fixing inputs, outputs, rules of transformation, and quantifying qualities renders the world analyzable.

Computer programs (algorithms), as systems of representation, are analytical instruments par excellence. They operate in a world of fixed inputs, outputs, and rules of transformation.

C. COMPLEXITY AND SYSTEMS DYNAMICS

1. Complexity and the Cybernetic Model

Contemporary debates in the philosophy of mind use the terms naturalism, materialism, and physicalism interchangeably without making the effort of "unpacking" these concepts. They oppose the physical or the material to the mental without taking the facts that not all natural processes are physical processes and that not all physical processes are mechanical processes into account. This use of the material, the physical, and the natural as one and the same thing is linked with the influence of mechanical models. Mechanical models define reality in terms of matter and motion. Moreover, quantifying qualities and representing them graphically allow the analyst to apprehend complex systems and processes in a medium that only takes material and mechanistic aspects into consideration. The metaphysical implications of the reduction of all natural processes to physical processes, especially mechanical processes, originate in the Cartesian reductionism. Brian Cooney denounces Descartes' reduction of a four-level model of the universe to two levels as a way of making it fit with the mechanical framework. By having rejected scholasticism, Descartes opposed an Aristotelian four-level, descriptive scheme for the only purpose of making it suitable for the mechanical model. As Cooney has pointed out:

> Most people then (as now) thought of our planet as populated by four categories of beings:
>
> 1. inanimate bodies – objects, such as rocks, soil, and even liquids and gases
> 2. plants- living bodies, such as vegetables and even mosses
> 3. animals – sentient living bodies, including birds, fish, and land animals
> 4. humans – sentient living bodies of a specific form with distinctive capabilities, such as reason and speech.[31]

The cumulative nature of this tetrad resides in the fact that "[e]ach higher level, from the first to the fourth, includes the lower with the addition of a further attribute"[32]. As a matter of fact, Descartes reduces the second and third levels of the tetrad to the first level on the grounds that "plants and animals were to be understood merely as machines, complex systems of movable parts that enable them to behave adaptively in their environment"[33]. Therefore:

> His (Descartes) reduction of life and sentience to the motion of material particles created an abyss between the human mind and body. It has the effect of suspending our consciousness in a world of bodies with which it has nothing in common. Each human mind became a ghost in its own machine.[34]

However, there is a possibility of reaching a better understanding of the structuring and the functioning of the universe beyond mechanics and Cartesian dualism. This does not only suggest rejecting Cartesianism, but also the mechanical model in which it originates. It is crucial at this junction to understand the dynamic and integrative nature of natural processes. Cartesian dualism still overshadows philosophical debates as its assumptions often remain unchallenged. On the one hand, Descartes is presented as the "father" of modern philosophy, the champion of the modern search for objective and universal knowledge. Being Cartesian is a fairly prestigious title for those who have managed to put aside their sentiments and their prejudices in order to investigate the world as it is. However, Descartes' own ambiguous situation remains unchallenged. On the one hand, Descartes maintains a dualism that opposes the material "substance" to the "mental" substance without providing any rational or empirical grounds for this distinction. Moreover, Descartes' introspective method makes us assume that there is an ontological difference between external "objects" and their internal representations, but Descartes does not provide any tangible boundaries between the "external" and the "internal" arenas of the human person. This distinction is either based on common sense, or it is a disguised replication of the scholastic distinction between the body, which is external since it is available to direct observation, and the spirit, which can only be accessed through introspective processes, such as meditation. This distinction does not hold in a world where air has been proved to be a physical element. There is a possibility of putting the material and the mental on a continuum where the structure and the functioning of the universe are not regarded in terms of matter and motion, but in terms of order and purpose.

A cybernetic model, for instance, adds order and purpose to natural processes and systems instead of reducing natural processes to matter and motion. In other words, when we deal with natural processes and systems by using a cybernetic model, we are not dealing with "dead" matter, which is static and immutable. Even the concept of motion itself is not restricted to change in spatial location. It can portray, according to its original usage by Aristotle, any change including not only material objects and particles in motion, i.e. changing spatial location, but also different patterns and processes of organization that confer a certain level of order, or negative entropy, or a certain amount of information to natural and material complex systems and processes. Matter, as understood this way, implies that we do not only look at fundamental particles in motion or immutable mechanical laws, but also at the various ways by which material elements are set in motion (mechanical aspects) and the various ways by which material elements organize themselves into structures and processes that are capable of fulfilling natural or artificial purposes. In addition to looking at matter from the point of view of its nature (substance), a cybernetic model is open for the possibility of adding structure, behavior and function (purpose) as significant aspects of reality. Reality, therefore, is not reduced to its mechanical aspects, but as material elements organize themselves into structures, systems, and processes with a certain degree of order, i.e. negative entropy or an amount of information, they are both significant (yield some meaning) and useful (have some value) in a such way that they can serve various purposes pertaining to the intelligent life with which we associate the mind.

The concept of order does not have to be associated with an intelligent organizer or designer. Organized matter can acquire properties that its fundamental constituents, such as atoms or molecules, do not have when looked at in isolation. Although this aspect of order is part and parcel of reality, it is not often mentioned because mechanical models by assuming a simple, ordered, and regular universe, take order for granted and miss the role it plays in the intelligibility and analycity of natural processes and systems. Mechanical models of the universe, therefore, seek universal and immutable laws in an assumed ordered universe where the same causes do not only generate the same effects, but where both the causes and the effects following the causal closure of the physical are also confined within the realm of a mechanical model of the universe, which is understood as constituted by self-moving material bodies and processes. A cybernetic model by linking information with order introduces another model of the universe as a natural and physical process without necessarily reducing physical processes to mechanical processes, i.e. matter and motion. Moreover, this model does not reduce natural processes to physical processes as a cybernetic model also operates in biological and social processes. Like the way the Greeks linked the *logos* with order and intelligibility, a cybernetic model, as introduced by Wiener, defines information as the opposite of disorder, i.e. negative entropy. Following Wiener's cybernetic model, any organized system or process is intelligible as it conveys a certain amount of information. In other words, the degree of organization of a natural system or process determines the amount of information it can convey, and hence its degree of analycity and intelligibility.

We can study material bodies in their constitutive dimensions by identifying a certain scalar measurement of their characteristics, such as their weight or their dimensions in space (length, width, height). However, when these bodies are set in motion, they can no longer be studied solely as matter in a three-dimensional space. Setting a material body in motion brings a change in spatial location that introduces time as a fourth dimension. Studying a body in motion does not only include studying the characteristics that lend themselves to scalar measurement, but also those that are best represented by vectors. Setting a material body in motion introduces other dimensions such as the direction and the sense of the motion, its intensity and its origin. In elementary physics, the study of the notion of force, for example, follows this pattern. The same pattern is applied when one introduces a criteria of order to the relationship between material bodies, be they stationary or in motion. Order is not an intrinsic characteristic of the bodies since it has to be characterized through the capacity to identify its criteria and to examine whether a given situation meets these criteria. There are many ways of proceeding, but checking whether a certain situation meets a certain criterion calls for an element of human judgment that goes beyond the impersonal nature of mechanical processes. Order then calls for principles of logic and rationality, which were once understood as organizing principles that amount to negative entropy and can take the form of information, structure, and/or pattern. Orderly processes, patterns, or structures can also be matched with human goals. While logic renders the processes, structures, and patterns meaningful through understanding, goals or purposes render the same processes valuable and, in addition to asking the "how question" normally linked with efficient causality, we are in a position to ask the "why question" linked with teleology and hence, with final causality. This theory of causality is due to the fact that organized processes convey information since organization by definition means order and negative entropy. Organized processes then, for the sake of being organized, do not occur randomly. They are purposeful. This idea of purpose implies that organized processes always have a goal. Therefore, it is important to take these goals into account when one studies an organized process. Reintroducing the idea of teleology in the study of causality implies that our goals play the role of an inviting final cause. This existence of inviting final causes upsets the assumption of normative epistemology that causality is linear and that the causes always precede the effects chronologically. In this context, the idea of a final cause should not be understood in an ultimate and absolute sense as it was associated with the Aristotelian "unmoved mover" and God in the Middle Ages. It should be understood in a more mundane sense as a goal that is not out of human reach. This type of goal has to be SMART, i.e. Specific, Measurable, Achievable, Realizable, and Timely.

It is worth noting that the fact that information processing operates on symbols and symbol structures that can be represented functionally regardless of their underlying hardware does not imply that hardware should be abolished altogether. It is important to take the role of physical symbolic systems both in the structuring and the knowing of reality into account. As Simon has noted:

> A physical symbol is a pattern (of chalk, ink, neural connections, electromagnetic fields, or what not) that refers to or designates another pattern or a detectable external stimulus. Printed words on a page are symbols, so are pictures and diagrams, so are numbers. A physical symbol system is a system that is capable of inputting symbols, outputting them, storing them in memory, forming and modifying structures of symbols in memory, comparing pairs of symbols for identity or difference, and branching in its subsequent behavior of the outcomes of such tests.[35]

In fact:

> A computer is obviously a physical symbol system. Its ability to perform these processes (and only these processes) can be verified easily from its physical properties and operation. A human brain is (less obviously) a physical symbol system. It can certainly carry out the processes specified in the definition of such as system, but perhaps other processes as well.[36]

Furthermore, the cybernetic model does not reduce natural processes to material and mechanical processes as, in addition to matter and motion, it recognizes logic and symbolism as part of parcel of reality. Logic and symbolism emerge as dimensions of order and meaning as a system/process can only be intelligible and meaningful when it is ordered, i.e. organized into a structure and ordered to a purpose. It is this double sense of order, which defines intelligibility in terms of organization and meaning, that is embedded in the Greek concept of the logos, which is both a principle of unity and a principle of intelligibility. The intrinsic link between order and meaning and the crucial role they play in intelligibility is well conveyed by the French word *sense*, which means both "meaning" and "direction". In order to make sense, therefore, natural processes have to be both organized into structures and able to fulfill goals (function). The fulfillment of goals implies changes in the systems'/processes' mechanisms as they adapt the constitutive characteristics of their internal environment to their ever changing external environment. Therefore, a full understanding of cybernetic systems/processes requires looking at their intrinsic qualities, such as the nature of their components, but also at their structure, their function(s), and their behavior because as originators of meaning the characteristics of cybernetic systems/processes are intrinsically structural, functional (teleological), and behavioral. On this account, cybernetic systems/processes should not be understood as aggregates of isolated and independent components. They are systems and processes since they are dynamically integrated in such a way that studying their components in isolation is, in fact, studying something else and not the systems and processes themselves.

Therefore, a cybernetic model of the universe implies recognizing that there are complex systems and processes that are not analyzable. These systems and processes are constituted by subsystems and subprocesses that are inherently interactive in such a way that separating them means destroying the system or halting the process. Reducing these systems and processes to a lower level of complexity implies generating properties and characteristics that are different from the ones of the original system or process. These systems and processes that are characterized by a very high level of complexity are not defined in terms of permanent characteristics that are considered as their essence. Instead, they are defined by various criteria that include their contents (substance), structure, behavior, and function/goal. Moreover, in addition to these "internal" criteria, they are also defined in terms of their possible or actual interaction with their environment. Therefore, while mechanical systems and processes can be considered as special cases where the inputs, the outputs, and the rules of transformation are fixed, cybernetic systems, given their inherent complexity and dynamism, are constantly subject to change in the levels of inputs and outputs; however, the rules of transformation also change according to the feedback they get from their environment. This model applies to natural systems with processes such as homeostatic systems or the functioning of endocrinal organs in human or in non-natural systems, such as the thermostat.

On the other hand, these interactive systems and processes operate by the use of patterns of information and control through feedback. Therefore, they do not follow a linear mode of causality with causes on one side and effects on the other. The world we live in measuring and analyzing are based on the assumption that the whole can be understood as a sum of its parts. However, the cybernetic model upholds that the world is inherently complex[37] and sometimes chaotic.[38] Whereas the analytic model has been very efficient in handling simple, regular, and ordered aspects, it is inadequate to handle complex systems and processes. The reason for this is that not all natural systems or processes fulfill the criterion of analycity. In a cybernetic system/process there are no causes or effects in the proper sense of these terms, but inputs and outputs. The inputs and the outputs inform each other as for the system to remain operational, both the inputs and the outputs have to remain within certain thresholds. These phenomena occur in biological systems, such as homeostasis or the functioning of endocrinal organs. In non-biological systems, devices such as the thermostat or the wheel controlling the balance of a ship illustrate systems and processes that function following a cybernetic model. Therefore, the assumption that all complex systems and processes can be reduced to simple, regular, and ordered subsystems that can be analyzed at a fundamental level is erroneous. However, mechanical and cybernetic systems should not be opposed to each other. Instead, mechanical systems should be considered as special cases of cybernetic systems where the inputs, the outputs as well as the rules of transformation are fixed. The passage from cybernetic systems to mechanical systems implies that aspects of dynamism and integration are either neglected, or eliminated or, when quantitative analysis is involved, they are given a null value. In brief, the analytic method should be used on systems and processes that are analyzable, i.e. (1) whose components can be clearly distinguished form each other, and (2) whose interaction follows a linear pattern of causality. For complex systems, where inputs and outputs inform and control each other through feedback, system thinking should be applied. System thinking implies acknowledging that reality is inherently complex and that the simple, regular, and ordered processes that are observed in the universe are special cases. Moreover, systems thinking does not only imply looking at the way components fit together (structure), but also taking the behavior and the function/purpose of the systems and processes of study into account. Systems thinking, therefore, transcends the analytic method as the analytic method is mainly concerned with the way components fit together. However, systems thinking by taking structure, behavior, and function/purpose both in the description of reality and the articulation of knowledge into account provides a form of knowledge that is more complete than the analytic method.

2. The System Idea

The conditions for analycity are not fulfilled by "entities called systems, i.e. consisting of parts in 'interaction'"[39]. Therefore, in my view, the analytic method can only be applied to systems and processes that are analyzable. Gestalt psychology has pointed to this fact by claiming that the whole is not merely an aggregate of the parts. Since most systems do not fulfill the conditions for "analycity", they should be handled by methods other than analysis. As an alternative to analysis, I suggest an approach called "systems thinking". Therefore, cybernetic systems/processes embody a certain level of complexity that renders their study difficult since as nature (substance) and structure fulfill purposes in dynamic and integrated ways, it becomes obvious that mechanical systems/processes are special cases of cybernetic systems/processes. The complexity is not only at the level of interaction of various material bodies, but it is also constitutive of material bodies even at the fundamental level. Pandit has pointed to this fact when he notes that:

> From an information-theoretic perspective, every active element in the living nature can be seen interacting with other such elements in its capacity as a non-unitary complex structure or system. Even an element relatively as simple as a *gene* in the nucleus of the cell is in this sense a complex structure with a physical basis embodying or accompanied by information/instruction as to how exactly to interact with other elements in its environment.[40]

In fact, although the idea of matter as active and able to carry information and instructions is associated with the emergence of the electronic computer age, connected to the possibility to store information and instruction on silicon chips, the phenomenon is much broader as the acclaim of the idea in the scientific community. Therefore, as Pandit notes again, "it is [...] true of every science that it seeks to understand the complexities of the natural processes in the world in terms of subject-specific laws of interaction at various levels of complexity"[41]. Therefore, complexity can be considered as an information inhibiting factor that would lead to the conclusion that the more complex systems and processes are, the less intelligible they become. Thus, as a model that understands reality in terms of information and control through feedback, the cybernetic model "is concerned with the *possibility* of the physical interactive ordering of nature itself, and the latter with the *necessary restrictions* on the interactions thus generated"[42]. The cybernetic model then does not assume a linear pattern of causality that leads to an infinite progress, but a pattern of information and control that maintains systems and processes within certain thresholds that trigger feedback processes and can reverse processes that tend to destroy the system by triggering a certain characteristic beyond or below the threshold of the system/process. Hence, instead of trying to determine how material bodies and mechanical processes lead to complex phenomena, such as life and the mind, the opposite should be done. Pandit suggests that:

> A general interaction theory in the sense just considered must, however, address itself to other problems as well: e.g. (1) how are interactions in the living world generally different from those in the non-living world? And (2) how are human interactions generally different from non-human interactions (in the living world)?[43]

For Pandit, "[t]hese questions assume considerable significance in the context of the problem of distinguishing knowledge (objective and subjective) from human interaction"[44]. There is no need to separate the two. Pandit considers knowing as a process at the level of the individual and posits an individual knower who tries to interact with others! On the contrary, the knower is, from the outset, an interactive being, who does not acquire most of his/her knowledge from the exercise of natural and individual rationality, but from learning not only the contents of knowledge (what to know), but also the skills of knowledge acquisition (how to know) from different communities of inquiry. Instead of assuming fundamental and simple particles as ultimate constituents of reality, one might begin by accepting that:

> all types of entities/active elements of interactions in the living world [are] so organised, in structure and function, as would warrant their characterization as information-constrained elements in some scientifically relevant and intelligible sense of the term.[45]

Moreover,

> These elements, from the most simple to the most complex, are not just unitary in character – just units of organisation of some kind – but complex organizations, each constrained as it were, an orienting field of information or instruction, embodying for that element alternative possibilities of interaction with other elements.[46]

Therefore, the paradigm shift from a mechanical model to a cybernetic model implies a shift from a metaphysics of substance to a metaphysics of relation. On that account, a cybernetic model does not define reality by looking for permanent qualifies of material objects that are believed to be their essence or by abstracting kinds from individuals. The cybernetic model takes reality for what it is, i.e. complex, and then, looks at four different aspects of systems/processes, namely the nature (substance), the structure, the behavior, and the function/goal of a system/process. From this point of view, "[i]t should not be surprising that this question employs the concept of information or instruction, besides a more general concept of organization"[47]. The concept of organization is central to the cybernetic model due to Wiener's linking of information and order. Only organized systems/processes can convey information, the amount of information depending on its degree of organization. In fact:

> The concept of organization could perhaps be employed as a self-sufficient concept so long as a general interaction theory addresses itself to biologically neutral aspects of interaction across the worlds living and non-living entities/processes, besides those of an abstract nature. Thus, in a biologically neutral sense, significant interaction is definable as interaction between the active elements of different orders of organization.[48]

Therefore, shifting from a metaphysics of substance to a metaphysics of relation does not imply defining reality in terms of principles of logic and mathematics, which are based on mechanical assumptions, such as the continuity of substance, the permanence of reality, and the possibility of regular and linear causality. The cybernetic model completes the mechanical model by acknowledging discontinuity (such as the succession of discrete signals in digital systems) and alternation (such as the regular succession of charges of opposite signs in alternative currents) as parts of reality. Therefore, reality can no longer be defined only in terms of substance (that imply permanence), but also in terms of patterns and relations. The cybernetic model does not reject the mechanical model. Instead, it completes it by incorporating elements of the electromagnetic model, such as discontinuity and alternation, although electromagnetic systems and processes can be reduced to the mechanical model on the grounds that electricity is the motion of electrons or ions.

Shifting from the metaphysics of substance to the metaphysics of relation implies replacing the normative element that is at the origin of human scientific inquiry. Our world is not a world "out there" that passively renders itself to our inquiries, be they scientific or other. Our world is a turbulent world, which may or may not be, since, according to Wiener's definition of "the amount of information" as what is transmitted as a single decision between equally probable alternatives, we are introduced to a metaphysics of alternatives where the invariant element expressed in terms of an objective world and universal laws is replaced by a probabilistic element. This probabilistic element excludes that there are any essences to be discovered "out there". However, there are patterns and relations to be discovered since:

> At the highest level of generality, therefore, we might speak of an organizational-theoretic approach as regards the problem of characterizing the significant interactions across the living and the non-living nature.[49]

However, we remain entangled within the mechanical model if we assume that mental states/processes are properties emerging from the complexification of matter. The theory of emergence still begins with non-living matter as the point of departure and looks for reasons such as the concentration of energy, or collusions that occur according to the laws of random probability. However, as a system of information, control, and feedback, the mind is not an entity, but a series of activities, which occur at different levels of complexity. Complexity can be linked with order and, hence, with information, but it does not lead to the emergence of metaphysically different kinds. Instead, "[t]he concept of information-constrained interaction seems to me, on the one hand, most relevant in distinguishing interaction in the living nature from those in non-living nature"[50]. For instance:

> The genetic code or the DNA molecule is indeed theoretically identified as spiral-like double helices wound around each other. Its very ability to trigger self-replication (transformation) and cellular control by a process of transcription/translation – the gene structure transforming itself into a structure of protein – points to its character as an 'innately' informed system capable of informing other systems, if only as part of an endless developmental process.[51]

In other words, the cybernetic model, by defining reality in terms of dynamically integrated systems/processes, locates complexity at the level of interaction of various interactive systems/processes that do not create the picture of a rigid world with immutable laws and eternal truths, which are only hidden and await to be unveiled by the mind. Instead, the cybernetic model deals with a turbulent world that is in a continuous flux of becoming. The cybernetic model, therefore, does not aim at replacing the mechanical model as a way of substituting a physical model by a biological model. Its aim is to restate the terms of the debate of the mind-body problem not in the Cartesian metaphysical opposition of material and mental substances. This is a shortcut that was made by Descartes as his scholastic mode of questioning was confronted with the explanatory mode of mechanics. In addition to materialism, the cybernetic model deals with reality in terms of levels of apprehension. Therefore, one can clarify that materialism, as a theory that deals with material bodies, cannot be reduced to dealing with material bodies only when they are at rest. Material bodies, when set in motion, can generate properties that are not easy to identify when these bodies are at rest. When a material body is at rest, then it has no kinetic energy, which would be tantamount to ascribing a kinetic energy level with the value of "0" to the material body in question. Moreover, in addition to motion, material bodies that are organized according to ordered patterns are as intelligible as unified and yet, they are complex systems/processes.

The merit of the cybernetic model is its recognition of the fact that some aspects of reality become obvious only when they are relevant to the system/process at hand. This is what abstraction means, namely not extracting qualities and essences from individuals, but looking at individuals in such a way that only aspects that are relevant to a given system and process are taken into account. On account of this, modern science seeks precise definitions and is prudent to state that it only operates in contexts where *ceteribus paribus* (everything is kept equal). The cybernetic model, which studies organized complexity in terms of information and control through feedback processes, and the mechanical model, which studies matter in/and motion, are not mutually exclusive. For this reason, it is not a wise suggestion to replace the mechanical model by the cybernetic model. As a matter of fact, the mechanical model has become difficult to supplant since it has been very efficient in its domain area, i.e. in mechanical systems/processes, namely systems/processes that can be studied in terms of matter in/and motion. Mechanical systems/processes are considered as models of how a rational universe works since they follow simple, regular, and ordered patterns. In other words, they still fit in the cybernetic framework, except that dimensions that the cybernetic model adds to the mechanical model (logic and symbolism) are merely ignored or given a "null" value in mathematical formulations.

The level of interaction of the components of mechanical systems/processes is so low that their formal structure can be identified clearly, their behavior can be fragmented into well-defined steps (or programmed into algorithms), and their function is not difficult to pin down since mechanical systems/processes operate in a stable environment and have fixed goals. The fixation (the attribution of the "null" value) of goals and the characteristics of the environment, and the clear delimitation and ordering of structures eliminate any amount of disorder from mechanical systems/processes. With negligible entropy, mechanical systems/processes are at the information end on the information-entropy spectrum. Information defined as negative entropy implies that the amount of information that a system/process can convey increases when the entropy (disorder) of this system increases. Therefore, there is a positive correlation between the information a system/process can convey and its degree of organization. Mechanical systems/processes, with their simple, regular, and repetitive patterns, are of a very high level, if not a perfect level, of organisation. Hence, they are not to be opposed to their cybernetic counterparts, but to be acknowledged as special cases where the entropy has been reduced to negligible levels or has simply been eliminated. Mechanical systems/processes with a "null" value of entropy are fully organized and convey a maximum amount of information that fulfills the Cartesian dream of achieving infallible, indubitable, and incorrigible knowledge through "clear and distinct ideas".

In practice, this type of knowledge cannot be achieved without imposing constraints on natural systems/processes. Therefore, knowledge defined in terms of “clear and distinct” ideas with its criteria of indubitability, infallibility, and incorrigibility does not emanate from the transparency of the mind and its special access to its contents, as Descartes assumed, but from a process of removing complexity and ambiguity from natural processes by submitting them to strict criteria of definition and identification. For this reason, indubitable, infallible, and incorrigible knowledge can only be propositional knowledge. Propositional knowledge imposes constraints on natural processes through axiomisation, i.e. reducing complex processes of human knowing to observational propositions of the type “S is P”. This explains, at least partly, the predilection for mathematics and formal logic by philosophers who subscribe to the Cartesian tradition. In other words, the success of the mechanical model is linked with the fact that mechanical processes/systems can be subjected to quantification and formalization and are fully analyzable. On the one hand, the rules that mechanical systems/processes follow are simple, repetitive, and constant (universal laws) and can be fully formalized into algorithms. Mechanical systems, by following simple, repetitive, and constant laws, have a negligible level of entropy; hence, they can convey maximum amounts of information that can lead to certainty. In other words, Descartes’ predilection for “clear and distinct” ideas and his project of eliminating doubt by providing new foundations for scientific knowledge do not originate in the transparency of the mind and its privileged access to its contents. On the contrary, Descartes’ ideal of knowledge is only possible when reality is reduced to mechanical models with simple, repetitive, and regular patterns. Mechanical models, unlike their cybernetic counterparts, lend themselves to full analysis and formalization since mechanical systems/processes are fully analyzable. A dimension of complexity can be added to the dynamic and integrative model of human knowing as follows:

Dimension of Complexity	Operation/ Activity	Greek Equivalent	Level of Consciousness	Achievement	Proponent School of Thought	Method
Substance/ Nature	Experiencing	*Pathos*	Empirical	Representations (data)	Empiricism	Phenomenology
Structure	Understanding	*Logos*	Intellectual	Meaning	Rationalism	Analytic
Behavior	Judging Evaluating	*Ethos*	Rational	Value	Critical Realism	Critical
Function/ Purpose	Deciding Acting	*Praxis*	Responsible	Purpose	Pragmatism	Experimental

3. Systems Thinking

The system idea as a possible successor of the analytic model has not emerged from a process of argument and counterargument as it is usually assumed to happen in philosophy. With the success of the scientific model both in academic circles and in mundane affairs, many independent scientific disciplines have emerged, with each having its area of concern, its method, and its jargon. Within established disciplines, the multiplicity and levels of specialization have generated abundant, but unrelated scientific knowledge. This situation has demolished the scientific aim of establishing a unified and universal model of knowledge. This failure has been attested by the fact that mathematics has more and more failed to cope with scientific complexity. However, what renders the system concept a possible successor to analysis is that it transcends specific academic disciplines and particular realms of inquiry. As Bertalanffy points out:

> System theory is a broad view which far transcends technological problems and demands, a reorientation that has become necessary in science in general and in the gamut of disciplines from physics to biology to the behavioral and social sciences and to

> philosophy. It is operative, with varying degrees of success and exactitude, in various realms, and heralds a new world view of considerable impact.[52]

Linked to systems theory is the emergence of the study of entities that are different from the basic components that classical science was searching for. According to Bertalanffy:

> Entities of an essentially new sort are entering the sphere of scientific thought. Classical science in its diverse disciplines, be it chemistry, biology, psychology or the social sciences, tried to isolate the elements of the observed universe – chemical compounds and enzymes, cells, elementary sensations, freely competing individuals, what – expecting that, by putting them together again, conceptually and experimentally, the whole or system – cell, mind, society – would result and be intelligible. Now we have learned that for an understanding not only the elements but their interrelations as well are required: say, the interplay of enzymes in a cell, of many mental processes conscious and unconscious, the structure and dynamics of social systems and the like. This requires exploration of the many systems in our observed universe in their own right and specificities. It turns out that there are general aspects, correspondences and isomorphisms common to "systems". This is the domain of *general system theor*y; indeed, such parallelisms or isomorphies appear – sometimes surprisingly – in otherwise totally different systems.[53]

Therefore:

> General system theory, then, is scientific exploration of "wholes" and "wholeness" which, not so long ago, were considered to be metaphysical notions transcending the boundaries of science. Novel conceptions, models and mathematical fields have developed to deal with them, such as dynamical system theory, cybernetics, automata theory, system analysis by set, net, graph theory and others.[54]

In other words, the system idea has emerged from the fact that unrelated entities and processes have manifested similar patterns that render them better apprehensible as than systems, i.e. interrelated and interacting parts rather than merely superposed parts. Therefore, the focus has shifted from the study of the structure of the system (how the parts get together) to the study of its functioning and its history. In addition to this observed pattern in various scientific areas, the system idea has been made evident with the concurrent emerging of system technology. Bertalanffy has identified aspects such as the "hardware" of computers, automation, self-regulating machinery, and the "software" of new theoretical developments and disciplines.[55] The realization of the overwhelming presence of systems and the development of system technology has led to the formulation of a system approach or a system philosophy. According to Bertalanffy:

> There is *system philosophy*, i.e. the reorientation of thought and world view ensuing from the introduction of “system” as a new scientific paradigm (in contrast to the analytic, mechanistic, one-way causal paradigm of classical science). As every scientific theory of broader scope, general system theory has its “metascientific” or philosophical aspects. The concept of “system” constitutes a new “paradigm” in Thomas Kuhn’s phrase, [...] a “new philosophy of nature,” contrasting the “blind laws of nature” of the mechanistic world view and the world process as a Shakespearean tale told by an idiot, with an organismic outlook of the “world as a great organization”.[56]

System philosophy leads to the consideration of the observed universe as a system with material, mechanical, logical, and symbolic components, but also to the observer of this universe as a system with emotional, intellectual, ethical and, pragmatic (behavioral) subsystems. In this context, the knower is involved in a dynamic and integrative process of experiencing, understanding, judging, deciding, and acting within a dynamic and integrative world of material entities, which can be stationary or in motion, but which are also enriched with value and meaning and subordinated to purposes through various insights accumulated by various communities of inquiry. System philosophy, in the first instance, implies “system ontology”. According to Bertalanffy, “[f]irst we must find “the nature of the beast”. This is *system ontology* – what is meant by “system” and how systems are realized at the various levels of the world of observation”.[57] Therefore:

> What is to be defined and described as a system is not a question with an obvious or trivial answer. It will be readily agreed that a galaxy, a dog, a cell, and atom are *real systems*; that is entities perceived in or inferred from observation, and existing independently of an observer. On the other hand, there are *conceptual systems* such as logic, mathematics (but e.g. also including music) which essentially are symbolic constructs; with *abstract systems* (science) as a subclass of the latter, i.e. conceptual systems corresponding with reality.[58]

System ontology, in other words, acknowledges the complexity inherent in the order of things. Material reality at the atomic and the subatomic level is complex since the atom although defined as indivisible, contemporary research technologies have demonstrated the complexity of particles both at the atomic and subatomic levels. The same applies to living matter where a high degree of complexity has been observed. For instance, a cell is not merely a compound of its components, but also a milieu where complex physiological processes take place. Discoveries such as the DNA have demonstrated how complex patterns and messages can be embedded in organs that are very small in terms of physical size. The recognition of this complexity calls for a paradigm shift in metaphysics. Classical metaphysics is dominated by the concept of substance, which represents being and stability. It is a metaphysics that considers becoming and change as states of a lower ontological status. However, systems ontology creates a ground for a paradigm shift from a metaphysics of substance to a metaphysics of relation. This metaphysics of relation could include elements in spatial relations (patterns) and elements in temporal relations (successions, alternations, etc) in reality. This paradigm shift at the metaphysical level would consequently create an understanding of the world that accommodates a *systems epistemology*. According to Bertalanffy:

> This is profoundly different from the epistemology of logical positivism or empiricism even though it shares their scientific attitude. The epistemology (and metaphysics) of logical positivism was determined by the ideas of physicalism, atomism, and the "camera-theory" of knowledge. These, in view of present-day knowledge, are obsolete. As against physicalism and reductionism, the problems and modes of thought occurring in biological, behavioral and social sciences require equal consideration and simple "reduction" to elementary particles and conventional laws of physics does not appear feasible. Compared to the analytical procedure of classical science with resolution into component elements and one-way or linear causality as basic category, the investigation of organized wholes of many variables requires new categories of interaction, transaction, organization, teleology, etc., with many problems arising for epistemology, mathematical models and techniques.[59]

Therefore, the dynamic and integrative model of human knowing is part and parcel of systems epistemology. It does not define knowing as the acquisition of true justified beliefs, but as the accumulation of insights through "organizing intelligence". Organizing intelligence implies complex and multidimensional processes to the extent that the scientific study of aspects of human knowing, which people take for granted, has shown a high degree of complexity. For instance:

> Perception is not a reflection of "real things" (whatever their metaphysical status), and knowledge not a simple approximation of the "truth" or "reality." It is an interaction between knower and known, this dependent on a multiplicity of factors of a biological, psychological, cultural, linguistic, etc., nature.[60]

For this reason, system epistemology acknowledges that theories of multiple intelligences are a great challenge to normative epistemology. Whereas these theories, especially as articulated by Gardner, show that intelligence is linguistic, logical-mathematical, spatial, musical, bodily-kinesthetic, intrapersonal, interpersonal, and naturalist, the Lonerganian model, which is, in my view, the most encompassing one, upholds that knowing implies experiencing, understanding, judging, choosing, deciding, and acting. In this model, knowing cannot be reduced to thinking as normative epistemology has claimed, but it has dimensions of feeling, judging, deciding, and doing. Moreover, in contradistinction to normative epistemology that reduces knowing to an activity of the mind, in my view, knowing is an activity (or rather a series of activities) of the whole organism. In fact:

> Physics itself tells that there are no ultimate entities like corpuscles or waves, existing independent of the observer. This leads to a "perspective" philosophy for which physics, fully acknowledging its achievements in its own and related fields, is not a monopolistic way of knowledge. Against reductionism and theories declaring that reality is "nothing but" (a heap of physical particles, genes, reflexes, drives, or whatever the case may be), we see science as one of the "perspectives" man with his biological, cultural, and linguistic endowment and bondage, has created to deal with the universe he is "thrown in," or rather to which he is adapted owing to evolution and history.[61]

This is a dynamic and integrative process where we create meaning and value to reach our purposes. Enriching the data of our immediate experience with meaning and value generates information that is used as input for decision making and problem solving. This approach cannot define the human by isolating minimal or essential qualities, such as reason, freedom, and will, or by separating "mental" from "physical" processes. It recognizes that human physiological processes are part and parcel of an integrated, but differentiated pattern where a person integrates material and mechanical processes with logical and symbolic processes to live a purposeful and meaningful life. This idea of leading a purposeful and meaningful life can be summed up in the French word *sense*. In French, *sense* means both meaning and purpose. *Sense* is then created by enriching material objects with meaning and purpose by giving them a social significance. This dimension of meaning is important to humans as enriching material objects with value and meaning implies that natural objects are transformed into artifacts that humans use as intermediaries (media) in their own relations. It is this possibility of enriching material objects with meaning and value that makes human culture and communication possible. Human living is then essentially linked with the human person's natural relatedness, which is attested by the fact that at the individual level, the human person integrates various physiological processes that constitute a substratum for emotional and intellectual processes. However, as a related being, the human person is characterized by ethical and behavioral processes that are integrated with the emotional and the intellectual processes in a way that the individual is capable of relating to his or her human and non human environment by the use of natural and cultural resources. We relate to our environment physically, emotionally, intellectually, and practically. By giving objects significance, we transform natural objects into cultural artifacts. From our capacity to create value and meaning, knowledge, technology, and culture as creations of the human mind find their importance and their uniqueness. Our relationship to the transcendent does not have to be associated with religious beliefs. Instead, this relationship consists in our capacity to transcend our temporal and physical limitations. Many of our contemporaries may not be aware that ordinary practices, such as writing time tables, booking appointments, preparing budgets, writing wills, are transcendent exercises since they help us to deal with the future while we are still in the present. Likewise, processes such as keeping records, building monuments, and learning, help us to deal with the past while we journey into the future. This natural relatedness introduces "the relations of man and world or what is termed "*values*" in philosophical parlance"[62] in systems epistemology. Therefore:

> If reality is a hierarchy of organized wholes, the image of man will be different from it is a world of physical particles governed by chance events as ultimate and only "true" reality. Rather, the world of symbols, values, social entities and cultures is something "real"; and its embeddedness in a cosmic order of hierarchies is apt to bridge the opposition of C.P. Snow's "Two Cultures" of science and the humanities, technology and history, natural and social sciences, or in whatever way the antithesis is formulated.[63]

Hence, there is a need to shift from the Cartesian scientific reductionism and the analytic model to systems thinking. Systems thinking is:

> any process of estimating or inferring how local policies, actions, or changes influences the state of the neighboring universe. It is an approach to problem solving that views "problems" as parts of an overall system, rather than reacting to present outcomes or events and potentially contributing to further development of the undesired issue or problem.[64]

In other words:

> Systems thinking is a framework that is based on the belief that the component parts of a system can best be understood in the context of relationships with each other and with other systems, rather than in isolation. The only way to fully understand why a problem or element occurs and persists is to understand the part in relation to the whole.[65]

In practice, systems thinking implies taking both hard and soft systems into account. Hard systems involve problems that can easily be quantified while soft systems involve problems that cannot be easily quantified. Whereas problems involved in hard systems call for a structured decision process, problems involved in soft systems mostly appeal to context, personal judgment, flexibility, and adaptability on the behalf of the decision maker. Technically, it is easy to write algorithms about solutions to problems involved in hard systems while it is difficult (and sometimes impossible) to program solutions to problems involved in soft systems. The reason for this is that soft systems call for an appreciative aspect, unlike hard systems, which can be strictly described. In fact:

> In soft problems the designation of objectives is itself problematic. Not surprisingly, hard system thinking was not usable in these problems, which were always those of a kind to which the concept of human activity system was relevant. It was found impossible to start the studies by naming 'the system' and defining its objectives. Without this base, hard systems thinking collapses. During nine studies in 1969-1972 a different methodology was evolved and has been subsequently tested and modified in more than a hundred studies since then. Such work yields, beyond the action in specific situations, a cumulative account of the concept *human activity system*.[66]

The concept of human activity systems accommodates well our contention that knowing is, first and most of all, an activity of the knower and that this activity is multidimensional. As Checkland notes:

> Regarded as a whole, the soft system methodology is a learning system which uses system ideas to formulate basic mental acts of four kinds: *perceiving* (state 1 and 2), *predicating* (stages 3 and 4), *comparing* (stage 5) and *deciding* (stage 6). The output of the methodology is thus very different from the output of hard system engineering: it is learning which leads to a decision to take certain actions, knowing that this will lead not to 'the problem' being 'solved' but to a changed situation and new learning.[67]

In this process, "[w]e attribute meaning to human activity and our attributions are meaningful in terms of a particular image of the world, or *Weltanschauung* which in general we take for granted"[68]. Therefore, the shift from a mechanical *weltanschauung*, which defines reality in terms of *energy* that puts material particles in motion, to a cybernetic weltanschauung, which defines reality in terms of *information* that organizes complex systems through processes of control and feedback, implies an epistemology that integrates the analytical patterns of hard systems and the dynamic and integrative patterns of soft systems. This integration implies that instead of reducing knowing to thinking, one has to recognize that knowing is a fourfold process of experiencing, understanding, judging (choosing), and deciding (acting). In this perspective, knowing is not the activity of an isolated mind, but the activity of the whole human organism, which is not only dynamic and integrated, but also in relation with its environment through the integration of material, mechanical, logical, and symbolic elements. While the analytic model compels us to consider solely the structure of systems, the dynamic and integrative model, which we called systems thinking, does not only imply considering the structure, but also the function, the evolution (history), and the purpose (finality, teleology) of a system under investigation.

D. CONCLUSION

The recognition of the fact that human knowing is a multifaceted and multilevel process calls for the integration of the phenomenological, the analytic, the critical, and the pragmatic models. One of the contemporary attempts to integrate all these approaches is "systems thinking". This model is still developing and sometimes confused with its early phase that is interchangeably called "system's analysis". As Schultheis and Sumner have noted:

> The major objective of systems analysis is to understand the current system and to determine the importance, complexity, and scope of problems that exist. The scope and boundaries of the system, including its people and procedures, must be defined. Much of this phase involves collecting data about what is being done, why it is being done, how it is being done, who is doing it, and what major problems have developed.[69]

Systems analysis leads to systems thinking as opposed to a linear pattern of thought that characterized the scientific age. The linear pattern of thinking was based on an attempt to establish simple patterns of efficient causality and relationships between cause and effect, means and ends, and inputs and outputs. Systems thinking goes beyond simple patterns. It is a major characteristic of what Drucker calls "the information based organization"[70] and what Peter Senge calls "the learning organization"[71]. The learning organization is characterized by personal mastery, mental models, building a shared vision, team learning, and systems thinking"[72]. If we apply systems thinking, "we shift from seeing problems as caused by outside forces taking responsibility for our own actions and recognizing that these actions sometimes create the problems we experience"[73]. In other words:

> Systems thinking is a discipline of seeing wholes; it provides a framework for seeing interrelationships, rather than static events and snapshots. Systems thinking provides

> an antidote for a sense of helplessness that prevails in complex situations. Systems thinking builds in a feedback loop that does not imply causality and does not establish blame. In systems thinking everyone shares responsibility for the problems, and everyone shares responsibility for overcoming these problems.[74]

The concept of systems thinking was recently elaborated by Peter Checkland. He elaborated a system cycle that begins by showing how we pass from an area of reality that contains concerns, issues, problems, and aspirations. These aspects of the area of realty give rise to ideas from which theories can be formulated. These theories create problems within the discipline that may be analyzed by using models. These models may be manipulated using techniques that may be used in methodology. The methodology itself is to be used in action, (intervention, influence, observation) in documented records that support the criticism of the theories. In his own words:

> It [the systems model] assumes that the focus of interest is a set of concerns, issues or problems perceived in the real world about which we have aspirations. [...] Whatever the focus, it will lead to ideas from which we can formulate two kinds of theories, *substantive* theories about the subject matter (for instance a theory about catalysis in chemistry) and *methodological* theories concerning how to go about in investigating the subject matter. Once such theories exist, it is possible to state problems, not merely as problems existing in the world, but as *problems within the discipline*. All the resources of the discipline –previous results within it, its paradigms, models, and techniques – can then be used in an appropriate methodology to test that theory. The results from this test, which will itself involve action in the real world (intervention, influence, observation) will provide [...] 'case records', records of happenings under certain conditions. These provide the crucial source of *criticism* which enables better theories to be formulated, better models, techniques, and methodology to be developed.[75]

ENDNOTES

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CHAPTER FOUR

INFORMATION, KNOWLEDGE, WISDOM

A. INTRODUCTION

The concept of “the information society” is often associated with the development and the diffusion of electronic computers and related information and communication technologies (ICTs). According to C. S. French, for instance:

> Looking at the national and international community, and at the way organizations are run, highlights the fact that modern society is heavily dependent of the communication, processing and storage of information. It is claimed that we are moving towards an ‘information society’ in which the majority of the labor force will be engaged in Information Processing and the use of ‘Information Technology’.[1]

This approach can be misleading since it creates a situation where, when epistemology or philosophy of knowledge is linked to information, one is tempted to introduce a computer metaphor quickly. It would be easy, for instance, to claim that images such as Locke’s “tabula rasa” (borrowed from painting) or the contemporary “camera” generating “mental pictures” (a metaphor borrowed from photography) are outdated and that a computer metaphor that likens human mental processes to electronic computers, especially Turing machines and computer algorithms, provides a better model of description and an improved system of explanation. This fashionable temptation goes as far as to claim that the human mind – if not the whole universe - is a computer. This temptation has also been reinforced by findings from neurophysiology that indicate that brain processes at the cellular level are electrochemical, i.e. synapses send electrical signals rather than material particles. These findings seem to create a bridge between neurophysiology and electronics at the conceptual level and a bridge between biology and physics at a generalized level. Another factor that plays a role for this temptation is the sharing of terminology between neurophysiologists and Artificial Intelligence (AI) researchers, with concepts such as “neural networks” being used by these two groups of scientists.[2] This linking of the “information society” with electronic computers is also shared by the sociologist Anthony Giddens, who speaks of a "late modern age" where "[t]he media, printed and electronic, obviously play a central role"[3]. Despite the existence of mobile and wireless communication devices in the "information society", James Dearnley and John Feather portray the information society as a "wired world"[4]. Building on Manuel Castells' idea of a "network society"[5], Anthony Giddens devotes a whole chapter to "organizations and networks" in the 6th edition of his masterpiece *Sociology*[6], which is a step backwards, in my view, in comparison to his chapter "information as networks"[7] in the 4th edition. According to Giddens, "[t]he inherent flexibility and adaptability of networks give them enormous advantages over older types of rational, hierarchical organizations"[8].

The reference to "rational and hierarchical organizations" by Giddens points to another way of describing the "information society", namely, as a series of sociological transformations. The most sophisticated and pervasive description of the "information society" as a series of sociological transformations can be found in Daniel Bell's characterization of the "information society" as a "post-industrial society"[9]. Bell's assessment compares three types of societies, which he respectively characterizes as the pre-industrial, the industrial, and the post-industrial society. He compares these three types of societies following eleven criteria, namely (1) the mode of production, (2) the dominant economic sector, (3) the transforming resource, (4) the strategic resource, (5) technology, (6) the skill base, (7) the mode of work, (8) methodology, (9) time perspective, (10) design, and, (11) the axial principle.[10] For Bell, while in the pre-industrial society, the mode of production was mainly extractive, privileging economic sectors, such as agriculture, mining, fishing, timber, oil, and gas, the mode of production in the industrial society was fabrication, privileging the production of goods in sectors such as manufacturing, both durable and non-durable products, and heavy construction. The industrial society is being supplanted, in Bell's view, by the post-industrial society, which produces through processing information and focuses on the tertiary sector (i.e.

transportation, utilities), the quarternary sector (trade, finance, insurance, real estate), and the quintinary sector (health, education, research, government, recreation entertainment). These sectors also differ from the point of view of their transforming resource. On the one hand, the pre-industrial society mainly relied on natural power, i.e. wind, water, draft, animal and human muscle, while the industrial society depended on created energy, i.e. oil, gas, nuclear power. The post-industrial society, on the other hand, relies on information and knowledge, i.e. programming and algorithms, computer and data-transmission. According to Bell's view, the strategic resource of the pre-industrial society was raw materials while for the industrial and the post-industrial societies, the strategic resources are respectively financial and human capital. The technology of the pre-industrial society was craft, the industrial society used machine technology while the post-industrial society uses intellectual technology. Bell indicates that, therefore, the skill base for the pre-industrial society was the artisan, the manual worker, or the farmer while in the industrial society, the skill base was embedded in the engineer and the semi-skilled worker. In the post-industrial society, the skill base lies in scientific, technical, and professional occupations. The mode of work in the pre-industrial society was physical labor, in the industrial society the division of labor, and in the post-industrial society it is networking. The pre-industrial society relied on common sense, trial and error, and experience, while the industrial society's methodology was empiricism and experimenting. The post-industrial society has devised various "new" methodologies, such as models, simulations, decision theory, and systems analysis. The temporal orientation of these three societies is also different since, according to Bell, the pre-industrial society was oriented to the past while the industrial society reacted to the present through ad-hoc adaptiveness and experimentation. The post-industrial society is future-oriented through forecasting and planning. The mode of design of the three societies is described by Bell as a series of games; the pre-industrial society played a game against nature, the industrial society played a game against fabricated nature while in the post-industrial society, persons play games against each other. The respective axial principles of these three types of societies are traditionalism for the pre-industrial society, productivity for the industrial society, and codification of theoretical knowledge for the post-industrial society. A detailed schematization of Bell's comparison of the pre-industrial, the industrial, and the post-industrial society can be found in the first appendix.

Moreover, in addition to linking the information society with electronic computers and related information, communication technologies (ICTs), and outlining the social transformations that is brings with it, there is an intrinsic link between information and knowledge in the information society. Bell describes the information/post-industrial society with eye-catching concepts, such as "processing information", and "information and knowledge", which he associates with "programming and algorithms, computer and data-transmission", "intellectual technology", "networking", "codification of theoretical knowledge", and so forth. Other authors, such as Dale E. Zand, refer to knowledge explicitly by talking merely about "the knowledge society"[11] rather than "the information society". The prominent role of knowledge in the "information society" is outlined by Drucker. For him, the "knowledge worker", an expert, is replacing the semi-skilled worker of the massive production of the industrial society. The semi-skilled worker is, in fact, the fruit of Cartesianism, i.e. the habit to "break apart problems, to fragment the world"[12]. The semi-skilled worker was precious in the industrial society since, at that time, the industrialist "analyzed tasks and broke them down into individual, unskilled tasks that could be learned quite quickly"[13]. It is this association of the information society and knowledge that catches the eye of an epistemologist with the possibility of undertaking an epistemological study of the information society. This undertaking is worthwhile as the information society, in addition to being a series of technological and sociological developments, is a paradigm, i.e. in Kuhn's words, "universally recognized achievements that for a time provide model problems and solutions to a community of practitioners"[14]. It is from the point of view of information as a paradigm that this philosophical study of the epistemological implications has been undertaken. Although there have been paradigm changes from a normative epistemology based on representation to a dynamic and integrative epistemology based on information processing, from a mechanical model of reality to a cybernetic model, and from the analysis synthesis dichotomy to systems thinking, one crucial question remains. What is philosophical about information? This chapter aims at answering this question by putting the notion of information in relation to two other important philosophical concepts, namely the concept of knowledge as this study has the aim of being a study in epistemology (philosophy of knowledge), and the concept of wisdom that etymologically defines philosophy. According to Luciano Floridi, one of the leading scholars in the area of philosophy and information [or philosophy of information, one may even say]:

> [P]hilosophy grows by impoverishing itself. This is only an apparent paradox: the more complex the world and its scientific descriptions turn out to be, the more essential the level of the philosophical discourse understood as philosophical prima must become, ridding itself of unwanted assumptions and misguided investigations that do not properly belong to the normative activity of conceptual modeling. The strength of the dialectic of reflection, and hence the crucial importance of one's historical awareness of it, lies in this transcendental regress in search of increasingly abstract and more streamlined conditions of possibility of the available narratives, in view of their explanation but also of their modification and innovation. How has the regress developed? The scientific revolution made seventeenth-century philosophers redirect their attention from the nature of the knowable object [i.e. ontology] to the epistemic relation between it and the knowing subject, and hence metaphysics to epistemology. The subsequent growth of the information society and the appearance of the infosphere, the semantic environment in which millions of people spend their time nowadays, have led contemporary philosophy to privilege critical reflection first on the domain represented by the memory and languages of organized knowledge, the instruments whereby the infosphere is managed – thus moving from epistemology to philosophy of language and logic (Dummett 1993) – and then on the nature of its very fabric and essence, *information itself. Information has thus arisen as a concept as fundamental and important as being, knowledge, life, intelligence, meaning, and good and evil – all pivotal concepts with which it is interdependent – and so equally worthy of autonomous investigation. It is also a more impoverished concept, in terms of which the others can be expressed and interrelated, when not defined.*[15]

This chapter will tackle this task in three steps. Firstly, it will detail the notion of information taking into account dimensions of order, behaviour and purpose as a way of describing the dynamism and integrative patterns embedded in the notion of information itself. This description can be an alternative to the predilection for fixity that is embedded in mechanical descriptions which define reality in terms of matter, motion, and immutable universal laws that are based on assumptions of order, simplicity and regularity in the universe leading to a energy based model. Secondly, a parallelism will be established between the notion of information processing, i.e. enriching data with value and meaning and subjecting them to purposes such as decision-making and problem-solving, and Lonergan's epistemological framework that defines knowing as accumulating insights through experiencing, understanding, judging (choosing, deciding), and acting. Thirdly, the notion of wisdom that defines philosophy etymologically will be examined in relation with knowledge (the object of epistemology) and information, the paradigm of our inquiry in this work. Last but not least, the way wisdom is applied in decision-making and problem-solving will be presented and a claim for integrating individual human rationality with institutional rationality will be established.

B. THE NOTION OF INFORMATION

1. Information as Patterns of (Self-)Organizing Matter and Energy

In this thesis so far, the notion of information has been presented from two angles. On the one hand, information has been presented according to Norbert Wiener's definition as "negative entropy"[16], i.e. "negative disorder", and hence, "positive order" or the measurement of a certain "degree of organization". On the other hand, information processing has been presented as enriching immediate data of experience with meaning and value for the purpose of decision-making and problem-solving.[17] Although these two notions of information seem to be remote from each other, they still conform to a cybernetic model that views "things social as interacting processing systems"[18] and "appreciate[s] the importance of communication and control in all such systems"[19]. However, although our approach from the onset has been historical by looking at the "information society" from the point of view of changing paradigms,

> history alone cannot explain why it is information that increasingly plays the crucial role in economy and society. The answer must be sought in the nature of *all* living systems – ultimately in the relationship between information and control.[20]

Cybernetics is, in fact, a science of "*Control and Communication in the Animal and the Machine*"[21], as Wiener has subtitled his book. However, the concept of information itself remains multifarious as:

> All the philosophical and social problems associated with the new information and communication technologies can be directly and indirectly related to one scientific category. This category is *information.* It has emerged in biology as hereditary information and behavioural control; in psychology it is associated with the phenomena of cognition, thinking and memory, as well as the question of communication and sense in human behaviour; in economics, it gives rise to a key technology; and in informatics it serves as a basis for modelling human mental processes.[22]

Information, as a scientific category, transcends disciplinary boundaries, on the one hand, and defies traditional definition of material objects in terms of physical extension or mental processes by opposing them to physical objects, on the other hand. However, this is not to say that information lacks spatial modes of existence. In fact, Wiener's definition of information as "negative entropy" gives pertinence to the idea of information as patterns of (self-)organizing matter and energy. This idea of information is linked with the fact that information appears in terms of spatial arrangements, be they arrangements of molecules and their parts (eg. DNA) at the macro-molecular level, arrangements of nerve cells and impulse patterns in the vertebrate nervous system, spatial arrangements of objects in the environment, spatial arrangement of signs in mediated reality, such as language (social form of language), or spatial arrangements of signs in meta-forms (personal forms of language or highly formalized languages, such as rules of logical inference, mathematical operations, and computer algorithms, which only apply to restricted domains).[23]

These spatial arrangements lead to various forms of consciousness. At the macromolecular level, the totality of molecules, their parts and their connections, lead to the interaction of molecules and their parts on the basis of electrochemical signals.[24] However, it is this totality of impulse patterns as an indivisible quality that controls behavior. These impulse patterns themselves are based on the spatial arrangements of nerve cells and impulse patterns in the brain. It is at this level that the brain's function of control is located and some contemporary philosophers of mind do not hesitate to locate mental activity at this level. However, it is the third level of organization of material objects in the environment that leads to a consciousness of objects in the environment as the totality of these objects in situations is seen as indivisible qualities which lead to meaningful reactions, to impulse patterns and their causes in the environment.[25] At this level, most normative epistemologists locate the point of departure of epistemology as a discipline by separating processes that occur at the macromolecular level and in the nervous systems (especially in the brain), i.e. "internal processes", from processes that depend on spatial arrangements of objects in the environment, i.e. "external processes". In standard normative epistemology, "internal processes" are considered as subjective, i.e. occurring within the knower, while "external processes" are considered as objective, i.e. constituting the reality or the object to be known. However, by going back to the macromolecular level in assessing information as patterns of (self-)organizing matter and energy, the gap between the subject and the object can be bridged as instead of a top-down approach that assumes that mental processes are non-material processes that occur within non-material processors, there is a possibility of reversing the trends and suggesting a bottom-up approach that does not only take our genetic heritage as a species into account, but also the physiological processes that the *homo sapiens* shares with other members of the animal kingdom. This bottom-up approach extends the boundaries of epistemology as a discipline since instead of focusing on the process of human knowing in the normal human adult, this approach looks at different time-frameworks that include how the genetic and physiological processes sustaining the process of human knowing have been established through selection and adaptation, on the one hand, and how the patterns of spatial arrangements of material objects in the environment influence physiological processes that lead to different patterns of behavior at the levels of psychomotor activities. These bottom-up activities challenge arbitrary boundaries within the animal kingdom, such as those established between humans and animals, and those that separate rational and instinctive patterns of behavior. Moreover, this approach can provide a solution to the problem of other minds as it does not suggest to begin the apprehension of knowing processes from an individual isolated mind, as it is done in the Cartesian tradition, but it begins by acknowledging that different patterns of spatial arrangements constitute the material, mechanical, or physiological basis (hardware) of the process of human knowing and that these spatial arrangements are not restricted to the physical constitution of the knower (i.e. the body as opposed to the mind). There is a continuum between spatial arrangements at the macromolecular level and at the level of the nervous system, but the impulses at these levels do not activate themselves. They are set into activity as "[t]he totality of objects in situations" is considered as "indivisible qualities"[26]. In other words, the consciousness of the environment arises when objects in situations are processed as indivisible qualities leading to meaningful reactions, to impulse patterns and their causes in the environment.

The level of consciousness of objects in the environment still corresponds to normative epistemology's realm of inquiry that restricts knowing to invariant relationships between invariant characteristics of material objects (essences or universals) and invariant non-physical processes "in" the human mind leading to universal and objective knowledge, which can easily be formulated into univocal propositions of the form S is P. However, this restriction of the domain of inquiry of epistemology is not only tributary to the attempts of modelling philosophy in general and epistemology in particular after the physical sciences, with the search for immutable universal laws that can be formulated into simple mathematical relations, but it also misses the fact that spatial arrangements of material objects are not established once and for all. Therefore, changes of the spatial arrangements of material objects in the environment may lead to changes in the patterns of impulses at the macromolecular level or at the level of the nervous system and, subsequently, to changes of behavior. Moreover, changes in the spatial location of the organism, which embodies the macromolecular and neurophysiological processes at hand, may equally lead to changes of the patterns of impulses and connections in such a way that behavior is changed. What normative epistemology misses by reducing the relation between the subject and the object to an invariant representation process, which is objective and universal, is "[t]he principle of *no immediate instructive interaction*"[27]. According to this principle, as stated by Fuchs-Kittowski, "[i]t is insufficient to view the generation and use of information only in terms of reception of available information from the outside world in order to obtain a direct representation"[28]. In fact:

> In studying the essence of information in living systems it becomes apparent that here information is not simply transmitted in one-sided, directed processes. Instead, the exchange takes place in a meaningful context allowing an evaluation and a creation anew.[29]

Therefore, the spatial arrangements that constitute the basis for conceiving information as patterns of (self-)organizing matter and energy are not limited to the spatial arrangements of material objects in the environment. Reducing reality to material objects leads to a mechanistic materialism that defines reality in terms of matter and motion and seeks immutable universal laws for an invariable relation of representations of the object by the subject. However, dynamic and integrative epistemology acknowledges the material and natural aspect of objects, but also their cultural value and symbolic significance. The symbolic significance of objects is at the origin of human culture and communication since humans can use these objects as intermediaries (media) for their own interaction. The fourth level of consciousness is, therefore, according to Fuchs-Kittowski, the consciousness of society, which is achieved through the spatial arrangements of signs in language (social form of language) with the totality of established forms of language leading to the communication of meaning in social interaction.[30] That is why a dynamic and integrative epistemology does not define the human person by isolating minimal or essential qualities, such as reason, freedom, and will, that are believed to constitute an immutable core, or by separating "mental" from "physical" processes. It recognizes that human physiological processes are an essential part of an integrated, but differentiated pattern, and this pattern makes human living possible by maintaining the human internal environment within certain limits through metabolism and homeostasis, but also by interacting with the human immediate and mediated environment. Human living is then essentially linked with the human person's natural relatedness. At the individual level, the human person integrates various physiological processes that constitute a substratum for emotional and intellectual processes. As a related being, the human person is characterized by ethical and behavioral processes, which are integrated with the emotional and the intellectual ones in such a way that the individual is capable of relating to his or her human and non human environment through the use of natural and cultural resources. Natural and cultural resources are part of an information and communicative process since, as vehicles of meaning and value, they are intermediaries, i.e. media that allow human persons to live purposeful and meaningful lives.

This unity of purpose and meaning is embedded in the French word *sens*. Therefore, human living makes sense through one's partaking in a human history that goes beyond one's limited life time. Through signs and symbols that are at the origin of purposeful and meaningful communicative processes, the human person transcends one's temporal and spatial boundaries and reaches out to other persons on the one hand, and on the other hand, creates techniques and technologies that allow the person to dig into the abyss of history and collective memory and, at the same time, to face challenges and seize opportunities of the present and to make plans for the future. Many of our contemporaries are not aware that usual practices, such as preparing budgets, making timetables, booking appointments with other people, are expressions of this self-transcendence since these are ways of handling the future while we are still in the present. The same applies to practices, such as keeping records and archives, that are ways of handling the past while our lives move forwards in the future. This explains the double sense of the French world *sens*, which means both meaning and purpose. Our lives make sense as we can look both forwards and backwards without losing the grip on the present. This is an essential quality of humans that allows them to partake in both natural and cultural resources.

It is through transcending one's temporal and spatial boundaries that one reaches the fifth level of organization, which is for Fuchs-Kittowski, the consciousness of Self and Values through the spatial arrangements of signs in meta-forms (personal form of language) where the totality of selected forms of language leads to the communication of meaning in personal interaction.[31] It is this consciousness of Self and Values that justifies the dimension of human knowing as self-appropriation.[32] Knowing as self-appropriation compels us to acknowledge that it is the knower and not the object of knowledge who is at the center of the process of human knowing. The knower is not solely a rational being in the intellectual sense, but a multidimensional unity with emotional, intellectual, ethical, and behavioral capabilities. The knower integrates the physical dimension made of material, mechanical, and electrochemical processes with logical and symbolic processes. Whereas the former renders the knower a natural being, the latter renders the knower a cultural being. As a cultural being, the knower is a creator of value and meaning as by enriching natural objects with value and meaning, the knower turns natural objects into artifacts. Therefore, any process of information generation through enriching data with value and meaning is an artificial, or better, an artful process. It is at this level of artistic creation that human natural processes, such as material, mechanical, and electrochemical processes, are given a cultural significance that goes beyond their material value and utility. On this account, gestures, such as greeting, do not have any value in terms of material utility, but yet, they are very important for human interaction due to their symbolic significance. The same applies to other symbols of status or power, such as bank notes, academic certificates, and contracts, which in terms of their natural constitution (hardware) are simple and almost valueless pieces of paper, but in terms of their symbolic significance (software) they acquire a high value and importance.

However, the notion of information as patterns of (self-) organizing matter and energy would remain unclear, unless one refers to the scientific milieu on which Wiener based his definition of information as negative entropy. The concept of entropy was borrowed from thermodynamics because, as Beniger has pointed out:

> questions raised about the organization of non-living matter early in the nineteenth century culminated in thermodynamics, the science of heat and its relationship to other energy forms.[33]

Thermodynamics, as a science, has emerged in a scientific paradigm dominated by mechanical models. Mechanical models, by defining reality in terms of matter and motion, consider energy as the underlying principle of all moving and self-moving systems and processes. With the demystification of air and the awareness that air is merely a material substance, the scientific principles which natural sources of motion followed are more and more better understood. Thermodynamics, in this context, has emerged with two apparently contradictory laws. The first law of thermodynamics, or the law of the conservation of energy, states that:

> In closed systems defined by impermeable boundaries, energy must remain constant in keeping with the first law of thermodynamics, the so-called principle of the conservation of energy, that matter and energy can neither be created nor destroyed.[34]

However, the second law of thermodynamics points to a continuous disorganization of matter owing to the loss of energy by doing work, for instance. In other words, there is a relation between the conservation of energy and the organization of matter. Beniger has pointed out that:

> According to the second law of thermodynamics, the so-called principle of the degradation of energy, a system's energy cannot be converted from one to another – including work – without decreasing its organization and hence abilities to do further work. A steam engine for example, can work only so long as it is organized into relatively more and less heated parts, the organization known as a *heat gradient.* Because this total energy must remain constant, the energy available to do work can only decrease.[35]

The second law of thermodynamics, which is considered as one of the great discoveries in scientific history, points to the fact that energy is not a derivative of material bodies in motion, but that there is a possibility of converting matter into energy leading nevertheless to a disorganization of matter. From this point of view, systems and processes that lack continuous supplies of energy would be condemned to destruction owing to the fact that since:

> this total energy must remain constant, a closed system can only lose its ability to do work. Inevitably, by the second law, such systems must lapse into the state of totally unorganized, randomly distributed, inconvertible particles, the state of totally bound energy known – appropriately enough as *heat death*.[36]

Therefore, according to the second law of thermodynamics, systems and processes that do any work are bound to convert matter into energy leading to their disorganization. However, living organisms seem to violate the second law of thermodynamics as they can do work and remain organized. This implies that their loss of conversion of matter into energy does not lead to their loss of structure. Beniger has noted this fact that living systems "sustain and even increase their organization, continuing to do work for many years in a apparent contradiction of the second law"[37]. This apparent contradiction is due to the fact that living organisms have been, most of the time, considered as closed systems. They have been considered as individual units with individual bodies embodying individual minds. Understanding humans as individual units would imply limiting their definition within the physical boundaries of physical bodies, which would delineate the limits between "internal processes" and "external processes." However, in epistemology, the words "internal" and "external" are used metaphorically as they do not refer to what happens inside and outside the skin, but to physical processes that are defined as *res extensa* and mental processes defined as *res cogitans.* However, looking at living organisms as violators of the second law of thermodynamics is due to the top-down approach that defines reality in terms of individual essences that are replicated in many copies of similar kinds. However, the bottom-up approach that looks at information as patterns of (self-)organizing matter and energy would imply looking at individual organisms not in isolation, but in constant interaction with their environments. The scientific community has become aware of the fact that the second law of thermodynamics has not been violated:

> as living organisms came to be seen, like the steam engines whose coal smoke blackened the skies of nineteenth-century industrial towns, not as closed systems but as open ones, that is systems with continuous inputs and outputs of matter and energy.[38]

Understanding living systems as open systems does not only explain how to solve the problem of the apparent violation of the second law of thermodynamics, but it also shifts the boundaries that are not only established between humans and other members of the animal kingdom on the one hand, but also between living organisms and inorganic matter on the other hand. Thermodynamics establishes a relation of symbiosis between inorganic matter and living organisms. On the one hand:

> Just as steam engines run off organic energy stored in wood and coal, vegetation also gets its energy from outside sources, usually actually directly from the sun through photosynthesis while animals steal energy from other organisms by eating them.[39]

On the other hand:

> Like steam engines, living things are open systems that continuously lose energy to their environments – witness the heat of the cushion beneath the cat. Even wastes excreted by living systems retain some energy in their molecules and this, too, is lost.[40]

The second law of thermodynamics, by linking conversion of matter into energy with the loss of structure, points to the intrinsic link between conversion of matter into energy and conversion of one form of energy into another with order or negative entropy. The only way to avoid "heat death" in living systems is control since:

> Thermodynamics thus explains what it is that all living systems must control, and why such control is essential to life itself. All open systems, if they are to postpone for a time their inevitable heat death, must control the extraction and processing of matter, its internal distribution and storage, continuous conversion into energy, and elimination as by-product wastes. Living organisms, for example, convert energy originally from the sun into forms more useful to the processes of life: body heat, chemical energy for metabolism, electric energy to fire nerve impulses, mechanical energy to contract muscles and move about (luminescent organisms can even convert the energy back into light).[41]

Therefore, defining information as patterns of (self-)organizing matter and energy implies linking the notion of information with structure. In fact, unstructured systems and processes are meaningless since the "amount of information" that systems and processes convey depends on their "degree of organization". Information is intrinsically multifarious and can be located at various levels of spatial arrangements that range from the macromolecular level (DNA, for instance) and include spatial arrangements of nerves and their impulses in the nervous systems, arrangements of material objects in the physical environments, and at a more abstract level spatial arrangements of signs and symbols that elevate material objects beyond their materiality and render them bearers of value and meaning. Spatial arrangements of signs include (syntax in human languages), but abstract symbols can reach a level where meaning and reference are fixed as a way of rendering these signs universal. Cases of symbols with fixed meaning and reference include, for instance, rules of logical inference, mathematical operations, and computer algorithms. At the other end of the continuum, there are symbols that mediate between humans and their human and non-human environment. Humans can attach values and meanings to objects and situations in such a way that allows them to attach various levels of importance to material objects and their attached meaning and value creating the possibility of solving ill-structured problems and pursuing complex and changing goals.

2. Information and Control

When defining information as patterns of (self-)organizing matter and energy, one becomes aware of the role of control in maintaining living systems alive. For this reason, Wiener does not separate information and control in his description of a cybernetic model as a science of information and **control** in the animal and the machine.[42] There are, in fact, striking similarities between Fuchs-Kittowski's "levels of information"[43] and Beniger's "levels of control"[44]. Both Fuchs-Kittowski and Beniger locate the first level of information or/and control at the macromolecular level (DNA) where, for , life is generated through genetically based sociality (many animal species) following an intermediate stage where replicating molecules generates diversity according to their level of success in reproducing exact copies. The first level of control corresponds to the stage of organic life. At all stages of control, Beniger distinguishes processors, i.e. spatial arrangements and programming, i.e. the presence of instructions or programs that guide subsequent behavior. A program, according to Beniger, is "any prearranged information that guides subsequent behaviour"[45]. This information at the macromolecular level of the DNA is genetically programmed. Control, on the other hand, is "purposive influence towards a predetermined goal"[46]. By looking at the levels of control (or levels of information in Fuchs-Kittowski's vocabulary) in terms of processors and programming, Beniger points to the fact that at the macromolecular level, molecules are not mere material entities, but, by bearing genetically inherited programs, they are geared for change, and not any kind of change, but a change that is predetermined by the genetic heritage. In other words, spatial arrangements of macromolecules enable these macromolecules to effect control, i.e. to fulfill predetermined goals. The dialectic of information and control, therefore, implies that living organisms are both past- and future-oriented. Genetically inherited programs tend to maintain some physiological and behavioral patterns that individual organisms have inherited from their species, but, at the same time, the ability to fulfill predetermined goals that imply that these behavioral patterns can change as goals change and that, in the long term, even the physiological patterns can change. Adaptation to changing goals, therefore, implies a possibility of change either at the structural (physiological) level or at the behavioral level. Hence, this potential for change calls for models that emphasize not only the fact that structures embody information but also the given the dynamic and integrative nature of the notion of information itself embodying information implies that information processing systems can not only change their structuring, but also their functioning following changes of goals or changes in the environment. Following this poing of view, the particularity of mechanical models resides in eliminating dynamic and integrative patterns through the fixing of goals, structure and function in a way that this triple level of fixation leads to invariant laws of transformation that are embedded not in the order of things but in systems of control that fixe one or the other aspects. This understanding of fixity as an exception rather than the rule leads to what Fuchs-Kittowski calls a "no-substance-understanding"[47]. A no-substance understanding implies that:

> Information is not a non-physical substance, a 'thing' whose identity is independent of any physical body to which it may temporally be 'attached'. Information must be understood as a specific effect and as a relationship.[48]

Therefore, looking at information as a special effect and as a relationship implies giving up a top-down approach that postulates that reality is constituted at the highest abstract level by substances that are exemplified by individual kinds. These substances are often associated with similarities that members of a species share. These similarities are believed to be unchanging, or the more unchanging they are, the more substantial they are considered to be. This is a vestige of ancient philosophical approaches that associated reality with permanence and change with appearance. However, a bottom-up approach that defines information as (self-)organizing matter and energy upholds that information is not an epiphany of essences, but the outcome of processes in the physical world where energy is not just a derivative of matter in motion, but a constituent of reality as a guarantor of change, growth, or decay. On that account, at the first level of control that Beniger associates with organic life, the macromolecules are not passive material entities, which would play the role of fundamental particles like those sought by physical chemistry, but integrated entities and processes, which embody their material constituents, the order in which these constituents determine the macromolecules structures, and the ways by which these macromolecules fulfill predetermined goals by following genetically inherited programs. A similar pattern can be observed at the second level of control, i.e. culture.[49] At the cultural level, control is effected through culture-based social structures that reinforce learned behavioral programs, which are stored in the vertebrate brain.[50] At this level, Beniger and Fuchs-Kittowski still agree on the role that spatial arrangments of neurons and their impulses play in determining levels of information and/or control. However, Beniger does not make provision for the spatial arrangements of objects in the environment. For Fuchs-Kittowski, it is the spatial arrangements of objects in the environment that are at the origin of the consciousness of objects. The consciousness of objects in the environment is at the origin of the traditional epistemological problem of distinguishing objects from subjects. Beniger, by skipping this aspect, locates control at the spatial arrangements of signs, in language for instance - the fourth level of information – without explaining how these signs have been formed in the first place. Beniger is right in stating that the vertebrate brain is the processor of learned behavioral programs that are themselves controlled by programming stored in memory.[51] However, these learned behavioral patterns are not independent of genetically inherited programming, which could have emerged on a long time scale from the direct interaction of former members of the species with spatially arranged objects in their environment. This interaction can explain the abilities of identifying useful and harmful substance in most animal societies, the development of the means of locomotion and communication that allow the access to useful objects and the avoidance of harmful objects, the organs and strategies of defence against harmful predators, the choice of habitats that are conducive to growth and reproduction, sedentarization or migration patterns that allow survival by remaining in useful habitats and leaving harmful habitats, the size of the populations in the same habitat, and the physical size and dexterity of individual kinds that allow either individual survival or survival in groups of different sizes. Beniger, therefore, locates culture from the point of view of how it is assimilated by individuals, unlike Fuchs-Kittowski, who places communication of meaning in social interaction before the consciousness of Self and Values, which leads to the communication of meaning and the creation of values in interpersonal interaction.

In other words, Beniger locates culture at the level where individual members of a species have self-appropriated, learned behavioral programs, unlike Fuchs-Kittowski, who places self-appropriation at the highest level of information after the consciousness of society. This difference in the levels where culture is located implies a difference in priority for Fuchs-Kittowski and Beniger. By omitting the consciousness of objects in the environment, Beniger takes the fact that sociality is always (or already) mediated for granted. However, Fuchs-Kittowski, upholds a principle of "*no immediate instructive interaction*"[52]. According to this principle, "[it] is insufficient to view the generation and use of information only in terms of a reception of available information from the outside world in order to get a representation"[53]. The reason for this is that, at the first level of control, the vertebrate brain, as a processor, is not a black box through inherited genetic programs, on the other hand, it is influenced by the long-term history of the species to which it belongs since this history does not only determine its physiological constitution, but also its inborn behavioral patterns that every member of a species shares with other members. At the second level of control, the vertebrate brain on learned behavioral programs that are acquired, in the case of humans, through early education and experience and that are developed and adjusted through adult life. The influence of the long-term past of a species and the short-term past (experience) of individuals on the constitution and the functioning of organs, such as the vertebrate brain, leads to a rejection of the definition of the human mind by categories that are borrowed from a metaphysical dualism that associates reality with permanence and change with appearance. Human minds do not only change as processors (vertebrate brains), but also in their programming. The latter, in humans for instance, changes due to genetic inheritance, experience, and education.

The third level of control, which would correspond to Fuchs-Kittowski's consciousness of society, is, for Beniger, bureaucracy. For him, bureaucratically controlled social systems imply formal organization of individuals through explicit rules and regulations.[54] The bureaucratic levels of control include collective conscious planning and predetermination of goals and means to achieve them. Bureaucratic structures and processes, therefore, operate through a process that Weber and his interpreters called *rationalization.* According to his interpreters:

> Weber identified another related control technology, what he called *rationalization.* Although the term has a variety of meanings, both in Weber's writings and in the elaborations of his work by others, most definitions are subsumed by one essential idea: control can be increased not only by increasing the capacity to process information but also by decreasing the amount of information to be processed.[55]

Rationalization, in Weber's context, implies standardization of systems and procedures so that similar data would lead to similar decisions and actions regardless of the personal judgment of the bureaucrat processing them. Understood in relation to a mechanical model of the universe, rationalization through bureaucracy implies automating behavior. In this way, bureaucracy can reduce favouritism as individuals in the same situation, i.e. provided with similar data, would be treated the same way. However, rendering bureaucracies efficient implies reducing the information to be processed to the strict minimum. In some situations, the information entered in bureaucratic systems is so standardized that it amounts to the reification of persons. From this point of view, therefore, rationalization implies a shift from "the government of men, to the administration of things"[56]. This is possible as:

> The reason why people can be governed more readily qua things is that the amount of information about them that needs to be processed is thereby greatly reduced and hence the degree of control – for any constant capacity to process information - is greatly enhanced.[57]

Therefore, the process of "rationalization might be defined as the destruction or ignoring of information in order to facilitate its processing"[58]. This is what happens in the model of rationality supported by normative epistemology, by which reality is defined as matter in motion with the assumption that at the lowest level of hierarchy there are fundamental particles that cannot provide any other information except for their material constitution and, in case they are set in motion, their mechanistic characteristics. The same principle is applied to mental artifacts when human knowledge is reduced to univocal propositions that can be formalized into symbols with fixed meaning and reference. Beniger, therefore, by locating the second level of control at the level of culture without making any reference to the spatial arrangements of objects in the environment, focuses on the outcomes of situations where material objects have acquired social significance through their social role and the meaning and value that humans attach to them as the object of his inquiry. The principle of rationalization has been applied so pervasively in modern societies that it is now assumed that:

> By means of rationalization, therefore, it is possible to maintain large-scale, complex social systems that would be overwhelmed by a rising tide of information they could not process were it necessary to govern by particularistic considerations of family and kin that characterize preindustrial societies.[59]

In other words, rationalization reduces the amount of information to be processed as a way of increasing the speed of processing. Rationalization conforms to the epistemological model of modern science since complexity is eliminated by idealizing physical bodies as points or, at least, by postulating the existence of simple fundamental particles. The complexities and ambiguities embedded in the description of reality are reduced by strict definitions while usual aspects of human language, such as synonymy and polysemy, are avoided through the use of formal languages. Rationalization, therefore, implies the generation of “clear and distinct” ideas, not through the transparency of the mind, but through the fixation of meaning. Moreover, rationalization eliminates ambiguity and the peculiarities linked with individual personal judgments through clear definitions, hence, generating a closed system of meanings and representations that can sometimes make scientific disciplines look like esoteric societies where the initiated can only understand both the vocabulary and the symbolism. Rationalization, therefore, eliminates particularity in the quest of universal descriptions and universal rules of transformation through the fixation of meaning and reference. The objects of a totally rationalized process would imply “clear and distinct ideas” that are represented the same way every time and everywhere through the fixation of meaning and the elimination of individual personal value judgments so that these representations acquire universality. Although in normative epistemology and modern science it has been assumed that the two disciplines mainly deal with universals and not particulars, and that universals represented by universal symbols can be acted on through logico-deductive processes, the process of rationalization is an ad-hoc activity, which is only possible when immediate data of experience has been preprocessed as a way of preparing it to be processed by systems that act on unambiguous, context-free environments. These types of processors require preprocessing as a way of reducing immediate data of experience to universal symbols by eliminating aspects that are not relevant to the processing context. Therefore, in a bureaucracy, for instance, people are defined according to similar and objective criteria that are only relevant to artificial processing environment. For instance, one’s weight may be an important criterion to be taken into account in sports, such as boxing or health control; however, a university does not need to know the weight of a student registering for an exam (unless the exam takes place in an artificial environment that can only support a limited amount of weight). In brief, although rationalization through bureaucratization increases controls, it reduces the amount of information. It is paradoxical "that the proliferation of paperwork is usually associated with a growth of information to be processed and not its reduction"[60]. However, whatever the common perception may be, the increase in paperwork decreases the amount of information. For instance:

> Imagine how much processing would be required [...] if each new case were recorded in an unstructured way, including every nuance and in full detail, rather than checking boxes, filling blanks, or in some other way reducing the burdens of the bureaucratic system to only the limited range of formal, objective and impersonal information required by standardized forms.[61]

In other words, like bureaucracy, normative epistemology rationalizes by reducing human knowing to its formal, objective, and impersonal aspects. Processes of rationalization both in society, modern science, and epistemology aim at a form of knowledge that is described as "clear and distinct ideas" following the Cartesian ideal. However, this type of knowledge is reached at a high price, namely by reducing knowledge itself to unambiguous and univocal propositions of the type S is P, eliminating ambiguity and any possibility of individual personal judgment through "clear and distinct" definitions, especially those which lend themselves to universalization through the use of formal languages and symbols with fixed meaning and reference, and to the systematization of the field of knowledge by limiting knowing to logical-deductive processes applying rules of logical inference and mathematical operations and now computer algorithms that are perceived as expressions of the necessary relationships embedded in the order of the universe.

However, this model of rationalization and rationality is at the origin of the fourth level of control, i.e. "the technocratic information society" that fulfills "purposefully designed functions and programs" through mechanical and electronic processors.[62] As Beniger has pointed out:

> Rationalization must therefore be seen, following Weber, as a complement to bureaucratization, on that served control in his day much as the processing of information prior to its processing by computer serves control today.[63]

The process of rationalization as applied in bureaucracies and in computers implies increasing the amount of processing by reducing the information processed. In bureaucracies, it implies reducing information about people to minimal details shared by all humans, such as name, date of birth, place of residence, and so forth. In electronic computers, the process of rationalization is enhanced by the ability to create systems and it operates on in-stored programs. These programs are written by means of univocal symbols (binary digits) and fixed rules of transformation. Computer language is considered as the most abstract symbol system that has ever existed due to its attempt to express other symbols systems, i.e. text, sound, and image, for instance, through programming languages that are based on a combination of binary systems. The leading technology is manufacturing and the operation of electronic microprocessors is the ability to use highly abstract computer languages in order to store data and programs that an electronic computer can use to act of this data on a silicon chip. This process implies a high level of standardization, not only of the machine language, but also of the procedures of encoding. In other words, translating facts of life, natural systems and processes, patterns of human behavior, the structuring and functioning of artifacts in computer languages, and making computer models of these facts, systems, processes and patterns requires a process of fixing meaning and reference in such a way that computer programs act of univocal symbols that generate the same outputs from the same inputs following fixed rules of transformation. In this way, computerization is a process that is similar to normative epistemology's search for a permanent foundation of knowledge by defining knowledge in terms of "clear and distinct" ideas and favoring a form of knowledge that is abstract, formalized, and systematized. Abstraction, formalization, and systematization are not only salient features of normative epistemology, but also of modern science. Abstraction is at the origin of universalistic ideals that base human knowledge on clearly delineated definitions of basic concepts that are better expressed in formalized languages, which allow systematic assessments, combination, and recombination following fixed rules of transformation. Electronic microprocessors are the epitome of modern instrumental rationality that has aimed at unambiguous knowledge systems that would reach the accuracy of mathematics in the hope for a possible deductive knowledge system that would handle the whole of human knowing through logico-deductive processes, such as the ones applied in formal logic, mathematical operations, geometry, and now in computer algorithms. Such a system of human knowing would imply a world where objects of knowledge are arranged in invariant linear patterns in such a manner that the patterns in the objects of knowledge would be easily replicated by representation systems and their rules of transformation, given the assumed isomorphism in normative epistemology and modern science between the universal laws embedded in the structuring and functioning of the universe and the rational laws of the mind.

However, understanding information as patterns of (self-)organizing matter and energy implies looking at these patterns from various levels of spatial arrangements, be they of molecules, material objects, human individuals, or symbolic artifacts. These multilevel patterns of spatial arrangements can raise the complexity embedded in objects of knowledge to levels that are not easily tractable. These levels of complexity set limits to the computational capacities of the human mind so that the Cartesian idea of a transparent mind that apprehends a transparent universe and, thus, generates “clear and distinct ideas”, which can be represented by univocal symbols, does not prevail anymore. The alternative becomes an epistemology that contends with types of human knowledge within human reach and with possibilities of supplementing the limited human abilities with artifacts, such as bureaucracies and electronic computers, as in early modern times human vision was supplemented by the telescope and later by the microscope. Moreover, taking these levels of spatial arrangements into account shows that some patterns of (self-)organizing matter and energy do not only go beyond the spatial boundaries of individual organisms, but they also go beyond the life-span of individual human beings. Our ancestry as information processors go back to genetically programmed patterns of organizing matter that include certain physiological aspects and processing abilities that humans share with other members of the animal kingdom. For instance, humans share optical, auditory, olfactory, gustatory, and tactile abilities with other animals, especially mammals, and it is, in fact, claimed that some animals are better than humans in respect to some of these abilities. Cats, it seems, see better, and dogs smell better than humans. The awareness of the patterns of spatial organization that humans share with other members of the animal kingdom implies that looking at human knowing as information processing is not a top-down process that assumes non-material processors (the mind in particular) and looks at the way these non-material processors function within organic bodies, which are assumed to play vicarious roles as compared to their mental counterparts. Instead, knowing as information processing calls for a bottom-up approach that looks at patterns of (self-)organizing matter and energy beginning from the molecular level up to human societies and their artistic creations. This approach shows that higher processes of enriching data with meaning and value and subjecting it to specific purposes cannot be dissociated from the spatial arrangements at the molecular level and the constitution and functioning of the nervous system through the transmission of electrochemical signals. Likewise, interactions between individual humans cannot be dissociated from the genetic heritage that humans as a species share since this heritage leads to mutual recognition despite differences in gender, race, ethnicity, cultural and social backgrounds, but these differences also allow us to set boundaries between ourselves as humans and other members of the animal kingdom, members of the vegetal kingdom, and the inorganic universe. This relationship between our processing abilities and the way processing abilities have developed in other members of the animal kingdom with similar abilities, and the tributary nature of our processing abilities as individuals to the evolution of processing abilities in the *homo sapiens* is a great challenge to normative epistemology, which limits its area of inquiry to the process of human knowing in average human adults. Human knowing considered from the perspective of genetic inheritance and long evolutionary processes that lead to the formation of the processing organs, such as the structuring and functioning of physiological processes that lead to a variety of interactions between humans and their immediate and mediated environment, calls for looking at the process of human knowing in such a way that substantive, structural, behavioral, and functional (teleological) aspects are integrated. This involves a consideration of various time spans that led to the process of human knowing as we know it in normal human adults in the 20th century. Otherwise, we remain with ideas of an ethereal mind that is both metaphysically and qualitatively different from the physiological processes that support i.e. a vestige of the medieval soul, which would survive physical decay at death as it is both separate and different from processes in the human body, on the one hand; and on the other hand, we remain entrapped in well-entrenched boundaries between the inorganic world and living systems, the humans and other members of the animal kingdom, and between rational processes that we attribute to humans and instinctive reactions that we relegate to non-human members of the animal kingdom. The boundaries go even far since even the individual human knower, the process of human knowing has often reduced the intellectual abilities to produce an objective and universal discourse on reality without realizing that in the long life of the philosophical enterprise there is no unanimity about what reality is and that paradigms and models that have been used to describe reality have been changing throughout the history of humanity.

There is a possibility of reaching a better understanding of the mind and its functioning through overcoming the Cartesian dualism. Instead of understanding the mind by radically opposing it to the body, it is important to understand the cumulative nature of the human processes that make the functioning of the mind possible. The Cartesian dualism has survived since the mind-body problem is often debated within the framework of the Cartesian dualism, but also philosophers limit themselves to human adults. However, even within naturalism a certain differentiation should be made. Given the wide range of techniques that psychiatric examination and treatment involve, a good and useful study of the mind should take both biological and psychosocial processes into account. Taking psychosocial factors into account indicates that the mind and the body are not irreconcilable entities that are unified at birth by divine authority or chance. They are human processes whose differences can be understood following the long history of human individual lives, but also the history of the human race as a whole. It is, therefore, possible to look at the mind from different time spans. On the one hand, there is a need to understand how the mind has emerged through various processes of selection and adaptation that have led to the current situation where humans display mental abilities that do not only allow them to claim dominion over animals and other non-human beings, but also to devise varied, complex, and complementary techniques that allow humans to control and coordinate natural processes and human actions. These techniques do not only include technological developments, i.e. the making of mechanical and electronic machines that humans use as tools, but also processes such as the domestication of animals and the design of various forms of institutions that allow social organization and regulation. Marvin Minsky laments that many scholars reduce the study of the mind to one time scale. For him:

> Good theories of the mind must span at least three scales of time: slow, for the billion years in which our brains have evolved; fast, for the fleeting weeks and months of infancy and childhood; and in between, the centuries of growth of our ideas throughout history.[64]

In addition to these three time scales from Minsky, I would also suggest the inclusion of the new realm opened by nanotechnology where “humans are acquiring the capacity to build machines that have dimensions and working parts at the level of DNA, ribosomes, proteins, and other systems that do the work of life in cells”. In the realm of nanotechnology:

> Much of the work consists of taking apart and putting together large molecules. We are already accustomed to hearing about feats of genetic engineering such as altering the genes of bacteria so that they produce chemicals that are useful to us. The cells that make up brain and other kinds of tissue are machines of the sort we will be able to build. There is no fundamental distinction between *naturally occurring* and *artificial* machines, between artificial and natural life.[65]

Taking temporal dimensions, as Minsky suggests, into account shows that mind and consciousness as activities rather than entities are not the acts of some kind of disembodied rationality that is subsequent to the superiority of the mind over the body or to the qualitative superiority of reason over emotion, but a dynamic and integrative rationality that aims at achieving human goals within the limits of human physical, emotional, intellectual, ethical, and behavioral abilities. In other words, the process of human knowing is the predicament of real subjects that are involved in the drama of existence through satisfying their needs and exploiting their capabilities. This involvement in the drama of existence is not passive, it amounts to a series of activities and processes that require "conscious performance" as the subject interacts with his or her human and non-human environment. Conscious performance implies, on the one hand, that mind and consciousness are not entities, but activities. On the other hand, mind and consciousness cannot be located "inside" the subject as normative epistemology and the common parlance have assumed. Instead, they play the role of "interface" that Simon attributes to artifacts. On that account, Ryle has pointed out rightly that:

> The statement 'the mind at its own place', as theorists might construe it, is not true, for the mind is not even a metaphorical 'place'. On the contrary, the chessboard, the platform, the scholar's desk, the judge's bench, the lorry-driver's seat, the studio and the football field are among its places. These are where people work and play stupidly or intelligently. 'Mind' is not the name of another person, working or frolicking behind an impenetrable screen; it is not the name of another place where work is done or games are played; it is not the name of another tool with which work is done, or another appliance with which games are played.[66]

Going through various levels of information and control creates the impression that traditionally established boundaries between inorganic matter and living systems vanish. However, this would be a great misunderstanding. It is true that "[i]nformation is an epiphenomenon of the physical world, one that even appears in inanimate matter and energy when they are ordered into comets or crystals"[67]. That is why the link between information and order is crucial. However:

> To reduce a living system to the level of information, therefore, would be to study the ordering of its matter and energy, that is, to analyze it in terms of chemistry and physics – a hardly new or inspiring idea. If we wish to exploit the higher order or derivative aspects of living systems, we must instead determine how they differ from inanimate matter studied by physical scientists; in this sense only will we eschew reductionism.[68]

Therefore, the notion of information cannot be reduced to spatial arrangements, i.e. structure, although the notion of order that underlies processes of structuring is crucial to information. Any ordered or structured system/process conveys a certain amount of information. However, "[w]hen we compare even the simplest living system to the most complex inorganic materials, one difference stands out: the much greater *organization* found in things organic"[69]. Although we have considered the concept of information from Wiener's association of information with order, there seems to be a difference between the type of complexity found in living organisms and the one found in organic matter. Beniger points out this difference by noting that "the complexity of crystals, [for instance], derives not from organization but from regularity and repetition, that is, from *order*"[70]. In other words, although some aspects of inorganic matter are well structured in such a way that they display negligible levels of entropy or no entropy at all, they are not organisms. This is the case for mechanical systems and processes that operate following invariable rules of transformation and linear patterns of causality so that when their initial conditions and the rules of transformation are known, it is possible to determine their outcomes using simple mathematical relations. However:

> Compared to organization, order contains relatively little information. A simple organism like the amoeba, for example, is not at all well ordered; it is a formless bag

> full of sticky fluid in which irregularly shaped molecules float haphazardly. In stark contrast to even the most complex crystalline structure, however, the amoeba is highly organized, and indeed its description requires several hundreds large volumes, the information capacity of the DNA in which the structure is in fact recorded. That living material has greater complexity of organization holds even at the molecular level, which explains why students normally learn physical before organic chemistry.[71]

What differentiates order and organization at the various levels of control is a certain idea of purpose. Order at the structural level would imply the explanation of complex systems and processes in terms of their components and the interrelations between these components. This implies that complex systems and processes that are looked at from the point of view of order are reduced to their structures and only considered from the point of view of their structure or a random succession of assembling and disassembling. However, an insight attributed to John von Neumann (1903-1957) is that the difference between order and organization is that the latter "always involves 'purposive' or end-directness"[72]. This insight that has originally aimed at introducing the idea of teleology within the life science would mean that "organization is more than mere order; order lacks end-directedness: organization is end-directled"[73]. In other words:

> What we recognize in the end-directedness or purpose of organization is the essential property of control, already defined as purposive influence toward a predetermined goal. Control accounts for the difference between even the most complex inorganic crystal and simple organisms like the amoeba: the amoeba controls both itself and its environment: the crystal does not.[74]

The link between control and information resides in the fact that "every living [system] processes information to effect control"[75]. Therefore, there is no information processing that does not effect control. Control implies setting limits and these limits are established through predetermined goals. It is these predetermined goals that determine the threshold values that trigger feedback processes in cybernetic systems. Otherwise, our contention that any ordered system/process conveys a certain amount of information would be inaccurate, given the fact that without control some processes may go on *ad infinitum* to the point of becoming meaningless through defying the limited human computational abilities. These processes may also become valueless through the lack of criteria of evaluation that are, most of the time, idealizations, such as principles and values. In the hypothetical case where some systems and processes would be able to process information without effecting control, these systems and processes may reach a degree of randomness that renders them unsuitable for our definition of information processing as enriching data with value and meaning for the purpose of decision-making and problem-solving. There is, therefore, a link between information and control on the one hand, and information and life on the other hand. The reason for this is, as Beniger has noted, that "nothing that is not alive can do [process information to effect control] – nothing, that is, except certain artifacts of our own invention"[76]. The ability of artifacts to effect through information processing originates in the fact that the goals are predetermined by the inventor and embedded in the structuring and the functioning of the artifacts. In brief:

> Purposive organization and control, in other words, define the tangible discontinuity that distinguishes life from the inorganic universe. On one side, the exclusive province of the physical sciences, we find only matter, energy, and their ordering in the epiphenomenon we call information. On the other side, our own side in that we are ourselves living systems, we find structures purposefully organized (in von Neumann's sense) for information processing, communication, and control, the special subject matter of the behavioral and life and life sciences.[77]

Therefore, despite the descriptive advantages and the insights brought by comparing Fuchs-Kittowski's and Beniger's levels of control reducing information to patterns of (self-)organizing matter does not give the whole picture. The spatial arrangements that determine the patterns of (self-)organizing matter and energy are important as they are at the origin of the physiological processes that make information processing in living systems possible. However, information itself is not only linked to control, but also to programming. Programming is important because:

> If purpose is to be explained in other than metaphysical terms, however, its goal must exist prior to the behavior that it influences in some material form, on the government rolls, for instance, that motivated the original Latin contrarotulare. All control is thus programmed: it depends on physically encoded information, which must include both the goals towards which a process is to be influenced and the procedures for processing additional information towards that end.[78]

The great achievement of microprocessors is that they can store both the programs and the instructions they act upon. In the early years of computing, this capacity created the impression that computers can perform all the functions that are traditionally ascribed to the human mind. Therefore, the strong AI (Artificial Intelligence) program aimed at elaborating computer versions of human minds. Looking at information from the point of view of a metaphysics of substance, which would imply that information is a "thing", material or not, remains unproductive. It only perpetuates static models that set themselves the goals of establishing permanent foundations of knowledge in a substance model of reality that implies that the human minds produce infallible, indubitable, and incorrigible knowledge. However, the model of knowledge that we have suggested aims at elaborating a model of human knowing that does not strive for a "God's eye view". So, it does not set a process of human knowing that leads to truth, the whole truth, and nothing else except the truth. The informational model of knowledge looks at how actual processes of human knowing occur on the basis of the physiological processes that sustain them leading to epistemological processes of enriching immediate data of experience with value and meaning and subjecting it to purposes such as decision-making and problem-solving. Following this model, human knowing is not the activity of an isolated individual mind, but the triggering of processes of insight accumulation through enriching immediate data of experience with meaning and value and subjecting it to purposes in a process that implies a continuous flux where new data is integrated in a pre-existing explanatory framework that determines which decisions can be made or which actions can be undertaken. In other words, information processing means that processes are triggered by the constitution of the processors themselves, i.e. spatial arrangements, but these spatial arrangements on their own are not sufficient. They operate within the thresholds of control processes that determine critical values that trigger feedback processes. In most living systems and artifacts, these critical values are pre-established either through genetic inheritance, learning, explicit rules, or programs on silicon chips, but these critical values also depend on predetermined goals that give information an intrinsic link with programming. Knowing as information processing implies that a "program must exist prior to the behavior that it influences"[79]. Programming, therefore, is a great challenge to linear patterns of causality and the metaphysical and epistemological models that support them. Traditionally, it is believed that causes and effects succeed each other chronologically, with the causes generating the effects. However, with programming the causes cannot be reduced to their structure or the processes that trigger and effect their behavior. Not only are causes and behaving systems structured, but also functional systems and processes. The function of any behaving system/process determines the system's end or purpose. From this point of view, information does not only act as a structuring factor and a trigger of behavioral processes, but also as an inviting final cause.

Information's acting as an inviting final cause implies the possibility of removing mystery from teleology. Removing mystery from teleology creates a possibility of studying organized complexity by reevaluating spacio-temporal relations not in terms of material bodies colliding randomly, but in terms of organized processes that are oriented towards a goal in a changing environment. In fact, "[f]eedback control shows how a system can work towards goals and adapt to a changing environment,[80] therefore removing mystery from teleology"[81]. Removing mystery from teleology implies the possibility of identifying mundane goal-oriented processes that fall within the limits of human capabilities and aspirations. Therefore, teleology in this context should not be confused with the ultimate and absolute requirements associated with the Aristotelian "unmovable mover" as the "final cause". Teleology should be associated with the awareness that causality should not be apprehended solely in an instrumental sense reducing rationality to the search for means to an end. Teleology should be integrated into all goal-oriented processes that aim at reducing the gap between a desired and an existing situation. These processes which include the defining of the goals themselves take place in a dynamic (changing) environment and within the limits of human cognitive abilities. Therefore, human knowing as a goal-oriented process should not be understood solely in terms of its mechanisms, but also in terms of its goals. Epistemology should then not be confined to asking questions about "what is knowledge" and "how it is acquired", but, as philosophers (lovers of wisdom), epistemologists should ask the question of "why to know" as well. Taking all these questions into account leads to a model of human knowing that integrates issues of meaning, value, and purpose into a goal-oriented dynamic and integrative process. Therefore, problem-solving is part and parcel of the process of human knowing. As Simon has pointed out:

> What is required is the ability to recognize the goal, and to detect the differences between the current situation and the goal, and actions that can reduce such differences: precisely the capabilities embodied in a system like the General Problem Solver.[82]

The intrinsic links between information as patterns of (self-)organizing matter and energy, control as a "purposive influence towards a predetermined goal"[83]and programming as prearranging "information that guides subsequent behavior"[84], puts information on a threefold time framework where information is related to its origin in genetic inheritance, learning, explicit rules, and mechanical and electronic programming, and, at the same time, is linked with its actual form of existence in macromolecules (DNA), human brains or nervous systems, bureaucracies and other social organizations, and human mechanical and electronic artifacts including symbolic and formalized artifacts, such as computer software. Information is also future-oriented since it acts as an inviting final cause that sets limits to structuring and behavioral processes that trigger feedback processes when critical values are reached. Information processors operate within thresholds of crucial values that determine their structure and behavior as these systems and processes fulfill predetermined goals. This threefold temporal framework creates a situation where information has structural, behavioral, and functional (teleological) aspects, given its role in taking memories of the past into account (including at the species level through genetic inheritance, at the individual level through learning, at the social level through explicit rules that are effected through coercion, persuasion, and other means, at the technical level through goals and rules embedded in artifacts through design and manufacturing), but also challenges and opportunities of the present, and expectations of the future (goals). It is this future orientation of information processing that links the concept of information with control through programming, but also with decision. As Beniger has pointed out, "programs control by determining decisions"[85]. In fact:

> The process of control involves comparison of new information (inputs) to stored patterns of instructions (programming) to decide among a predetermined set of contingent behaviors (possible outputs).[86]

In other words, "[t]o decide is to control, in short, and to control is to decide; information processing and programming make both possible"[87]. Therefore, knowing as information processing implies looking at the process of human knowing not as a mental process detached from its physical substrate, but as a series of interacting processes that include the various levels of spatial arrangements that lead to purposefully organized physiological and behavioral processes that lead to the generation, the storage, the use, the transformation, and the transmission of human knowing and its possible outcomes (knowledge). This calls for a dynamic and integrative epistemology that does not look at the outcomes of the process of human knowing, i.e. knowledge, but at the process itself. This change of focus has the advantage of showing that various approaches and schools of thought that are normally opposed in normative epistemology are stages in one continuum or that the radical separation, or even opposition of mental processes to physical processes, is an artificial boundary that separates and opposes processes that occur at different levels of control, but nevertheless contribute to all the possibilities of human knowing as a dynamic and integrative process.

3. The Three Facets of Information

Inquiring about knowing as information processing does not exclude looking for immutable characteristics that one can associate with universal substances or metaphysical essences. In addition to taking the fact that information processing depends on processes and structures (spatial arrangements) that take place at various levels, i.e. the macromolecular, the neurophysiological, the social, and the artificial, into account, one also has to take the fact that information processing occurs according to a temporal framework into account. Fuchs-Kittowski and his colleague Bodo Wenzlaff have elaborated, in addition to the framework that locates information at five levels of organization and is in many respects similar to Beniger's levels of control, a horizontal approach that links information with three aspects, namely form, content, and effect. In Fuchs-Kittowski's own words:

> We have come to distinguish five qualitatively different levels of organization which support one another. Each level is connected with three aspects – *form*, *content*, and *effect* – pertaining to three qualitatively different process stages – *mapping*, *interpreting*, and *evaluating* – in the generation and use of information.[88]

Information, therefore, can not only be understood, from a hierarchical point of view that links information processing to various spatial and temporal processes at each level of organization from the molecular level to the personal and social level, but information can also be understood from the point of view of its three modes of existence, namely spatial, temporal, and spatial *and* temporal. From this perspective, information can be apprehended as stabilized by mapping resulting in structure as the relevant aspect. In case information is in a linguistic form, for instance, structure is equivalent to syntax. Information, therefore, looked at from the point of view of its spatial existence can be associated with various patterns of (self-)organizing matter and energy. However, information evolves over time, and this evolution amounts to a process of interpreting mapped information. Interpreting mapped information generates meaning, and, for the special case of linguistic information, it is interpreting syntax that makes the passage from syntax to semantics possible. Except in highly formalized languages, such as those used in logical inference, mathematical operations, or computer algorithms, there is no necessary relation between syntax and semantics. In highly formalized languages, it becomes possible to link syntax and semantics since the symbols are assigned fixed meanings and references in their definitions. The effect of integrating the spatial and temporal existence of information amounts to evaluating the outcome of one's interpretation of mapped information. This stage results in behavior after the structure and the meaning of information have been grasped. For linguistic information, evaluating and behavior are the special realms of pragmatics.

This characterization of information according to three aspects, i.e. form, process/content, and effect, implies that information cannot be reduced to one or the other aspects. On the one hand, information cannot be reduced to its form as this would amount to reducing information to its spatial existence, i.e. various spatial arrangements allow mapping and create structure or, for linguistic information, syntax. Moreover, information cannot be reduced to generating meaning through interpreting or semantics as these processes are only possible given that information is first presented in form of certain temporary arrangements, i.e. mapping. Information cannot even be reduced to the effects of the two processes that would amount to evaluating behavior or pragmatics. Information should be understood from the point of view of a dynamic and integrative framework since, as Fuchs-Kittowski has noted, "none one of the levels of organization of living systems, can the phenomenon of information be reduced solely to the aspect of form"[89]. This is what Fuchs-Kittowski calls the principle of the *irreducibility of information*.[90]

Understanding the notion of information within a dynamic and integrative process of mapping, interpreting, and evaluating points to the fact that information processing itself is indeed a process that cannot be reduced to its final result. Not only does information processing occurs at many levels, but it also takes place in many steps. Fuchs-Kittowski focuses on mapping, interpreting, and evaluating as a process that results in structure, meaning, and behavior, but this process also depends on the spatial, the temporal, and the spatio-temporal (an integration of the spatial and temporal) existence of information. In the special case of linguistic information, this process amounts to syntax, semantics, and pragmatics. Therefore, in addition to viewing information as a multilevel process, information can also be viewed as a multi-step process that combines a form (structure or spatial arrangement), a content, or a process that results in the evolution of informational processes over time, and an effect, or a goal. On an abstract level, one can characterize information not as a substance or a "thing", but as a series of processes that integrate structure, behavior, and function (teleology). For the specific case of linguistic information, information integrates syntactic, semantic, and pragmatic aspects in a dynamic and integrative process that involves enriching the immediate data of experience with meaning and value for purposes such as decision-making and problem-solving.

Not surprisingly, despite a difference in terminology, Beniger confirms the intrinsic relation between information processing and control by identifying three analytic dimensions of controls that result from (self)-organizing matter and energy.[91] From the perspective of the intrinsic links between information and control, Beniger confirms this pattern by locating analytic dimensions of control systems to the levels of existence, experience, and evolution.[92] These levels imply that at each level of control there is a static and a dynamic dimension, which imply that the three aspects of information, i.e. mapping, interpreting, and evaluating, attest to a pattern of being, behaving, and becoming[93] that is embedded in the notion of information itself. That is why information can only be understood from a dynamic and integrative point of view as static and dynamic aspects are intrinsically linked in such a way that from the static point of view of being and in the absence of external change that counters entropy, living organisms fulfill the need of maintaining the processing of matter and energy through a control system that amounts to some fixed programming that runs throughout the system.[94] Otherwise, the system itself loses its structure. The dynamic process that ensures the supply of energy in living organisms is a metabolism that transforms matter from external sources, food, for instance, into forms of energy usable by the living organisms themselves for their self-maintenance and for doing work. Behaving or experience implies from a static point of view responsiveness during the life of one system as the external environment changes. The dynamic aspect of behaving is adaptability. Behaving implies that organisms fulfill the need for goal-directed responses to changes in external conditions through feedback processes that control external inputs and outputs. These feedback processes operate through the ability to reweigh (change in the quantity of matter) or to reprogram (change in the predetermined course of behavior).[95] Evolution or becoming implies preservation of programming with advantageous modification and this goal is achieved through the ability to replicate or otherwise to communicate programs to new generations with high fidelity, and sometimes with modifications linked with adaptation patterns within the species due to important changes in the environment. Changes are effected across generations of programs through differential selection of systems.[96] In other words, information understood from the point of view of the different levels of spatial arrangements (processors) at processing occurs through patterns of (self-)organizing matter and energy, on the one hand, and processes of being, behaving, and becoming, on the other hand, information itself cannot be understood following a static framework that would reduce it to structure. In addition to structure, there is behavior that determines the patterns of changes over time and function (or goal/end) which set boundaries at critical values in a way that when these critical values are reached feedback processes are triggered. Information, therefore, has structural, behavioral, and functional (teleological) dimensions that make information a notion that can better be understood from the point of view of its dynamic and integrative patterns.

All in all,"[i]n order to understand information, cybernetics has produced models such as the computer metaphor, by which it is possible to grasp some characteristics of information in a first step"[97]. Cybernetics, therefore, was considered as a great achievement as it provided a possibility of linking information with physics. In other words, cybernetics defined information as "a measurable magnitude whose transformation can be described by a physical formula"[98], i.e. negative entropy. In this respect, cybernetics as a conceptual framework made a step forward as an alternative to mechanics, given the fact that mechanical models by reducing reality to matter, motion, and immutable mechanical laws have no place for aspects such as order and organization. Moreover, mechanical models remain entrapped in a metaphysics of substance that reduces reality to its permanent and immutable characteristics that are considered as features of reality itself, i.e. substances or essences as opposed to appearance or accidents. Applying a mechanical model to the notion of information would be counterproductive as according to a mechanical view:

> The nervous system works with representations of the outside world; information is a substance, and the mind like a vessel receiving and storing information. If we adopt this view, we forfeit the possibility of understanding the nervous system as an operationally closed system with ever possible new structures emerging from one moment to the next.[99]

However, "[i]nformation is embedded in the interaction of natural physical forces, and it allows a new dimension for determining the way they act"[100]. Therefore:

> In examining how information is physically possible, the discussion of the essence of information is closely related to physics. In looking at what information brings about, it is related to biology and all the branches of science concerned with the investigation of organization.[101]

In other words, "we need to recognize that information itself is a physical structure and, at the same time, a force dominating physical structure"[102]. From this point of view:

> the essence of information can only be grasped if we regard the structure and function if information as a basic relationship between the physical effects of natural forces and organization.[103]

This approach does not only allow an understanding of the notion of information in its dynamism, but it also avoids the tendency of "reducing information to its sources and channels"[104] as is done in classic information theory.

B. THE DYNAMIC AND INTEGRATIVE NATURE OF HUMAN KNOWING

Defining knowing as insights accumulation through information processing implies a change of perspective in epistemology. While normative epistemology begins its inquiries by asking the question "what is knowledge?" and then attempts to circumscribe the realm of knowledge by eliminating its possible conceptual competitors and confounders and examining its nature, possibilities, limits, and conditions, dynamic and integrative epistemology upholds that knowing is, first and most of all, an activity of the knower. As such, dynamic and integrative epistemology avoids reducing the process of human knowing to its end, i.e. knowledge itself. This would be similar to reducing one's journey to one's destination. Dynamic and integrative epistemology, therefore, does not begin by asking the question "what is knowledge?". From the perspective that human knowing is an activity of the knower, dynamic and integrative epistemology instead asks the question "what am I doing when I am knowing?"[105].

This question that is at the beginning of Lonergan's epistemology also implies a change of method. Instead of beginning by defining knowledge and then pinning down various aspects of the concept,

> First, we shall appeal to the successful sciences to form a preliminary notion of method. Secondly, we shall go behind the procedures of the natural sciences to something both more general and more fundamental, namely, the procedures of the human mind. Thirdly, in the procedures of the human mind we shall discern a transcendental method, that is, a basic pattern of operations employed in every cognitional enterprise. Fourthly, we shall indicate the relevance of transcendental method in the formulation of other, more special methods appropriate to particular fields.[106]

Lonergan then points out that as humans when we are knowing we are not always doing one and the same thing. The process of human knowing includes activities such as seeing, hearing, touching, smelling, tasting, inquiring, imagining, understanding, conceiving, formulating, reflecting, marshalling and weighing evidence, judging, deliberating, evaluating, deciding, speaking, writing [and reading].[107] These activities can be classified into four operations, namely experiencing, understanding, judging (choosing, deciding), and acting.[108] These operations correspond to four levels of consciousness, namely (1) the empirical, (2) the intellectual, (3) the rational, and (4) the responsible.[109] The empirical level is the level of the sensual; the intellectual level is the level of inquiry, understanding, and expression; the rational level is the level of reflection and judgement of the truth or falsity of a proposition; while the responsible level is the level by which we apply what we know to ourselves and come to a decision of how we should act, given what we know.[110] Lonergan's method is described as transcendental because:

> any attempt to modify it will inescapably utilize the very method it speaks about. Anyone advancing a proposition will go through the process of attending to data; understanding the data by means of imagining what it can possibly mean; reflecting upon the resultant conceptions and theories in order to determine if it matches with the facts; and finally deciding what implications the resulting knowledge has for one's life and actions.[111]

Lonergan's epistemology, therefore, does not only focus on knowledge, but on the process of human knowing itself. It looks at the various operations that are involved in this process. Lonergan's epistemology does not focus on "contents of consciousness", but on the transcendental method as "a heightening of consciousness that brings to light our conscious and intentional operations and thereby leads to the answers to three basic questions"[112]. These questions are: "What am I doing when I am knowing? Why is doing so knowing? What do I know when I do it?"[113]. Answering these three questions brings together various areas of philosophy as:

> The first answer is a cognitional theory. The second is an epistemology. The third is a metaphysics where, however, the metaphysics is transcendental, an integration of heuristic structures, and not some categorical speculation that reveals that all is water, or matter, or spirit, or spirit or what have you.[114]

Therefore, Lonergan, by focusing on the operations themselves and not on their outcome, i.e. focusing on the process of human knowing itself and not on a fixed idea of knowledge thought of as a "thing", Lonergan goes beyond normative epistemology's attempts to define the contents of consciousness first, and then determine how these contents of consciousness are related to concrete objects in time and space. Instead, Lonergan suggests that:

> We must, then, enlarge our interest, recall that one and the same operation not only intends an object but also reveals an intending subject, discover in our own experience the concrete truth of that general statement. That discovery, of course, is not a matter of looking, inspecting, gazing upon. It is an awareness, not of what is intended, but of the intending.[115]

This founding of the epistemological enterprises not on the objects of human intentionality and the contents of consciousness that are generated by their apprehension, but on the intending inquirer who is aware of various operations of inquiry implies that "[a]ll of these operations are directed towards, intend, an object"[116] and that, in fact, "the operations are the operations of a subject"[117]. There is, therefore, no confusion between the subject and the object. What is important from the point of view of founding epistemology on knowing as an activity of the knower rather than separating the object and the subject and then attempting to establish invariant relationships between the contents of consciousness and the objects they refer to is that "[t]he subject is aware of these operations"[118]. If the word introspection is to be used to describe this awareness it must overcome its underlying conception of knowing as a process similar to the understanding of consciousness as a container where sensations and ideas are stored. Instead, introspection "must be understood to signify what the subject does when the contents of consciousness are objectified"[119]. It is this process by which the contents of consciousness are objectified that the subjects do not only become aware of the objects, but also of their awareness of these objects. This awareness does not only lead to insights, but it also points to the fact that:

> Just as we move from the data of sense through inquiry, insight, reflection, judgment, to statements about sensible things, so too we move from the data of consciousness through inquiry, understanding, reflection, judgment, to statements about conscious subjects and their operations.[120]

However, the link between Lonergan's epistemology and the dynamic and integrative model of epistemology, which we have suggested, may remain obscure unless one takes the dynamic and integrative patterns that are embedded in the notion of information itself into account. When these patterns are taken into account, one becomes aware that Lonergan is aware of the dynamic and integrative nature of human knowing although he himself does not use the notion of information itself. Setting the problem of human knowing as a problem of information, i.e. "one depending on its solution on the interrelationships among programming, information processing, decision and control"[121], implies that Lonergan' epistemology can be linked to information by noting that as one attends data at the experiential stage of the process of human knowing, one tries to achieve accurate representations by paying attention. Whereas understanding achieves meaning through intelligence, judging creates value by comparing concrete situations with principles and values that are, in fact, idealizations. The resource needed at the level of judgment is reasonableness since the third level of consciousness is mainly evaluative; the level of deciding and acting achieves concrete goals and has responsibility as its resource. Therefore, the schematic representation of the dynamic and integrative model of epistemology that we have been building from the second chapter can be completed as follows:

Dimension of Complexity	Operation/ Activity	Greek Equivalent	Level of Consciousness	Achievement	Proponent School of Thought	Method	Resource
Substance/ Nature	Experiencing	*Pathos*	Empirical	Representation (data)	Empiricism	Phenomenology	Attention
Structure	Understanding	*Logos*	Intellectual	Meaning	Rationalism	Analytic	Intelligence
Behavior	Judging Evaluating	*Ethos*	Rational	Value	Critical Realism	Critical	Reasonableness
Function/ Purpose	Deciding Acting	*Praxis*	Responsible	Purpose	Pragmatism	Experimental	Responsibility

This pattern is in many respects similar to Schultheis' and Sumner's definition of information as data enriched with meaning and value for the purpose of decision-making and problem-solving[122] and to Drucker's definition of knowledge as information that transforms someone or something in order to make better decisions and carry better actions. Acting or deciding not to act achieves concrete practical goals.[123] In other words, if we establish a parallelism between the three facets of information, i.e. mapping, interpreting, and evaluating, and the patterns described by Schultheis and Sumner, Lonergan, and Drucker, we realize that information processing has an intrinsically transforming ability linked to the notion of information itself. By defining knowing as accumulating insights through information processing, one enhances dynamism and integration by setting as one's horizon an equally dynamic and integrative end, i.e. insight. Insight, as the result of an integration of new data/experiences into an existing explanatory framework, acts as a limiting factor or critical value that triggers feedback processes. One should keep in mind that feedback processes can either reserve the behavior of a system/process or start or influence other adaptive changes, such as the reduction or the increase of inputs, the change of structure, or the increase/decrease of outputs.

In the case of a process of human knowing, insight operates as a feedback trigger since (a) new insight does not only solve the puzzle(s) that is/are at the origin of the tension of inquiry, but it also assists in understanding some areas of the existing explanatory framework that were still misunderstood. Metaphorically, new insights shed light to obscure aspects of existing explanatory frameworks. For instance, defining knowing as information processing implies not focusing on the end of the process of human knowing, i.e. knowledge itself, but by tackling the whole process in its dynamic and integrative patterns. Reducing the process of human knowing to its outcome would be similar to reducing one's journey to one's destination, a practice that become prevalent in mechanics' search for fixity and uniformity as characteristics of universal and objective knowledge. However, in mental processes, fixing is only achieved by fixing meaning, reference, and rules of transformation in such a way that the same causes lead to the same effects regardless of the context or the actor. This only happens in artificial environments or in constrained natural processes where uniformity is achieved through fixing structure, behavioral processes, and goals. The fixed models work well in symbolic systems, such as rules of logical inference, mathematical operations, and computer algorithms, as the symbols and the rules of transformation used in these systems acquire fixed meanings without having any specific reference.

However, a dynamic and integrative epistemology that bases itself on cybernetic rather than mechanical models implies that human knowing is an ongoing process of insight accumulation which involves integration of new data/experiences in existing explanatory frameworks. These explanatory frameworks emanate from genetic inheritance, childhood experiences and upbringing, learning through conscious pratice and rules and procedures of verification embedded in scientific institutions and bureaucracies or testing by various mechanical and electronic artifacts which can indicate the occurring and the degree of other phenomena, given the fact that the designers and manufacturers of these instruments would have calibrated this function in the structure and the functioning of these artifacts. Insight does not only play the role of integrating new data/experience in existing explanatory frameworks, but it can also challenge these frameworks by pointing at biases, oversights that have been taken for granted for a long time and foresights that have been neglected or simply ignored. Knowing, therefore, as a process of insight accumulation through information processing, is not an activity of isolated minds as normative epistemology would contend. Knowing is an activity of the whole organism. Even at the level of organism, individual organisms cannot be reduced to the physical dimensions of the body. These organisms are in continuous interactions with their human and non-human environments and they are tributary to the physiological structures and processes they share with other members of the animal kingdom through genetic inheritance. Moreover, individual organisms partake in cultural and social patterns acquired in early childhood and adult life through upbringing and conscious practice and follow various principles and rules established various institutions. Individual organisms integrate themselves in these institutions by self-appropriating these principles and rules through coercion, persuasion, and other means of securing compliance. Genetic inheritance, learned behavioral patterns, principles, and rules all act as programs that influence people's behavior in various contexts.

Dynamic and integrative epistemology, therefore, implies a knower who is an "open system" and who continuously accumulates insights by integrating new inputs, i.e. data/experiences, in existing explanatory frameworks, but who also discards outputs that do not enhance the process of human knowing, such as biases, oversights, and the negligence of foresights, and retains useful insights, such as solutions to problems and successful decisions. This implies that human knowing is an ongoing process that builds on the physiological and genetic resources of individual knowers, but also on the cultural, institutional, and technological heritage of humankind. That is why in the information society, for instance, electronic computers enhance the process of human knowing by performing a number of tasks that are traditionally performed by humans, such as calculations, but also by providing new methods, such as computer simulations, or even paradigms, models and metaphors, such as computer models of the mind or of the whole universe.

However, there is a difference between information processing, i.e. enriching data with value and meaning for the purpose of decision-making and problem-solving, and computing. Computing is a mechanical process that is often associated with Turing machines. There is an intrinsic link between computability and decidability. According to Beniger:

> Any decision tree of finite length can be duplicated by a finite automaton, thereby equating the question of decidability with that of computability, a connection that has brought considerable convergence of mathematics, logic, and computer science with traditionally humanistic disciplines like philosophy, linguistics and cognitive psychology.[124]

This linking of computability and decidability does not only originate in the relation between decision and programming since etymologically, " the origin of *decision* in the Latin verb *decidere*, to cut off"[125] implies "purposefully to determine the ultimate function – to influence towards a desired goal"[126]. Computability and decidability are also linked from the perspective of information as a measurable magnitude. Wiener defines the unit amount of information as "a single decision between equally probable alternatives"[127]. However, Beniger is quick in pointing out that:

> As we have already seen with programming, such decision implies neither voluntarism nor free will; it carries no vitalist or other metaphysical implications. All decisions are determined in the sense that, for a given program, the same input will always result in the same decision or output.[128]

Computing, therefore, radicalizes the assumptions, the procedures, and the methods of normative epistemology as computing does not only fulfill fixed goals by transforming fixed inputs (univocal propositions or abstract symbols) following fixed rules of transformation, such as mathematical operations, rules of logical inference, and computer algorithms. Those who confuse computing and information processing miss the fact that computing requires preprocessing. Preprocessing is necessary for computing as "[a]ttention to symbols rich in meaning shifts the essence of control from communication to prior programming of its receiver"[129]. This implies that:

> For the engineer, communication involves a quantifiable amount of information that "flows" from A to B; for the semiotician, A communicates by "pointing" (by whatever means) to information already stored in B.[130]

In practice:

> pointing must involve information flow (symbols must be sensed before they communicate, and the engineering model requires "decoding" of information by its receiver for communication to occur"[131]

However, computing eliminates the interpreting processes associated with sensing symbols and decoding information as computing by relying on unambiguous "nominal definitions"[132] or abstract symbols in a way that members of a set and non-members are mutually exclusive. Unlike explanatory definitions that "include something further that, were it not in the definition, would have to be added as a postulate"[133], nominal definitions play the role of fixing meaning and reference which eliminates any possibility for interpretation. Computing, therefore, amounts to a process of digitalization which creates a pattern of "all or nothing". In fact, in information systems digital signals are distinguished from analog signals by the fact that analog signals are sent continuously while digital signals are discrete.[134] This distinction can be used to describe the difference between information processing and computing. Whereas information processing is an ongoing process of encountering data/experiences that can be enriched with meaning and value for the purpose of making decisions and finding solutions to problems, digitalization is a form of packaging insights into compartments that are circumscribed by ridigity both in the definition of inputs and the formulation of the rules of transformation. There is, therefore, a certain continuity between modern science, normative epistemology, and computing since the three approaches operate on nominal definitions that establish rigid boundaries between members and non-members of domains of inquiry and control processes by rigid, invariable rules of transformation. Computing, in other words, radicalizes the methods, procedures, and models of modern science and normative epistemology as it aims at levels of accuracy that are only possible in artificial or constrained natural environments.

Information processing, in contradistinction to computing, is a continuous process of accumulating insights through enriching data with value and meaning for the purpose of decision-making and problem-solving. This process implies that as we come across new data, experience, or new events, we integrate them in existing explanatory frameworks. This process implies an awareness of the experiences themselves and the process of experiencing and achieving representations as accurate as our perceptive abilities allow. However, information processing does not end with perceiving, regardless of how accurate the perceptions are. Humans are not passive spectators of external stimuli, they also inquire, understand, and express themselves actively. Through the processes of inquiry and understanding perceptions become meaningful, adding to the process of human knowing semantic aspects. In other words, perceiving spatial arrangements, i.e. patterns of order or (self-)organizing matter and energy, is not sufficient to render data or new experiences meaningful. There is active involvement of the knower, which has a transformative effect. Piaget has pointed to this fact. For him:

> Knowing does not really imply making a copy of reality but, rather, reacting to it and transforming it (either apparently or effectively) in such a way as to include it functionally in the transformation systems with which these acts are linked.[135]

Therefore, knowing cannot be reduced to a speculative enterprise that reduces reality to linear processes that can be univocally translated into the predication calculus as computing would require. Knowing implies enriching the immediate data of experience with value and meaning as knowing culminates in acting or, at least, in deciding not to act. Piaget has added to the transformative nature of human knowing the fact that:

> The active nature of knowledge is manifest from the start in its most elementary forms. Sensorimotor intelligence consists in the direct coordination of actions without representation or thought. Perception is meaningless without some accompanying action.[136]

In other words, "all knowledge at all levels is linked to action"[137] because insights accumulation through enriching the immediate data of experience with value and meaning and subjecting it to purposes of decision-making and problem-solving. Information processing, therefore, is a dynamic and integrative process that is cumulative, iterative, recuurent, and open to correction and revision. Therefore, it is erroneous to reduce the process of human knowing to its successful outcomes, i.e. knowledge understood as clear and distinct ideas or true justified beliefs. The paradigm shifts that we have suggested imply looking at the process of human knowing in its complexity and dynamism since knowing as a process should not be confused with its product (knowledge). As Dretske has pointed out, "[a] process [...] is not simply a temporally extended entity, a mere succession of events. [...] Processes are something else. Or, something *more.*"[138] According to Dretske:

> A process is the bringing out, the causing, of a terminal condition, state, or object – what I have so far called, and will continue to call, its product. The product is a *part* of the process, and therefore, the process isn't complete until that product is produced.[139]

Knowing as information processing is not merely representing the external world, but also creatively selecting meaningful and valuable perceptions and transforming them into useful knowledge as in every process of human knowing something new is learned, existing knowledge is confirmed, or past errors are corrected or either simply acknowledged. According to Putnam, "learning is not merely a matter of applying what one already knows to additional cases, but of making conceptual leaps, of projecting oneself imaginatively into new ways of thinking"[140]. The process of human knowing, therefore, implies an active involvement of the knower, but it is also selective. Not all data we come across becomes meaningful or valuable so that we can subject it to purposes. In Lonergan's terms:

> The intending of our senses is an attending; it normally is selective but not creative. The intending of our imaginations may be representative or creative. What is grasped in insight, is neither an actually given datum of sense nor a creation of the imagination but an intelligible organization that may or may not be relevant to data.[141]

Defining knowing as accumulating insights through information processing implies setting insight as a dynamic limit that can trigger feedback processes, but also as a new experiential context that can be at the origin of new inquiries. The process of accumulating insights is not a linear process, but it goes on and on in a spiral pattern. Insight is, therefore, a determinant of wisdom as accumulating insights through information processing militates against the "fragmentation of reason"[142], which is at the origin of the diversity and the lack of communication between certain academic disciplines. Not only are areas of inquiry fragmented in different areas of specialization that emanate from the traditional distinction between the natural and the social sciences, from established disciplines, such as biology, economics, medicine, sociology, and chemistry, but fragmentation also emanates from various combinations and re-combinations, such as "A History of Philosophy and Economics", "A Philosophy of the History of Economics", or "The Economics of Philosophizing about History". In addition to this limitless possibility of creating areas of inquiry, methods can be retrospective, descriptive, and prospective and, in practice, methods can range from laboratory experiments, quantitative and qualitative analysis, or they can be descriptive, analytic, hermeneutic, or critical. However, following Lonergan's "transcendental" method, we become aware that:

> As many operations are conjoined in a single compound knowing, so too the many levels of consciousness are just successive stages in the unfolding of a single thrust, the eros of the human spirit. To know the good, it must know the real; to know the real, it must know the true, to know the true, it must know the intelligible, to know the intelligible, it must attend to data.[143]

This process implies that instead of considering each operation in isolation or being trapped in disciplinary and methodological boundaries, there is a possibility of identifying aspects of representation, meaning, value, and purpose that are embedded in various processes of human knowing, be they explicit or tacit. Human knowing dynamically integrates "knowing that" and "knowing how" with "knowing why" and "knowing when and where". This approach does not only bridge the gaps between various academic disciplines, but also between philosophical disciplines themselves including metaphysics, epistemology, ethics, and other philosophical disciplines and their applications. This dynamic and integrative approach to epistemology also has the advantage that at the level of an individual knower it overcomes the traditional opposition of experiential and intellectual processes through opposing empiricism to rationalism, for instance, and the elimination of evaluation processes from the realm of rationality. It also militates against the contempt of practical action and the reduction of human rational processes to the intellectual dimension. Moreover, by linking information processing to genetic inheritance, physiological constitution, cultural and behavioral learning, conscious practice, allegiance to institutions, their rules and their principles, and to the use of mechanical and electronic processors, dynamic and integrative epistemology overcomes solipsism. It shows that knowing is not confined to individual isolated minds or individual organisms restricted to the physical boundaries of the body, which assumingly host non-physical minds. Dynamic and integrative epistemology bridges the gap between processes of human knowing in individual subjects and knowing as embedded in groups of humans through the ability of creating and communicating meaning through the use of language and other artifacts. On the other hand, dynamic and integrative epistemology bridges the gap between humans and other members of the animal kingdom by acknowledging a number of possible common genetic inheritance that would explain similarities in physiological constitution and patterns of behavior, such as caring for the young.

This genetic closeness of the *homo sapiens* to other members of the animal kingdom is a challenge to the traditional reduction of human rational processes to slow processes, especially those that can be monitored consciously (following the Cartesian tradition), and to the relegation of fast, tacit processes to the instinctive level that are associated with animals. However, studies in biology and neurophysiology have pointed out that some neural processes take place at a speed of nanoseconds. In my view, a process does not lose its rationality due to its speed, which renders it untraceable by normal forms of human awareness. Furthermore, dynamic and integrative epistemology by defining knowing as accumulating insights through information processing and then defining information as patterns of (self-)organizing matter and energy, bridges the gap between matter and mind so that it brings new perspectives on the mind-body problem.

C. WISDOM TO AND FRO AND BACK

1. The DIKW (Data, Information, Knowledge, Wisdom) Process

Although wisdom etymologically defines philosophy, wisdom literature is scarce in today's philosophical literature. Most of the time, wisdom is associated with ancient traditions or beliefs emanating from old Asian cultural setups. In popular imagination, wisdom is sometimes associated with religious esotericism delving in mystery and being practiced in secret societies. For instance, the concept of wisdom is absent from the glossary of Robbins' textbooks on organizational behavior, which are considered to provide an interdisciplinary approach to human related issues. Even a well-furnished library, like the one at Heidelberg University, does not offer a lot of recent literature on wisdom, except for one book edited by the psychologist Robert Sternberg.[144] However, the issues of wisdom have come to the fore in management sciences, given their association with "knowledge management" and the "information society", which also defines itself as a "knowledge society". Contemporary literature on wisdom is often associated with R. L. Ackoff's article "From Data to

Wisdom"[145]. In this article, Ackoff puts data, information, knowledge, and wisdom in a hierarchical pattern, which implies a filtering process. This filtering process is often captured by commentators in the following verses from T. S. Elliot's poem "The Rock":

> 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?[146]

Some commentators add the line "Where is the knowledge we have lost in data." This filtering pattern would imply, as Neil Fleming has pointed out that:

> A collection of data is not information.
> A collection of information is not knowledge.
> A collection of knowledge is not wisdom.
> A collection of wisdom is not truth.[147]

Therefore, some commentators have, according to Ackoff's original insight, presented the process from data to wisdom as a process of increase in understanding following increased context independence. According to this assessment of the process, information is understanding relations, knowledge is understanding patterns, and wisdom is understanding principles. For other authors, the process of data to wisdom implies a knowledge pyramid with a large base of data and wisdom at the top. However, the portrayal of this process suffers from a number of assumptions of normative epistemology that go unquestioned. For instance, it reduces knowing to understanding i.e. a practice that, in my view, that reduces human knowing and human rationality to the intellectual dimension. This would imply, in Lonergan's terms, reducing the whole process of human knowing to its second level of consciousness. Moreover, portraying the process from data to wisdom as a hierarchical process, Ackoff's portrayal of the passage from data to wisdom implies certain linear patterns and linear causal relationships that are not suitable for the dynamic and integrative nature of human knowing as described in this thesis. Following Ackoff's model, data is defined as "symbols" by Bellinger, Castro, and Mills.[148] However, they miss the fact that transforming data into symbols requires preprocessing or digitalization. Transforming the immediate data of experience into symbols involves fixing meaning and reference, which renders these symbols univocal. This implies that the immediate data is translated into a medium that renders it suitable for computability. Preprocessing or digitalizatoin implies an increase of computability by reducing information. The immediate data of experience is then approached following only a limited number of characteristics (most of the time one) that are considered as a variable in the given process of inquiry, or in the case of continuous processes, spatial and temporary references are established, such as the study of the evolution of a continuous process over time, where values at given time units have to be established, or a population is classified according to regular and objective criteria, such as age groups, income, etc. This classification of data according to a fixed time unit or other criteria establishes a certain regularity in complex data, which then acquire discernible patterns and certain levels of simplicity. These discernable patterns bring order (i.e. negative entropy) into complex data so that this data can convey information. By defining data as symbols, Bellinger, Castro, and Mills, are one step ahead, namely, they avoid the preprocessing or digitalization that is involved in transforming immediate data of experience into symbols and the fixing of meaning and reference that is involved in the establishing of nominal definitions which depend on the paradigmatic nature of predication that we have pointed to in the first chapter. Preprocessing or digitalization is a crucial step that many proponents of the reduction of knowing to logico-deductive processes skip as they consider data as raw, when it is already represented by univocal symbols and described by nominal definitions. In fact, the elaboration of Bellinger, Castro, and Mills contradicts their initial reduction of data to symbols. They contend that:

> data is raw. It simply exists and has no significance beyond its existence (in and of itself). It can exist in any form, usable or not. It does not have meaning of itself. In computer parlance, a spreadsheet generally starts out by holding data.[149]

If data "can exist in any form, usable or not"[150], it cannot be reduced to its symbolic representation. However, they are right in pointing out that "data has no significance beyond its existence"[151]. Data, therefore, occurs at the perceptual level, the first or the empirical level of consciousness in Lonergan's terms. Its aim is to achieve accurate representations from the continuous flux of perceptive experience in such a way that is both selective and integrative. On the one hand, there is a lot of perceptive experience we come across, such as the various faces we see in a crowd, but that remain insignificant to us as we cannot integrate them into our patterns of knowing as they are neither significant nor meaningful to us. The same would apply, for instance, when we encounter a chain of letters (a secret code for instance) with no discernable patterns for us, unlike the order involved in the syntax of a language that we understand. Therefore, data, raw as it can be, in any form, emanates from immediate perceptual experience. Transforming data into symbols implies preprocessing or digitalization, which occurs through the establishing of nominal definitions or the representation of this data with univocal symbols through fixing meaning and reference. For this reason, the preprocessing or digitalization of data is always a selective process.

However, Bellinger, Castro, and Mills point out rightly that "information is data that has been given meaning by way of relational connection"[152]. The human mind is not a *tabula rasa*. Insight is reached through integrating new perceptual experience into preexisting explanatory frameworks in such a way that perceptual experiences that are meaningful and valuable are the only ones that are preprocessed and integrated into the process of human knowing. It is through this integrative process that in the specific case of linguistic information we proceed from syntax (spatial arrangements of signs and symbols) to semantics, i.e. making sense of the arranged (preprocessed) signs and symbols. Bellinger, Castro, and Mills are right also in pointing out that "[t]his 'meaning' can be useful, but does not have to be."[153] The implication of the fact that meaning can be useful but does not have to be shows that at the level of information the aim is understanding through enriching data with meaning. Preprocessing as a way of putting order (negative entropy) or discernable patterns in immediate perceptual experiences implies putting data into temporal and spatial arrangements that render data capable of conveying information. It is up to the human mind to make sense of these patterns in a way that when enriched with meaning, these patterns are understood. This is what occurs at the second level or the understanding level of consciousness by which ordered data conveys a certain amount of information and the human mind makes sense of them. However, grasping the meaning of data organized in regular and simple patterns is not sufficient to count for the whole process of human knowing. The distinction here is subtle as if we concur with normative epistemology's reduction of the process of human knowing to its outcome, i.e. knowledge. We can accept that understanding is knowing, however, given our broad conception of knowledge as polymorph understanding leads only to intellectual insights and cannot count for the whole of human knowing in the broad sense that we conceive it as accumulating insight through information processing in a processes that integrates many operations i.e. experiencing, understanding, judging (choosing, deciding), and acting and that occurs at four levels of consciousness, i.e. the empirical, the intellectual, the rational, and the responsible.

Knowing, therefore, as accumulating insights through information processing is different from both information and knowledge, but it requires various processes that are dynamically integrated. Therefore, "knowledge is the appropriate collection of information, such that it's intent is to be useful"[154]. Knowledge's intent to being useful confirms Piaget's contention that "all knowledge at all levels is linked to action"[155]. Hence, the process of human knowing is better understood in its dynamism and integration instead of fragmenting it in its various possible components. Not only is its outcome, i.e. knowledge, multifarious, but the processes that generate knowledge themselves are also multifarious in addition to the fact that they occur at various levels of physiological structuring and functioning and various levels of interaction with the environment with various degrees of complexity. On this account, knowing cannot be reduced to understanding since "understanding is an interpolative and probabilistic process"[156]. This probabilistic aspect of understanding links understanding to information since the unit of measurement of information is also a probabilistic occurrence between two equally probable alternatives.[157] This probabilistic aspect contradicts normative epistemology's predilection for success and reduction of knowledge to only successful processes of knowing in a way that following normative epistemology's mechanical assumptions, knowing is considered as a deterministic process. Unfortunately, Bellinger, Castro, and Mills still hold this view[158], maybe because they tackle the concepts of information and knowledge within the tenets of an implicit mechanical framework. Instead of overhauling the whole conceptual framework and defining knowing within a dynamic and integrative framework, which considers deterministic processes as special cases that emanate from artificially fixing inputs, outputs, and the rules of transformation, they try to cope with the integration of deterministic and probabilistic aspects of human knowing by distinguishing information that is "deterministic"[159], understanding that is "an interpolative and probabilistic process"[160], and introducing the concept of wisdom, which they describe as "an extrapolative and non-deterministic, non-probabilistic process"[161]. However, their description of wisdom shows striking similarities with the dynamic and integrative model of epistemology that we have suggested so far. In their own words:

> wisdom is an extrapolative and non-deterministic, non-probabilistic process. It calls upon all the previous levels of consciousness, and specifically upon special types of human programming (moral, ethical codes, etc.). It beckons to give us understanding about which there has previously been no understanding, and in doing so, goes far beyond understanding itself. It is the essence of philosophical probing.[162]

Furthermore, wisdom:

> asks questions to which there is no (easily-achievable) answer, and in some cases, to which there can be no humanly-known answer period. Wisdom is, therefore, the process by which we also discern, or judge, between right and wrong, good and bad.[163]

Therefore, by setting insights as a determinant of human knowing and wisdom, one is invited to broaden the scope of epistemological inquiry not by defining knowledge and pinning down its nature, possibility, conditions, and limits, but by pointing to the way real processes of human knowing occur. Returning to "love of wisdom", as the etymological definition of philosophy suggests, therefore requires to take into account "extrapolative, non-deterministic, non-probabilistic" processes that are dynamically integrated in producing meaningful, valuable, and useful processes of human knowing. Returning to "love of wisdom" is not a retrospective process, but a challenge to the modeling of philosophy on the physical sciences – given their success during the last three hundred years – and an attempt to instigate of a series of reformulations and suggestions that are based on contemporary natural and social science. This reformulations and suggestions imply an epistemological enterprise that adequately reasonably Lonergan's questions "What am I doing when I am knowing? Why is doing that knowing? What do I know when I do it. By answering these three questions, we set insight as a determinant of both knowing and wisdom as we have defined human knowing as accumulating insights through information processing. The sequence from data to wisdom, as established by Ackoff and his commentators, is informative, but it sometimes lacks the rigor we need for a philosophical description of a dynamic and integrative model of epistemology based on the notion of information. Sometimes, this sequence is caught up with mechanical assumptions that we have challenged in our description of a cybernetic model and our advocacy for systems thinking and the idea of a sequence itself or a hierarchy plays against the dynamic and integrative model of epistemology, which we are suggesting. Some clarifications need to be made. Some of them have, in fact, been made by Bellinger himself in a different publication. He has pointed out, for instance:

> That a collection of data is not information, as Neil indicated, implies that a collection of data for which there is no relation between the pieces of data is not information. The pieces of data may represent information, yet whether or not it is information depends on the understanding of the one perceiving the data.[164]

Therefore, the starting point of a dynamic and integrative epistemology that is based on the notion of information is not knowledge itself since this would imply a "substance" understanding that tends to portray knowledge as a fixed entity that transcends the circumstances and the dynamically integrated processes that lead to its production. A dynamic and integrative model of epistemology begins by acknowledging that knowing is, first and most of all, an activity of the knower. This does not imply an exaltation of subjectivism, but a recognition that objectivity as a result emanates from a strategy of detachment and external controls that allow the establishment of scientific knowledge, which "is concerned with things as related among themselves"[165], unlike common sense, which "is concerned with things as related to us"[166]. Objectivity, therefore, is not attained by eliminating the knower from the process of human knowing, but by predefining the type of knowledge one wants to attain and putting in place strategies to attain this type of knowledge through external controls including artifacts, such as institutions, or mechanical and electronic devices.

The entanglement of Bellinger in the tenets of "substance" thinking is shown by his description of information as static. According to Bellinger:

> While information entails an understanding of the relations between data, it generally does not provide a foundation for why the data is what it is, nor an indication as to how the data is likely to change over time. Information has a tendency to be relatively static in time and linear in nature. Information is a relationship between data and, quite simply, is what it is, with great dependence on context for its meaning and with little implication for the future.[167]

This assessment of information is erroneous. In addition to the fact that it is based on a wrong idea of data, i.e. data reduced to symbols, i.e. after preprocessing or digitalization, this conception of information tends to render information a substance, a thing. This is only possible if one reduces information to its mapping, and eliminates the interpretive and evaluative aspects. Reducing information to its mapping would imply reducing information to the various spatial arrangements that constitute it, be they arrangements of macromolecules

(DNA for instance), arrangements of neurons and their pulses (the nervous system), arrangements of physical objects in the environment, which are, in normative epistemology, at the origin of delineation between the object and the subject, or arrangements of cultural, mechanical, and electronic artifacts, such as signs and symbols, institutions and machines. However, associating information with control and looking at information from its three facets of mapping, interpreting, and evaluating shows that the notion of information itself embodies aspects of behaving and becoming. Defining information in terms of structure remains incomplete. The notion of information is a complex notion that includes substantive, structural, behavioral, and functional (teleological or teleogenic) aspects. All these aspects are dynamically integrated in such way that the teleological or teleogenic aspects provide an antidote to the linear patterns of causality embedded in a substance metaphysics, a mechanical model of the universe, and a representational theory of human knowing. Substance metaphysics, mechanical models of the universe, and representational theories of human knowing aim at fixed by describing reality in terms of characteristics that transcend changes in time and space, i.e. substances, immutable mechanical laws that are embedded in the order of the universe, and representations that amount to eternal truth. On the contrary, teleological or teleogenic processes turn the patterns of linear causality upside down by goals or effects that determine means and causes in way that goals/effects constitute limits that either trigger feedback processes or end the processes themselves. This has a double advantage. On the one hand, the teleological or teleogenic aspects of information systems/processes set limits of behavioral processes in a way that avoids the potential limitlessness that is embedded in linear patterns of causality which may make them unintelligible, given the limited human computational abilities; and, on the other hand, this potential limitlessness that eliminates any possibility of feedback may reduce linear processes and their patterns of causality to mere randomness eliminating their capacity of conveying information. The way of the conundrum of unintelligibility that would emanate from a lack of limiting factors and, hence, of feedback processes or sheer randomness (lack of discernable patterns, or order which would imply the highest levels of entropy and, therefore, the absence of information) would imply acknowledging that beyond the fixed aspects associated with substance, the notion of information embodies a possible metaphysics of relation that looks at spatial arrangements not as fixed, but as capable of behaving and becoming in a way that substantive, structural, behavioral, and teleological or teleogenic processes are continuously dynamically integrated, given the continuous interaction of information processors with an ever changing environment. This creates a situation where any change in the environment triggers responses in terms of change of structure, behavior or goal in a way that not only spatial arrangements, i.e. structures, are the only aspects taken into account, but also relationships and their changing patterns. Bellinger has pointed to this fact by noting that:

> Beyond relation there is pattern where pattern is more than simply a relation of relations. Pattern embodies both a consistency and completeness of relations which, to an extent, creates its own context.[168]

Therefore:

> When a pattern relation exists amidst the data and information, the pattern has the *potential* to represent knowledge. It only becomes knowledge, however, when one is able to realize and understand the patterns and their implications. The patterns representing knowledge have a tendency to be more self-contextualizing. That is, the pattern tends, to a great extent, to create its own context rather than being context dependent to the same extent that information is. A pattern which represents knowledge also provides, when the pattern is understood, a high level of reliability or predictability as to how the pattern will evolve over time, for patterns are seldom static. Patterns which represent knowledge have a completeness to them that information simply does not contain.[169]

Therefore, returning to philosophy as "love of wisdom" implies a dynamic and integrative epistemology that takes into account the dynamic and integrative nature of human knowing through dynamically integrated processes of experiencing, understanding, judging (choosing, deciding), and acting in an ever changing environment. On this account, taking the facts that "[w]isdom arises when one understands the foundational principles responsible for the patterns representing knowledge being what they are" and that "wisdom, even more so than knowledge, tends to create its own context" into account, one can conclude that:

> Information relates to description, definition, or perspective (what, who, when, where).
> Knowledge comprises strategy, practice, method, or approach (how).
> Wisdom embodies principle, insight, moral, or archetype (why).[170]

However, these distinctions remain unclear unless one understands the process from data to wisdom following a pattern of understanding of how integrated patterns of knowing deal with differentiated contexts. The first assessment of data, information, knowledge, and wisdom by Bellinger, Castro, and Mills ranks these processes following a pattern of increased understanding and context independence. This ranking has objectivity and universality as its horizon and remains in the context of normative epistemology. It is when one adds to this ranking an aspect of complexity, complexity defined as "the degree to which something is simultaneously differentiated and integrated"[171] that one realizes that dynamic and integrated human knowing original in the way dynamically integrated human processes interact with an ever changing environment. It is insight understood as the integration of new data or experiences into preexisting explanatory frameworks in a way that not only achieves meaning through understanding, but also creates value through evaluating existing matters of fact by comparing them to principles and values that are, most of the time, idealizations of actual objects, systems, and processes. In order to achieve a dynamic and integrative epistemology, a series of integrations are required, especially the integration of the formal and informal aspects of human knowing, the integration of the various levels of consciousness, and the integration of the various artifacts that enhance human processing abilities in the realm of the epistemological inquiry, such as institutions, and mechanical and electronic machines.

2. Wisdom in Decision-making and Problem-solving

It would be an omission to conclude this thesis without looking at the way wisdom is applied in decision-making and problem-solving. Not only are these concepts part of our definition of knowing as information processing, i.e. enriching data with meaning and value for the purposes of decision-making and problem-solving, but they are also affected by overall epistemological assumptions and frameworks. For instance, in the context of normative epistemology, the rational choice model of decision-making and problem-solving has been put forward. This model depends on assumptions of modern science and normative epistemology, such as the idea of a transparent mind whose processes can be monitored. The rational choice model of decision-making and problem-solving follows a mechanical model that upholds that modern principles of rationality are essentially instrumental. These principles match means with goals, or vice-versa. For instance, the practice of budgeting in modern societies requires that either one matches one's budget with what one desires to purchase or, when the financial resources available are not sufficient, one has to be contented with undertaking only what the financial means allow. According to the principle of instrumental rationality, "if you intend that a situation, X, occurs and you believe, in agreement with your evidence, that another situation, Y, is the most effective means to X, then you rationally should have Y occur"[172]. Therefore, instrumental rationality implies a linear pattern of causation where one cause leads to one effect. It also implies that "purposive human action requires deliberate calculation"[173]. From this assumption follows that human decisions and actions are deliberate rational choices, hence, the prominence of a rational choice model of rationality. Weizenbaum, for instance, denounces a certain "imperialism of instrumental reason" that leads to the replacement of judgment by calculation.[174] The rational choice model assumes that human decisions and actions are deliberate acts of will emanating from the nature of humans as rational animals. In other words, decisions and actions, like minds, fall within the realm of an individual's control. Therefore, it is upon one's acts of will to control one's rational processes in a "hardheaded"[175] way in order to achieve not only certainty, but also success. From the point of view of rationality, Raymond Geuss, in reference to the purely instrumental conception of reason, states that:

> This conception of reason denies that there can be any such thing as inherently rational ends or goals for human action and asserts that reason is concerned exclusively with the choise of effective instruments or means of attaining arbitrary ends.[176]

The underlying problem is that despite ample evidence that human decision-making and problem-solving processes appeal to a multilevel form of rationality, decision theorists are reluctant to extend the concept of rationality to its experiential, evaluative, and pragmatic dimensions. Instead, they reproduce assumptions and techniques based on the mechanical model as a way of rendering decisions analyzable. Decision theorists, in fidelity to the Cartesian tradition, are of the view that:

> The basic idea of rational choice theory is that patterns of behavior in societies reflect the choices made by individuals as they try to maximize their benefits and minimize their costs. In other words, people make decisions about how they should act by comparing the costs and benefits of different courses of action. As a result, patterns of behavior will develop within the society that result from those choices.[177]

In other words, “[r]ational decision-making entails choosing an action given one's preferences, the actions one could take, and expectations about the outcomes of those actions”[178]. Rational decisions and actions involve processes of identifying preferences, ranking, and fulfilling the decision/action at its best. This is made possible through a technique of fixing preferences by formalizing them. Formalization renders preferences objective and measurable since abstraction turns various preferences into similar kinds. Therefore, they can be manipulated as abstract entities. Formalization renders preferences quantifiable and suitable for mathematical models. In fact:

> it was originally taken for granted that people’s preferences correspond to abstract points to money. (originally the numbers in payoff matrices represented rank orders of preferences, but there was a tendency to interpret the numbers as having properties of “normal” numbers that can be added, divided, and so on.)[179]

Quantification and formalization render preferences analyzable and suitable for the application of logico-deductive models. Although preferences are subjective and versatile even at the individual level, efforts are made to lend themselves objective, univocal, and measurable. There are always attempts to translate preferences into clear and distinct ideas by defining them, quantifying them, and ranking them. Self-report questionnaires request subjects to give their preferences a numerical value or to rank their preferences on a scale of various ranges (from 1 to 5, for instance, 1 being the most preferred and 5 the least preferred or vice-versa). The assumption behind these ranking procedures is that human preferences cannot only be generalized from one person to another, but they vary from an invariant scale. The quantification and formalization of preferences allow the calculation of utility and the assignment to all decision-making and problem-solving processes of one goal, namely "maximizing utility". As Messik again has pointed out:

> Rationality, theoretically, a type of choice coherence or consistency, meant expected utility maximization in the nonsocial context but something much more complex in competitive or mixed motives situations.[180]

There is, therefore, a transposition of assumptions and methods of normative epistemology in the rational choice model of decision-making and problem-solving, especially the formalization and quantification of preferences as a way of translating them into univocal symbols to which rules of logical inference, mathematical operations, and computer algorithms can be applied. This transposition aims at giving the study of decision-making and problem-solving processes a scientific flavor by assigning them fixed values and subjecting them to linear patterns of causality. In this context, human rationality, reduced to its intellectual level, remains inherently instrumental and mathematical models of utility calculation and decision under uncertainty can be elaborated. Assuming that the rational choice model of decision-making and problem-solving can succeed, the model of rationality it presents implies that the rational processes involved in decision-making and problem-solving are explicit and can be monitored objectively. Moreover, these processes are autonomous, i.e. independent of non-rational processes within the human person, such as emotions and prejudices, and, at the same time, they are not subject to any external influence, be it changes in the environment of the decision maker or the problem solver. The rational choice model implies that rationality is mainly instrumental and procedural so that one only needs to follow a series of predefined steps in order to achieve success.

In other words, proponents of the rational choice model implicitly assume that as rational human beings we operate in a world of clear and distinct ideas or preferences. We can program our decisions and actions by giving our preferences a quantitative value. This quantification of preferences allows us then to rank our preferences in a decreasing or an increasing order since, as quantities, preferences become similar in kind and can be compared on one scale. By quantifying preferences, they are endowed with univocal meanings and made suitable for formalization. The process is indeed not different from the scientific process of quantifying qualities and providing them with a spatial dimension through graphic representation. The quantification of preferences, like the quantification of quality, puts preferences into a medium that renders them analyzable. Following the process of abstraction, the rational choice model creates a situation where we can act on preferences by acting on their representations. Hence, preferences, quantified and formalized, are suitable for normative epistemology as univocal meaning introduces them into a world of fixed symbols and rules of inference, which is simple, regular, orderly, and predictable. This world of univocal symbols allows individual rational beings to operate in clearly defined contexts where the relationships between causes and effects are necessary and where the rules of inference, like the rules of the mechanical universe, are immutable. This process of "fixation" of both meanings and rules of inference implies that a rational human being operates like a mechanical machine with fixed goals, procedures, facts, and values.

Despite the diversity of preferences and values, the rational choice model, in fact, imposes one value to all rational human beings, namely maximizing utility. Not only does it imply a fixation of inputs, outputs, meanings, and rules of inference, but it also fixes its goals. In other words, objective and universal rational processes, i.e. processes of enriching the immediate data of experience with value and meaning for the purpose of decision-making and problem-solving, are processes where univocal meanings produce clear and distinct ideas through a mechanical process of transforming symbols. This process of transfoming univocal symbols following fixed rules of inference is not endless. It ends when certain requirements are fulfilled. Modern conceptions of rationality put forward one requirement, namely maximizing utility. Utility as a criteria of evaluation of rational processes of decision-making and problem-solving implies that, on the one hand, "all actions can be ranked in an order of preference (indifference between two or more is possible)"[181] and, on the other hand, "if action a_1 is preferred to a_2, and action a_2 is preferred to a_3, then a_1 is preferred to a_3"[182]. The first principle is called the principle of "completeness"[183] while the second one is the principle of "transitivity"[184]. Some theorists distinguish between situations of "strict preference"[185], i.e. "when an individual prefers a_1 to a_2, but not a_2 to a_1"[186] and situations of "weak preference"[187], i.e. when "an individual has a preference for *at least* a_1, similar to the mathematical operator $\leq$"[188]. Situations of indifference occur when "an individual does not prefer a_1 to a_2, or a_2 to a_1".[189] Other assumptions include that "[a]n individual has full or perfect information about exactly what will occur under any choice made [...] [since] decision aims at maximizing outcomes"[190], and that "[a]n individual has the cognitive ability and time to weigh every choice against every other choice"[191].

However, the rational choice theory is only applicable in a mechanical universe since it assumes that natural systems/processes are linear and continuous causal chains whose immutable universal laws can be identified and formulated into simple mathematical relations. However, prior to the formulation of laws in mathematical relations, there is a criterion of clarity that has to be fulfilled since the type of causal relations that mechanical systems/processes assume demands a certain kind of formalization that emanates from univocal representation. Univocal representation eliminates ambiguity, maximizes accuracy, and hence, offers a possibility for certainty and “clear and distinct” ideas. This reduction of rational processes to mechanical processes implies defining mental states/processes in terms of matter and motion, but also clearly delineating their components in clear-cut steps that can be formalized into step by step algorithms. Reducing rational processes to mechanical processes is tributary to reducing the whole process of human knowing to the empirical (experiencing) and the intellectual (understanding) levels of consciousness.

This double reduction automatically excludes the third level of consciousness (judging), which is relegated to the level of subjectivity, and the fourth level (acting), which is considered as a byproduct of rational or irrational mental processes that it is believed the trail. However, in practice not only the process of human knowing is differentiated, but it is also integrated since it includes four types of operations, i.e. experiencing, understanding, judging, and acting, but as Lonergan has pointed out, the human mind also operates at four levels of consciousness, namely the empirical (experiencing), the intellectual (understanding), the rational (judging), and the responsible (acting) level. At each level, the human mind performs a qualitatively different operation; however, the four levels of consciousness can neither be reduced to one nor isolated from each other since they operate in synergetic patterns. Not only do they inform each other, but they also provide foundations for each other. What is worth noting is that the various levels of consciousness do not have the same *telos*. Whereas the empirical level aims at achieving accurate representations, the intellectual level aims at achieving universal and objective knowledge identifying the principles underlying the diversity of facts and events. The rational level is mainly evaluative since it compares existing facts and situations with desired facts and situations using principles and values that are, most of the time, idealizations. This difference in *telos* implies that the different levels of consciousness do not use the same "mental" tools as each level involves the mind in a qualitatively specific activity that is different from others, but related to them in a dynamic and integrative way. Moreover, according to Simon:

> First, the [subjective expected utility] theory assumes that a decision maker has a well-defined *utility function*, and hence that he can assign a cardinal number as a measure of his liking of any particular scenario of events over the future. Second, it assumes that the decision maker is confronted with a well-defined *set of alternatives* to choose from. These alternatives need not be one-time choices, but may involve sequences of choices or strategies in which each subchoice will be made only at a specified time using the information available at that time. Third, it assumes that the decision maker can assign a consistent *joint probability distribution* to all future sets of events. Finally, it assumes that the decision maker will (or should) choose the alternative, or strategy that will maximize the expected value, in terms of his utility function, of the set of events consequent on the strategy. With each strategy, then, is associated a probability distribution of future scenarios that can be used to weigh the utilities of those scenarios.[192]

However, shifting from a normative epistemology that does not look for "clear and distinct ideas" or "infallible, indubitable, and incorrigible[193] beliefs to a dynamic and integrative epistemology that accumulates insights through information processing, i.e. enriching data with value and meaning for the purpose of decision-making and problem-solving, integrates a fourfold process of experiencing, understanding, judging (choosing, deciding), and acting. This fourfold process implies a model of rationality that involves a process of searching through the maze of an "external" environment constituted by various material, mechanical, logical, and symbolic entities and processes and an "internal" environment constituted by genetic inheritance, physiological constitution, and other forms of programming, such as childhood experiences, upbringing, behavioral patterns learned through conscious practice, explicit rules from organizations and institutions to which one has pledged allegiance, and operational rules of mechanical and electronic microprocessors. At the individual level, this form of rationality integrates emotional, intellectual, evaluative, and pragmatic abilities while at the collective level, it takes substantive, structural, behavioral, and functional/teleological dimensions into account. The complexity involved in decision-making and problem-solving processes themselves and in both the internal and the external environments implies that the human mind, which dynamically integrates four levels of consciousness, operates through heuristics (rules of thumb) rather than algorithms. As a matter of fact:

> In some very well structured problem domains, formal procedures, usually called algorithms, are available for finding systematically the solution that is best or maximal by some criterion. Elementary calculus provides an example of simple algorithm of this kind: to find the maximum of a function, take the first derivative, set it equal to zero, and solve the resulting equation.[194]

"In most problem-solving domains of everyday life, however, and even in many formal ones, like chess, no such algorithm has been discovered."[195] Therefore, "[i]n most cases of interest, the selection of the paths to be searched is not governed by foolproof, systematic procedures, but by rules of thumb we call *heuristics*"[196].

By adopting heuristics rather than algorithms, one acknowledges that rationality is not a limitless resource that automatically leads to universal and objective knowledge. The rationality of heuristics is a tool for searching rather than a direct and infallible path to discovery. This type of rationality has been characterized by Simon as "bounded rationality"[197]. "Bounded rationality" is task-oriented, context-dependent, and operates within the limits of the computational capabilities of the subject. Instead of constituting itself into a limitless resource, the main role of "bounded rationality" is actually to set limits. In fact, Simon has pointed out that paradoxically:

> Rationality, then does not determine behavior. Within the area of rationality behavior is perfectly flexible and adaptable to abilities, goals, and knowledge. Instead behavior is determined by the irrational and nonrational elements that bound the area of rationality.[198]

Therefore, Simon suggests that, for instance, "administrative theory must be concerned with the limits of rationality, and the manner in which organization affects these limits for the person making decisions"[199]. This focus on the limits of rationality rather than on rationality itself is based on the fact that "behavior is adapted to goals, hence it is artificial, hence reveals only those characteristics of the behaving system that limit the adaptation"[200]. Therefore, for human knowing and human behavior as for any artificial process, "fulfilment of purpose or adaptation to a goal, involves a relation among three terms: the purpose or goal, the character of the artifact, and the environment"[201]. Moreover, "bounded rationality" introduces a criterion of "good enough" that brings an evaluative element into the process of human knowing. This evaluative element links rationality with reasonableness and implies that knowing cannot be reduced to thinking or understanding, but that judging, choosing, and deciding are part and parcel of the process of human knowing. This evaluative element confirms Lonergan's view that knowing occurs at four levels of consciousness, namely the empirical, the intellectual, the rational, and the practical. In fact, for Lonergan:

> What promotes the subject from experiential to intellectual consciousness is a fuller unfolding of the same intention: for the desire to understand, once understanding is reached, becomes the desire to understand correctly; in other words, the intention of intelligibility, once an intelligible is reached, becomes the intention of the right intelligible, of the true and, through truth, of reality. Finally, the intention of the intelligible, the true, the real becomes also the intention of the good, the question of value, or what is worthwhile, when the already acting subject confronts his world and adverts to his own acting in it.[202]

A dynamic and integrative model of decision-making and problem-solving based on the dynamic and integrative model of epistemology, which we have suggested, would imply adopting a model of human knowing that integrates issues of meaning, value, and purpose into a goal-oriented dynamic and integrative process. This model would integrate decision-making and problem-solving in the process of human knowing, unlike normative epistemology that separates the realm of thought from the realm of action. In practice, as Simon has pointed out:

> What is required is the ability to recognize the goal, and to detect the differences between the current situation and the goal, and actions that can reduce such differences: precisely the capabilities embodied in a system like the General Problem Solver.[203]

In other words, whereas previously reality was apprehended in terms of material bodies in motion (mechanics), we suggest a paradigm shift from mechanics to a more encompassing cybernetic model where "information theory explains organized complexity in terms of reduction of entropy (disorder) that is achieved when systems (organisms, for example) absorb energy from external sources and convert it to pattern or structure"[204]. In other words, "[i]n information theory, energy, information and pattern all correspond to negative entropy"[205]. The recognition that energy, information, and pattern correspond to negative entropy creates the possibility of studying organized complexity by reevaluating spacio-temporal relations not in terms of material bodies colliding randomly, but in terms of organized processes that are oriented towards a goal in a changing environment. In fact, "[f]eedback control shows how a system can work towards goals and adapt to a changing environment[206], therefore removing mystery from teleology"[207].

Removing mystery from teleology implies the possibility of identifying mundane goal-oriented processes that fall within the limits of human capabilities and aspirations. Therefore, teleology in this context should not be confused with the ultimate and absolute requirements associated with the Aristotelian "unmovable mover" as "final" or "efficient" cause. Teleology should be associated with the awareness that causality should not be apprehended solely in an instrumental sense reducing rationality to the search of means to an end. Teleology should be integrated into all goal-oriented processes that aim at reducing the gap between a desired and an existing situation. These processes that include the defining of the goals themselves take place in a dynamic (changing) environment and within the limits of human cognitive abilities. Therefore, human knowing as a goal-oriented process should not be understood solely in terms of its mechanisms, but also in terms of its goals. Teleology, in other words, should be understood in a more mundane sense as a goal that is not out of human reach. This type of goal has to be SMART, i.e. Specific, Measurable, Achievable, Realizable, and Timely. This implies that as we shift the goal post from absolute and universal requirements to human attainable boundaries, we are no longer interested in finding the best solutions, i.e. optimizing, as the rational choice model suggests, but in finding solutions that are good enough. This shift in the level of goals has been called "satisficing" by Simon. According to Simon:

> In the face of even moderate uncertainty, it seems almost hopeless to strive for "optimal" courses of action. When conflicts in values exist, as they almost always do, it is not clear how "optimal" is to be defined. But all is not lost. Reconciling alternative point of view and different weightings of values becomes somewhat easier if we adopt a satisficing point of view: if we look for good enough solutions rather than insisting that only the best solutions will do. It may be possible – and it is often possible – to find courses of action that almost everyone in a society will tolerate, and that many people will even like, provided we aren't perfectionists who demand an optimum.[208]

A dynamic and integrative model of rationality implies that one acknowledges that the subject has limited information processing and cognitive abilities and yet, at the same time, that human knowing cannot be reduced solely to an activity of the mind. Hence, the aim of the process of knowing is not the ideal of acquiring true justified beliefs through an infallible process of instrumental rationality as defended by normative epistemology. The process of human knowing implies adapting one's abilities to one's goals following the limited and the limiting resources of Simon's "bounded rationality". "Bounded rationality" is, in addition to acknowledging that knowing includes experiencing, understanding, judging, choosing, deciding, and acting, at the origin of an information processing model of human knowing that is itself based on the view that:

> (1) a theory of human rationality "must be concerned with procedural rationality – the ways in which decisions are made – as with substantial rationality – the content of those decisions"; (2) In terms of procedural rationality, "the task is to replace the global rationality of economic man with a kind of rational behavior that is compatible with the access to information and the computational capabilities that are actually possessed" by humans; (3) "human rational behavior is shaped by a scissors whose two blades are the structure of the task environment and the computational capabilities of the actor".[209]

Therefore, the information processing model of human knowing acknowledges the impossibility of omniscience.[210] Instead of aiming at a type of certainty that transcends all times and environments, it engages the subject into a process that is flexible, adaptive, and open to correction and learning. In other words, both in decision-making and in problem-solving, the subject relies on heuristic rules rather than on normative principles embodied in formal logic, probability calculus, or decision theory. In fact, "most problems of any importance are computationally intractable, that is, we do not know the optimal solution, nor a method for how to find it"[211]. Moreover:

> The same uncertainty holds for less well-structured problems, such as which job to accept, what stocks to invest in, and whom to marry. When optimal solutions are out of reach, we are not paralyzed to inaction or doomed to failure. We can use heuristics to discover good solutions.[212]

This is possible as heuristics exploits both the evolving capacity[213] of the subject and, at the same time, the evolving structures of environments[214]. As an instrument of "bounded rationality", "a heuristic is a rule whose purpose is to describe the actual process – not merely the outcome – of problem-solving"[215]. In other words, "the rationality of heuristics is not simply a means to a given end; the heuristics itself can define what the end is"[216].

Simon has pointed out that "the criterion of 'good enough', which adjusts in this way [to the task, the environment, and abilities of subject] is called an *aspiration level*"[217]. However, normative epistemology and subsequently the rational choice model of decision-making and problem-solving remain silent on the way our aspiration levels are established. Simon points out rightly that "[a]t best, the model tells us how to reason about fact and value premises; it says nothing about where they come from"[218]. Moreover:

> When these assumptions are stated explicitly, it becomes obvious that SEU [subjective expected utility] theory has never been applied – with or without the largest computers – in the real world. Yet one encounters many purported applications in mathematical economics, statistics, and management science. Examined more closely, these applications retain the formal structure of SEU theory, but substitute for the incredible decision problem postulated in that theory either a highly abstracted problem in a world reduced to a few equations and variables, with the utility function and the joint probability distribution of events assumed to be already provided, or a microproblem referring to some tiny, carefully defined and bounded situation carved out of a larger real-world reality.[219]

The key issue is that:

> It [the SEU model] is applied to highly simplified representations of a tiny fragment of the real world situation, and that the goodness of the decision it will produce depends

> much more on the adequacy of the approximation assumptions and the data supporting them that it does on the computation of a maximizing value according to the prescribed SEU decision rule.[220]

The previous remarks by Simon indicate that in addition to making wrong assumptions about the knower cum decision maker and problem solver, the rational choice theory also makes wrong assumptions about the world in which the process of human knowing takes place. The world in which the rational choice model operates is a simplified, ordered, and predictable version of the real world. In this emaciated world, one could be able to examine all the available alternatives and predict all the possible outcomes of one's choices and actions accurately. However, the main trait of the real world is its complexity. Even in natural sciences, some entities, such as atoms and cells, that are considered as the simplest, fundamental, and indivisible units of non-organic and organic bodies, display unprecedented complexity both in their constitution, their functioning, and their interaction with other elements. Some authors even postulate that the orderly world of Newton's physics is an abstraction that applies to a very small portion of the world. For these authors, deterministic chaos[221] as well as complexity are essential features of the world. [222] Therefore, a realistic study of the process of human knowing and subsequently of decision-making and problem-solving processes should face the challenge of the complexity of the real world. The challenge posed by the complexity of the real world is met by the fact that:

> One doesn't have to make choices that are infinitely deep in time, that encompass the whole range of human values, and in which each problem is interconnected with all the other problems in the world. In actual fact, the environment in which we live, in which all creatures live, is an environment that is nearly factorable into separate problems. Sometimes you're hungry, sometimes you're sleepy, sometimes you're cold. Fortunately, you're not often all three at the same time. Or if you are, all but one of these needs can be postponed until the most pressing is taken care of. You have lots of other needs, too, but these also do not impinge on you at once.[223]

In other words, when we make decisions and solve problems in the real world, we are neither dealing with the whole world nor are we taking all existing human conditions and values into account. We are capable of focusing on limited parts of the world and of using limited abilities. The nature of our decisions does not require us to deal with all the problems at the same time. As human beings we are limited both in time and space. Our spatial and temporal bond is attested by the fact that we cannot be at two places at the same time. Kant was right to suggest that space and time are the a priori of our experience. Our decisions, like ourselves, are spatially and temporally bounded. Simon has pointed out that:

> Your decisions are not comprehensive choices over large areas of your life, but are generally concerned with rather specific matters, assumed, whether correctly or not, to be relatively independent of other, perhaps equally important dimensions of life.[224]

Moreover:

> We live in what might be called a nearly empty world – one in which there are millions of variables that in principle could affect each other but that most of the time don't. [...] Perhaps there is actually a very dense network of interconnections in the world, but in most of the situations we face we can detect only a modest number of variables or considerations that dominate.[225]

Satisficing is intrinsically linked with "bounded rationality" as limiting our goals to "good enough" solutions instead of optimizing our goals implies adopting a modest approach to epistemology that is descriptive rather than normative.

3. Institutional Rationality

Overall processes of human knowing are not necessarily bound to physical and physiological processes of the human body. The body as the receptor of sensations and the location of immediate experience plays a great role in the process of human knowing and the organization of elementary processes. These processes include operations such as (1) comparing symbols to determine whether they are identical or not, (2) creating or copying symbols lists and associations, (3) finding information that is structured and stored in memory. However, processes of human knowing cannot be confined within the physical boundaries of individual organisms. As Simon has pointed out:

> provided with only the program output, and without information about the processing speed, one cannot determine what kind of physical devices accomplished the transformations: whether the program was executed by a solid-state computer, an

> electro-tube device, an electrical relay machine, or a room full of clerks! Only the organization of the processes is determinate.[226]

In other words, these processes cannot be limited to individual human beings, but they can be extended to other artificial systems. Simon has noted that there are several kinds of artificial systems, and in his *The Sciences of the Artificial* he has examined particularly "economic systems, the business firm, the human mind, sophisticated engineering designs, and social plans"[227]. In fact:

> Actors are persons, groups, organizations, or networks that are capable of making decisions and acting in a more or less coordinated way. The actors may have been newly formed, or they may have been newly transformed – but only by a finite set of forces. Among them are political struggles, shifts in cultural forms, the development of new technologies, and the emergence of opportunities to make economic gains.[228]

Therefore, actors in their interactions that include cooperation, competition, conflict, and exercise of power[229] are not totally bounded by rational principles as they engage in "purposeful behavior"[230]. On the contrary, "[s]ocial activity is determined by contextual factors, constitutes a fluid and dynamic force maintaining or changing games and their contexts"[231]. On this accout, it is not adequate, in my view, to reduce decision-making and problem-solving to thinking.[232] This is a vestige of the normative epistemology's reduction of knowing to thinking. Instead, it is important to recognize that:

> (a) the theoretical goal of CPS [complex problem-solving] research is to understand the interplay among cognitive, motivational, personal, and social factors when complex, novel, dynamic, non-transparent tasks are solved, and
> (b) the interplay among the various components can be understood within an information processing model.[233]

This implies the elaboration of a model that includes "the problem solver, task and environment"[234] in a situation where "information processing includes the task strategies that are selected and processes of task monitoring and progress evaluation"[235]. This model also recognizes the role of the environment, which potentially offers both barriers and opportunities. As Frensch and Funke have noted:

> The environment includes the resources available for problem-solving, as well as feedback, expectations, cooperation, peer pressure, disturbances, etc. The environment affects both problem solvers and the task. It affects problem solvers by constraining the information process that can be used in influencing which knowledge is accessible. The environment affects the task by providing additional information, constraining which tools may be used, and so on. In addition, the environment can be changed actively by the problem solver but not by the task.[236]

The challenge is rooted in the fact that problems are defined in terms of barriers or gaps between an existing and a desired situation and these barriers themselves "are assumed to be complex, dynamically changing, and non-transparent"[237]. This non-transparency of the real is due to the complexity of the real, on the one hand, and the limited human processing abilities on the other hand. Therefore, knowing defined as accumulating insights thought information processing does not aim at providing true answers once and for all; it points to a dynamic and integrative process that improves itself through its "ability to learn from success and failure"[238]. All in all, it is important to note that decision-making and problem-solving, as part and parcel of the process of human knowing, are embedded in the notion of information itself, but they are also generally confronted with limiting factors, such as "(1) the complexity of the situation, (2) the connectivity of the variables, (3) the dynamic development of the situation; (4) intransparency or opaqueness, (6) polytely (pursue of multiple goals)"[239]. Therefore, "this complex task demands the acquisition and integration of information, the elaboration and attainment of goals, action planning, decision-making, self-management"[240]. All these tasks cannot be accomplished by individual minds assumingly hosted by individual human beings. They require, in addition to the fact that individual human beings are tributary to their genetic inheritance, their early childhood experiences, upbringing, and conscious practice, they are also in constant interaction with other humans and their non-human environment. The process of human knowing is also, in fact, enhanced by artifacts created by humans themselves to enhance their limited computational abilities. These artifacts do not only include mechanical and electronic processors, but also organizations specially designed to accomplish specific goals. These artifacts, in my view, found the notion of institutional rationality. Institutional rationality is based on the fact that:

> Our institutional environment, like our mental environment, surrounds us with a reliable and perceivable pattern of events. We do not have to understand the underlying causal mechanisms that produce these events, or the events themselves in all their detail, but only their pattern as it impinges on our life, on our needs and wants. The stabilities and predictabilities of our environment, social and natural, allow us to cope with the limits set by our knowledge and our computational capabilities.[241]

It is in relation to "institutional rationality" that some popular concepts such as Peter Senge's "learning organization" [242], or more generally, the characterization of the information society as "knowledge society". As corollaries to "institutional rationality", it is worth noting that in its framework there are "structural rationality"[243], "substantive rationality"[244], "procedural rationality"[245], and "evaluative rationality"[246]. Structural rationality "guides the establishment of the structure of organizational decision-making"[247], i.e. the establishment of both adaptive "internal controls"[248] and adaptive "external controls"[249]. In other words:

> structural rationality is always involved with the organization of decision-making where structure of a system is defined by the set of relationships between subsystems (groups, departments: WHO decides?), between aspects systems (the issues, topics about which decisions are taken: WHAT is decided and HOW?) and phase systems (the phases: WHEN are decisions taken?).[250]

Substantive rationality, on the other hand, "is concerned with questions of 'content', 'substance', or 'knowledge' which guide the outcome of actions over a certain universe of discourse"[251]. Substantive rationality is illustrated by the fact that every universe of discourse has its ways and procedures to solve problems that are specific to that universe. For instance, economic theory is substantive rationality in solving economic problems[252], but the same substantive rationality cannot be applied to other domains. For instance, while charity is a praiseworthy action in the context of religion or humanitarian action, charity would not be accepted following the substantial rationality of economics where it would amount to allocating resources to an area that is not productive. Another example of substantive rationality is rules of law, such as statutes and legal substance when deciding legal matters,[253] or technical procedures in the operation of machinery, etiquette, language, and rituals in formal social interactions.

Procedural rationality "is concerned with the choice of procedures by which decisions over the universe of discourse are taken" while:

> without entering into a discussion of the origin or the teleological orientation of organizations (that is whether goals 'exist' or are 'attributed' to decision makers), evaluative rationality refers either to goals towards which decision makers appear to strive and/or the criteria by which goal attainment is defined and evaluated.[254]

In brief, "structural rationality is concerned with *structure*, evaluative rationality with *ends*, substantive rationality with *content* and procedural rationality with *form*"[255]. Institutional rationality is confronted with some problems that have to do with our limited attention, multiple values on which various individuals hold dear, and uncertainty. However, these limits that are intrinsic to our individual rationality can be superseded by institutional rationality. For instance:

> The routine and repetitive requirements of a society are handled in parallel by creating specialized groups and organizations, each of which deals with one set of issues while the others are dealing with the remainder. If it were not so obvious, we might label this the "fundamental theorem of organizational theory".[256]

Moreover:

> Over a wide range of matters, we can use markets and pricing to limit the amount of information each person must have about the decisions he is going to make. When I go to a supermarket, I can decide what to buy and what I am going to eat without knowing very much about how Wheaties and oatmeal are made, or what the manufacturer's problems are. I need only to know the price at which he is offering these commodities to me. For this reason, markets and prices have proved to be extremely powerful mechanisms in modern societies for helping each of us to make decisions without having to learn a whole lot of detail about other people who may be involved. All relevant information is summed up in the price we have to pay in order to make the transaction.[257]

In addition to organizations and markets, experts have proved to be very reliable if not exclusive solution and advice providers in situations where we do not know which decision to make or how to solve a problem. In fact, “in matters of public policy as in matters of medicine or plumbing, we turn to experts. Sometimes we even take his advice without asking to have it fully explained”[258]. Experts are not only knowledgeable in their domains, but they also have devoted time, talent, and efforts to acquire levels of information and know-how that are unmatched by non-specialists. In this situation, it is important that “decentralization of decision-making has proved to be a solution to organizational and market boundaries”[259]. Moreover:

> When a domain reaches a point where the knowledge for skillful professional practice cannot be acquired in a decade, more or less, then several adaptive developments are likely to occur. Specialization will usually increase (as it has, for example, in medicine), and practitioners will make an increase use of books and other external reference aids in their work.[260]

In situations where the domain is so vast that the opinion of one expert may not be enough or where a domain, such as an academic discipline or a problematic situation, has not yet reached the stability of “normal science”[261], “adversary proceedings”[262] that include experts with different views can provide unprecedented insights. According to Simon:

> Adversary proceedings are like markets and organizations in reducing the information that participants must have in order to behave rationally. Thus, they provide a highly useful mechanism for systems in which information is distributed widely and in which different system components have different goals. Each participant in an adversary proceeding is supposed to understand thoroughly his own interests and the factual considerations relating to them. He need not understand the interests or situations of the other participants. Each pleads his own cause, and in doing so, contributes to the general pool of knowledge and understanding.[263]

In addition to human experts, there are non-human “experts” tools, such as maps, dictionaries, encyclopedia, reference books, codes of legal principles and proceedings, quality and standard control organizations. With the development and the wide diffusion of electronic computers, most of the non-human “expert” tools have both print and electronic versions. The most common are, for instance, the possibility of navigation through GPS [Global Positioning

Systems], which can be used instead of traditional paper based maps when one travels. There are also "expert systems" in various domains of specialization. According to Frank Puppe, "expert systems are [computer] programs for reconstructing the expertise and reasoning capabilities of qualified specialists within limited domains"[264]. Puppe points out that:

> The preliminary basic assumption is that experts construct their solutions from single pieces of knowledge which they select and apply in a suitable sequence. Hence expert systems require detailed information about the domain and the strategies for applying this information to problem-solving. In order to construct an expert system, the knowledge must therefore be *formalized*, *represented* in the computer and *manipulated* according to some problem-solving method.[265]

Moreover, in the context of "bounded rationality", complexity, uncertainty, and the limited computing capabilities of individual experts limit the scope of individuals in both decision-making and problem-solving. In addition to human and non-human experts, there are technical tools for decision-making and problem-solving. According to Simon:

> These new tools are usually assigned to the disciplines of operations research and management science – and today to artificial intelligence as well. It is a special characteristic of these tools that they allow us to formulate, model, and solve problems with thousands of variables and thousands of constraints on the variables, and to take account of the interactions of all these variables and constraints in arriving at a solution.[266]

However, some of these techniques pose the problem of applicability. For instance:

> One serious limitation on the applicability of operations research and management science techniques is that they require problems to be quantified in such a way that known mathematical techniques become applicable to them. For example, to employ linear programming for solving a problem, the problem first has to be translated (or folded, or beaten) into a form that expresses it in terms of linear equations, linear constraints, and a linear payoff function. If the world doesn't have these properties, or can't be approximated adequately in this way, linear programming won't work.[267]

D. CONCLUSION

Defining human knowing as accumulating insights through information processing implies challenging in an unprecedented way assumptions that normative epistemology has inherited from modern science and its attempts to model human knowing on the physical sciences. It implies, therefore, an assessment of how the notion of information has emerged in relation to the physical sciences and other successful sciences, such as biology, neurophysiology, the social sciences, computer science, and so forth. The last chapter was an attempt to achieve this task by linking the notion of information to Wiener's definition of information as "negative entropy". Hence, information defined as a certain degree of organization means that information can be understood as patterns of (self-)matter and energy. This conception of the notion of information links information with some spatial arrangements, be they at the macromolecular level, at the neural level, at the social level, or at the technological level. Understanding information as patterns of (self-)organizing matter and energy only gives a static view of information that can be entrapped in a well-entrenched substance metaphysics, which would make a dynamic and integrative model of epistemology, like the one we have suggested, impossible. However, when one looks at information from the point of view of its capacity for behaving and becoming, one becomes aware that the predilection for fixity in both modern science and normative epistemology is unproductive as it limits human knowing to its formalized aspects that have emanated from modern science's search for "clear and distinct" ideas, which can only be attained by acting on univocal symbols following invariable rules of transformation. These univocal symbols are reached through a process of fixing meaning and reference that occurs through preprocessing or digitalization of immediate experience. Preprocessing and digitalization imply fragmenting continuous processes into regular temporal and spatial parts by fixing temporal and spatial references, such as in the calibration of measuring instruments.

By integrating information's ability to behave and become, the perspective in epistemology is changed, which constitutes a dynamic and integrative model of human knowing that considers knowing, first and most of all, as an activity of the knower. This approach suggests that instead of asking the question "What is knowledge" and trying to clarify its nature, possibility, conditions, and limits, one can ask Lonergan's questions "What am I doing when I am knowing? Why is doing that knowing? What do I know when I do it?"[268]. Answering these three question implies a dynamic and integrative model of epistemology that defines knowing as accumulating insights through information processing as the notion of information itself integrates spatial arrangements and processes that occur at various levels, i.e. at the macromolecular, neural, social, and cultural levels. These processes have static and dynamic aspects and are, thereore, not only embedded with the capacities of being, but also with the capacities of behaving and becoming. From this perspective, knowing is understood in a conceptual framework of complexity by considering substantive, structural, behavioral, and functional (teleological, or teleogenic) aspects, which requires taking account of one's goals, changing patterns of behavior over time, structures that act as processors, and the "materials" that make the structuring and the functioning of the processors possible at the molecular level.

The three facts of information, i.e. being, behaving, and becoming, show striking similarities with Lonergan's process of human knowing as the definition of knowing as information processing suggests an assimilation of the two frameworks. The levels of spatial arrangements that define the notion of information do not invite epistemology to consider processing by individual, disembodied minds, as normative epistemology has often assumed, but to take account of the genetic inheritance that determines not only the physiological constitution and a number of behavioral patterns of humans and other members of the animal kingdom, but also early childhood experience, upbringing, conscious practice, and the assignment of explicit rules and other forms of "programming" that influence the process of human knowing. Beniger has identified four such types of programming, namely genetic, cultural, organizational, and mechanical/electronic programming.[269] In Beniger's view, "each program is a contributing cause"[270]. Taking these levels of spatial arrangements into account creates a link between information and organization on the one hand (confirming Wiener's definition), but also the link between information and predetermined goals (programming). Moreover, the notion of information is also linked with embedded processes that determine the way an organism's behavioral processes achieve predetermined goals (control). Linking information with organization, control, and programming shows that knowing as information processing does not only involve achieving accurate representations, as normative epistemology has assumed, but it also involves enriching the immediate data of experience with meaning and value for the purpose of decision-making and problem-solving. This process relies on resources such as attention, intelligence, reasonableness, and responsibility in such a way that dynamic and integrative epistemology integrates metaphysical, epistemological, and ethical concerns. All in all, knowing as information processing implies that, as Simon has pointed out:

> in an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it.[271]

However, when knowing is regarded as a dynamic and integrative process that amounts to the accumulation of insights through experiencing, understanding, judging (choosing, deciding), and acting, it also needs to be acknowledged that knowing occurs at different levels of consciousness. These levels of consciousness, the experiential, the intellectual, the ethical, and the practical, do not only correspond to the various operations that lead to them, but they also require specific skills that are dynamically integrated in order to enrich data with value and meaning in order to fulfill purposes. These skills are not isolated acts, but attitudes that shape the process of knowing despite its dynamic and integrative nature. Lonergan has called these skills transcendental precepts. For him:

> Progress proceeds from originating value, from subjects being their true selves by observing the transcendental precepts, Be attentive, Be Intelligent, Be reasonable, Be responsible. Being attentive includes attention to human affairs. Being intelligent includes a grasping of hitherto unnoticed or unrealized possibilities. Being reasonable includes rejection of what probably would not work but also acknowledgement of what

> probably would. Being responsible includes basing one's decisions and choices on an unbiased evaluation of short-term and long-term costs and benefits to oneself, to one's groups, to other groups.[272]

It is worth noting that:

> Progress, of course, is not some single improvement but a continuous flow of them. But the transcendental precepts are permanent. Attention, intelligence, reasonableness and responsibility are to be exercised not only with respect to the present situation but with respect to the subsequent, changed situation.[273]

All in all, patterns of human knowing in the information society imply a dynamic and integrative epistemology that, following Lonergan's framework, integrates processes of experiencing, understanding, judging (choosing, deciding), and acting.[274] Information processing consists in integrating these processes since experiencing data alone is not knowing; the processing of human knowing means that the data that is experienced has to be understood through enriching it with meaning, but solely experiencing and understanding data do not complete the process of knowing as data that is experienced and understood has to be usable. From this point of view, there is an interaction between what happens inside the human organism, namely experiencing and understanding, and what happens outside the human organism. For this reason, as the knower interacts with his or her human and non-human environment, the knower has to judge situations, determine whether to act or not, how experienced and understood data should be used or if it should be used at all, and how real situations stand in relation to principles and values that are, most of the time, idealizations used as yardsticks in assessing these real situations. This interactions with the environment imply that in addition to experiencing and understanding, human knowing involves processes of judging, evaluating, choosing, deciding, and acting, which militate for an epistemological model that goes beyond normative epistemology's reduction of knowing to its intellectual dimensions. Dynamic and integrative epistemology does not find its foundation in the search for immutable universal laws that assumingly represent substances, but in a process that dynamically integrates the knower's emotional (*pathos*), intellectual (*logos*), evaluative *(ethos*), and pragmatic (*praxis, phronesis*) abilities. These abilities are not to be opposed to each other as some of them have been considered as enemies of rationality by normative epistemology and modern rationalism. They are part and parcel of the process of human knowing since knowing as information processing, i.e. enriching the immediate data of experience with value and meaning for the purposes of decision-making and problem-solving, means operating at four levels of consciousness, i.e. the empirical, the intellectual, the rational, and the responsible, as Lonergan has indicated.[275]

Dynamic and integrative epistemology by describing knowing as information processing brings together Lonergan's epistemology and Schultheis' and Sumner's distinction of information and data with Drucker's definition of knowledge as information that changes something or someone for better decisions or actions.[276] The impact of these changing paradigms are great, not only since dynamic and integrative epistemology solves traditional philosophical problems, such as opposing emotion to reason, and empiricism to rationalism, creating an epistemology of unsolved and assumingly unsolvable binary oppositions, instead of building an epistemology of successions that shows that empiricism, rationalism, critical theory, and pragmatism are steps in one dynamic and integrated continuum. From this integration of different schools of thought also follows an integration of different methods since each operation in the process of human knowing corresponds to a specific level of consciousness and a specific school of thought in philosophy. From this point of view, dynamic and integrative epistemology integrates empirical, analytic, critical, and experimental methods, with each method being used for its specific purpose, instead of using analytic methods as a master key that allows us to find out facts (data), grasp their meaning, appreciate their value, and assign them various purposes. Moreover, dynamic and integrative epistemology overcomes scientific reductionism as it does not look for fundamental particles or univocal propositions as foundations of knowing, but it tackles reality in its complexity and dynamism considering its substantive, structural, behavioral, and functional (teleological or teleonomic) dimensions. Not only are human mental abilities as reduced to intellectual abilities called in by normative epistemology, but there are also other knower's resources, such as attention, intelligence, reasonableness, and responsibility that play a contributing role since knowing does not solely mean reasoning, but it also includes skill, connoisseurship, and commitment.[277] Even in the case of scientific knowledge, from which normative epistemology draws assumptions and aspirations, skill, connoisseurship, and commitment are important as, for instance, the manipulation of scientific equipment is not a logico-deductive process.

Last but not least, dynamic and integrative epistemology overcomes solipsism by founding itself on the notion of information, which implies, on the one hand, patterns of (self-)organizing matter and energy, and patterns of being, behaving, and becoming, on the other hand. In this way, information and control are intrinsically linked, which leads to situations where the knower is not considered as an isolated and immutable entity with an equally isolated mind. Instead, the knower is a living human being, who shares with other human beings and some other members of the animal kingdom a physiological constitution that is tributary to a genetic inheritance that all humans as a species share. Moreover, the knower partakes in the cultural, institutional, and technological programming that influence both individual and institutional rationality. With the notion of information spatial patterns at the level of macromolecules (DNA for instance), the nervous system, culture, institution, and technology are taken into account, which creates a possibility of considering the human mind not as an immutable entity or an ethereal reality that eludes direct observation and scientific experimentation. The human mind can be considered as a control system that regulates the interaction of living human beings with their material, mechanical, logical, and symbolic environment. Moreover, the human mind as a control system would be an interesting further research area. Further research then would involve a study of the human mind that is not based on a mechanical model, as it is usually done, but on the cybernetic model on which dynamic and integrative epistemology itself is based. When taking substantive, structural, behavioral, and functional (teleological or teleonomic) patterns into account, one tackles “the inherent complexity of the real”[278].

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CONCLUSION

This philosophical study of the epistemological implications of the information revolution was a complex undertaking. On the one hand, it was historical in its focus attempting to establish relationships of continuity and/or discontinuity with previous conceptual frameworks, especially the medieval synthesis, modern science, and normative epistemology. The historical focus did not only point out that the information society is a sociological process, but also a conceptual framework. As a conceptual framework, the information society puts forward information in such a way as the information society itself can be studied philosophically as a paradigm that yields as much power as similar paradigms that, for instance, have fostered the passage from a medieval age, which was dominated by supernaturalism and based its epistemological assumptions on tradition, revelation, and reliance on (religious) authority. Looking at the information society from a historical point of view showed that there are intrinsic links between metaphysics and epistemology as both the description of reality and the articulation of knowledge depend on what is considered as real. These links between metaphysics and epistemology prompted us to assess the metaphysical changes that fostered the emergence of modern science, namely a pervasive shift from supernaturalism to naturalism, but also a shift from the reliance on revelation, tradition, and (religious) authority, as sources of knowledge, to observation, reasoning, and experimenting. In anticipation of the links between epistemological paradigms and sociological processes, the historical point of view accounted for a crisis of authority that questioned the assumptions of the practices of the medieval Christendom in an unprecedented way. These social transformations fostered a certain disintermediation of knowledge that favored individual experience over mediation by authority so that an emerging urban elite would undertake knowledge functions without associating them with clerical status. Moreover, in this context, the Reformation and the invention of the printing press facilitated the access of the masses to devotional books that were previously reserved to the clergy. The abundance and the accessibility of knowledge, as compared to previous periods, led to a crisis of authority and diversity of opinion. Observations of scientists, such as Galileo, challenged the doctrines of the universe that were supported by church authorities and that approved of the prevailing social order. People who claimed to be enlightened by reason tried to spread their doctrines based on Galileo's cosmological observations and Descartes' spread of "methodological" doubt and promise of a "new" foundation of indubitable, infallible, and incorrigible knowledge. It is, therefore, not surprising that, given Descartes' method based on doubt, normative epistemology aimed at establishing certainty, unlike ancient philosophers who defined philosophy as the love of wisdom.

Modern science became the model of human knowing since it did not only expand the horizon of the human mind through unprecedented observations and precise calculations of the dimensions of the universe, but it also provided an alternative foundation of truth, given the prevailing Fideism and disputes that led to the religious wars that ravaged Europe. There was an urgent need to replace the authority of the Church by the authority of reason, and thereby avowing the arbitrary nature of supernatural beliefs and the tyranny of authority that led to recorded tragic actions, such as the execution of Galileo, and to coercive and repressive institutions, such as the inquisition. Modern science, by founding knowledge on the authority of reason rather than on the authority of the Church, fostered the emergence of a new conceptual framework based on naturalism rather than supernaturalism, and based on observation, reasoning, and experimenting as sources of knowledge instead of revelation, tradition, and authority. Moreover, this new framework described the universe as a material, mechanistic, and deterministic system, which did not need any explanation and justification outside itself. This universe was regulated by universal laws, which could be identified and formulated into simple mathematical relations. This conception of the universe influenced normative epistemology in various ways as it defined reality in terms of material bodies in motion (the mechanical model) and set certainty as the aim of human knowing so that, unlike in ancient times when philosophy was the foundations of all the sciences, philosophy strived to be scientific by modeling all sciences and knowledge after the physical sciences. This modeling of all knowledge after the physical sciences led to the emergence of a normative epistemology that aims at certainty and defines knowledge as true justified belief, which reduces knowledge to univocal propositions of the form S is P, similar to mathematical formulations of universal laws as found in the physical sciences. The reduction of knowledge to univocal propositions of the form S is P has been called the Gettier problem in standard epistemology books, but there is no agreement on which form of justification leads to the certainty embedded in indubitable, infallible, and incorrigible knowledge. In other instances, justification has been replaced by warranty. What complicates the debate is that the historical origins of these debates are often eliminated from epistemological inquiry in an attempt to articulate an a-historical and universal epistemological discourse.

Nevertheless, normative epistemology, in its attempt to model all human knowledge after the physical sciences, contends that knowledge is true justified belief, which amounts to univocal propositions. This reduction of human knowledge to propositional knowledge does not only reduce the area of epistemological inquiry, but it also ignores the paradigmatic nature of predication. As such, normative epistemology sets normative criteria for human knowledge instead of describing how real knowledge processes occur. The dynamic and integrative model of human knowing, which we suggest as a possible alternative, does not only focus on knowledge as an end product, but also on the process of human knowing. It acknowledges that human knowing is a multilevel and multifarious process, which integrates emotional (pathos), intellectual (logos), evaluative (ethos), and practical (praxis) dimensions creating a diversity that is commensurate to various areas of human specialization and expertise. All forms of human knowing are insights since insight integrates new data or experiences in pre-existing explanatory frameworks in such a manner that new insights influence subsequent courses of action. From this point of view, knowing cannot be reduced to logico-deductive processes that easily lend themselves to formalization and mathematical models. Instead, dynamic and integrative epistemology requires to take both explicit and tacit forms of human knowing into account so as to integrate, for instance, scientific knowing, which deals with the way things relate to each other, with common sense, which deals with the way things relate to us. These two forms of human knowing do not have be put in a hierarchical relationship, which would imply that one form of human knowing is better than the other. It is more academically and practically enriching to realize that the two forms of knowing cannot be expected to produce the same results as they are different both in their *telos* and procedures. Whereas scientific knowing aims at establishing a coded (nominal definitions), formalized, systematized, and controlled form of knowledge, which appeals to objectivity and universality, common sense appeals to less structured and highly context-dependent skills. Scientific forms of human knowing and common sense are at two different antipodes of a possible continuum, which would be established by using universality and context-dependence as criteria of demarcation.

The conceptual framework of a dynamic and integrative epistemology is not a mechanical model, but a cybernetic model. Mechanical models of the universe are based on a number of assumptions of the physical sciences, such as the simplicity, the regularity, and the orderliness of the universe itself; hence, scientists or natural philosophers have the ability to formulate the laws that regulate the universe in simple mathematical relations. These assumptions are carried into other areas of human knowing that claim the status of a science in such a way that suitability for formalization and mathematical models becomes a criterion of evaluating whether a discipline is a science or not. However, dynamic and integrative epistemology builds on a cybernetic model that does not define reality in terms of matter in/and motion, but in terms of information and control through feedback processes. A cybernetic model is more general than a mechanical model since the latter can be understood as a special case of a cybernetic model where inputs, outputs, and rules of transformation have been fixed. Having the possibility of linking information with matter by defining information as patterns of (self-)organizing matter and energy, a cybernetic model is broader than a mechanical model as a cybernetic model defines reality in terms of matter, motion, logic, and symbolism. This way a cybernetic model includes aspects of order and teleology in the process of human knowing and these aspects are generally missing in mechanical models. A cybernetic model, therefore, goes beyond the linear patterns of causality that characterize mechanical models and defines reality in terms of behaving systems that do not operate according to linear patterns of causality, by which the same causes lead to the same facts, but according to differential laws, where there are no proper causal relations, but inputs and outputs that influence each other as when the system/process reaches certain critical values that trigger feedback processes.

A cybernetic model of reality, therefore, allows the articulation a dynamic and integrative epistemology that does not focus on knowledge, but on the process of human knowing itself. Its approach is descriptive rather than normative. It describes how actual processes of human knowing occur instead of setting unattainable standards of accuracy, given the limited human processing abilities. Dynamic and integrative epistemology defines knowing as accumulating insights through information processing. This multilevel and multifarious process is rooted in the complexity of the real since complexity renders linear patterns of causation and analytic methods unsuitable for its apprehension and requires adequate methods for tackling complexity, such as systems thinking. Systems thinking does not only take material and mechanistic aspects into account, but also substantive, structural, behavioral, and functional (teleological/teleogenic) aspects. Taking these aspects into account creates a situation where predetermined goals play a limiting role: they trigger feedback processes or halt behaving systems. Predetermined goals also establishes thresholds that a system or a process cannot go beyond without destroying itself. Predetermined goals restrict the apparent limitlessness of linear causal patterns and their possible randomness at high magnitudes. System thinking, by considering teleological/teleogenic processes, does not look for levels of accuracy that would solve all the problems once and for all, but it integrates new insights into existing explanatory frameworks in such a manner that enhances subsequent actions and solutions to problem.

System thinking is, therefore, suitable for a dynamic and integrative epistemology as the latter sets insight as its goal and insight itself is multifarious. Insights can, not only be theoretical or practical, but they can also be associated with each step in Lonergan's process of human knowing. In this process, specific insights can occur at the emotional, intellectual, evaluative, and pragmatic level, in such a way that new insights can not only be integrated into existing explanatory frameworks, but some insights are so profound that they challenge the explanatory frameworks themselves in a way that they create new experiential contexts that lead to new tensions of inquiry. System thinking, given its multilevel and multifarious approaches, is also suitable for an information-based, dynamic and integrative epistemology. Systems thinking can take into account various levels where patterns of (self-)organizing matter and energy generate information. Moreover, systems thinking integrates various aspects of being, behaving, and becoming that are embedded in the notion of information itself. Systems thinking, in brief, is a method of handling complexity and can constitute a possible alternative to analytic methods, given its multifarious and multilevel approach.

Dynamic and integrative epistemology, therefore, derives its dynamic and integrative patterns from the notion of information itself. Information, defined by Wiener as negative entropy, implies a certain degree of order or organization so that information in living systems is associated with various patterns of spatial arrangement, be they at the molecular, neural, social, cultural, or technical levels. These patterns of spatial arrangements constitute various forms of programming as they convey physiological constitutions and patterns of behavior that humans share with other members of the animal kingdom through genetic inheritance. At the neural level of organization, the vertebrate brain and various neural connections convey information from early childhood experience, upbringing, and conscious practice in such a manner that these forms of programming influence subsequent behavior and action. Moreover, forms of programming can also be embedded in artifacts, such as bureaucracies, and mechanical and electronic microprocessors. Therefore, the notion of information embodies different forms of programming, but also different forms of control, which trigger feedback processes and stop the potential randomness of linear systems/processes. Moreover, the notion of information embodies aspects of being, behaving, and becoming, which are at the origin of the intrinsic dynamic and integrative patterns of information processing. Information, through its aspects of mapping, interpreting, and evaluating, integrates static and dynamic aspects so that information processing systems always adapt to their environment. Failure to adapt to the environment leads either to the transformation of information processing systems into something else or simply to their destruction. The interaction of information processing systems is characterized by adaptive patterns that involve various possible changes, such as change of structure, change of behavior, and sometimes change of goals. However, sometimes these changes are difficult to isolate as they happen concomitantly or as they follow slow temporal patterns. Some adaptive changes even remain undetected as they occur in temporal frameworks that are beyond the life-time of individual knowers since they involve adaptive changes that occur at the species level as changes in the environment trigger changes in either physiological structure or patterns of behavior.

All in all, dynamic and integrative epistemology, which is based on a definition of knowing as information processing through accumulating insights, responds to three shortcomings of normative epistemology, i.e. (1) the reduction of human knowledge to univocal propositions, (2) solipsism, and (3) the arbitrary boundaries between rationalism vs. empiricism, idealism vs. positivism, principles vs. facts, ideas (concepts) vs. objects, and theory vs. practice. Dynamic and integrative epistemology defines knowing in a broad way that does not only include true justified belief, i.e. knowing "what", but it also includes "knowing how", "knowing why", and "knowing when and where". The unifying aspect of all these forms of knowledge is insight, which implies integrating new data/experiences into existing explanatory frameworks or creating new experiential contexts that lead to new tensions of inquiry and subsequently new insights. Solipsism is overcome since knowing is no longer founded on introspective processes or on the assumption of a transparent mind to which each subject has a privileged access. Dynamic and integrative epistemology shows that knowing is not an introspective process, which involves monitoring one's ideas, but a dynamic and integrating process, in which the interplay of genetic inheritance, early childhood experience, conscious practice, explicit rules and principles with new situations leads to insights that influence subsequent action and processes of human knowing. Therefore, in the complex and dynamically integrated world we live in, human knowing does not always lead to certainty, but rather to a progressive process of insights accumulation that is open to revision, learning, and complementation. In such processes of insight accumulation, the human mind operates through heuristics in place of clearly defined algorithms and seeks "good enough" solutions instead of apprehending reality in an either/or or an all or nothing patterns. Seeking "good enough" solutions instead of permanent and absolute foundations is "satisficing", as contrasted to optimizing. One resorts to "satisficing" instead of optimizing solutions since human rationality is not an unlimited resource. Our rationality is "bounded" by our goals, which remain within the scope of our horizon, our limited computational capabilities, and the complexity of the environments in which knowing processes take place. There are a number of remedies to the limitations imposed on individual knowing subjects by their bounded rationality, such as complementing individual rationality by institutional rationality. Satisficing through carrying on heuristics in the contenxt of bounded rationality creates the image of the human mind as dynamic and integrative process of information and control through feedback as a human organism interacts with its environment, on the one hand, and on the other hand, maintains its defining characteristics within certain thresholds as a way of avoiding destruction or transformation into something else.

In this context, knowing does not occur in individual minds of individual knowers but in dynamic and integrated organisms that operate as wholes and that are related to their environments and to other organisms. Different forms of programming do not only influence how we know, but also why we know. Moreover, dynamic and integrative epistemology, by differentiating information and data, shows that knowing is, first and most of all, an activity of the knower with limited computational abilities and an increasingly complex world in such a way that individual human rationality has to be complemented with institutional rationality as a way of dividing computational labor. Thirdly, dynamic and integrative epistemology, by locating the process of human knowing at various levels and taking the aspects of being, behaving, and becoming that are embedded in the concept of information itself into consideration, militates in favor of an epistemology of succession rather than an epistemology of opposition. An epistemology of succession would imply that emotional, intellectual, evaluative, and pragmatic aspects of human knowing are various operations in one dynamic and integrative process, which leads to insight in its diversified forms and enhances subsequent actions and problem solving.

In consideration of the core concern of this thesis, which was changing paradigms, a dynamic and integrative model of epistemology implies a shift from a classical to a historical consciousness. Bynum and Moor have recognized that:

> From time to time, major movements occur in philosophy. These movements begin with a few simple, very fertile ideas – ideas that provide philosophers with a new prism through which to view philosophical issues. Gradually, philosophical methods and problems are refined and understood in terms of these new notions. As novel and interesting philosophical results are obtained, the movement grows into

> an intellectual wave that travels throughout the discipline. A new philosophical paradigm emerges. Like a phoenix, philosophy is transformed.[1]

In our case, this historical consciousness would imply that we look at the world through the lenses of cybernetics and that, without rejecting the materiality of objects, we have extended our conceptual framework from a world of material atoms to a world of symbolic binary digits (1 and O), or BITS in short.[2] Moreover, this shift would imply that as we recognize the world as a bundle of information, we recognize the emergence of a new metaphysics that is a fertile ground for a new epistemology. This new model has been conceptualized by Pagels when, with a pinch of Darwinism, he notes that information is part and parcel of reality both at the microscopic and at the macroscopic level. In his own words:

> Information, be it embodied in organisms, the mind, or the culture, is part of a larger selective system that determines through successful competition or cooperation what information survives. Information can be encoded in genes, nerve sets, or institutions, but the selective system that promotes survival remains similar.[3]

The centrality of the concept of information both at the metaphysical and the epistemological level renders information an inviting final cause. This means that human knowing as information processing by enriching data with value and meaning for the purpose of decision making and problem solving reinstates the very aspects that normative epistemology has marginalized, namely purpose, value, and meaning in the process of knowing. If these aspects are reinstated, human actions and social organizations can no longer be reduced to mere material entities, which interact mechanically through the exchange or the transformation of energy. In addition to being systems and structures, they are embodiments of meaning and value and they serve specific purposes. This dimension is manifested in the ability to create value and meaning by creating and transmitting signs and symbols. Therefore, various areas of human interactions and different social organizations are not merely subjected to mechanical, universal laws, but they integrate material and mechanic aspects with logical and symbolic aspects. If we maintain an informational nature of the meaning and value that humans attach to material reality and to the signs and symbols they create and communicate, human interaction is not merely a mechanical process where energy is exchanged or transformed, but also a flow of information. Paradoxically, many of our contemporaries are unaware of the symbolic aspect of our interactions, such as exchanging money (a symbol of value) for goods and services, appending signatures (symbols of our self-appropriation) to documents, respecting certain dress codes in certain circumstances (symbols of our role and status in society), referring to individuals by their titles, wearing wedding rings, and abiding by traffic rules. This informational aspect of human interaction is not a random process, but it is purposeful. In this respect, information is an inviting final cause.

With the flow of information within and outside systems, the ordered and simple universe of classical science is more and more challenged. We are more and more aware that science is a specialized type of knowledge which is achieved through codification, formalization, and systematization. Hence, science cannot embody the whole of human knowledge. Therefore, the limitations that the scientific model and its subsequent normative epistemology face when applied to human affairs (including knowing) are real, though dissimilar to those it faces when applied to natural phenomena. As Prigogine and Stengers have noted:

> Today we are beginning to see more clearly the limits of Newtonian rationality. A more consistent conception of science and nature seems to be emerging. This new conception paves the way for a new unity of knowledge and culture.[4]

The special conditions in which scientific knowledge occurs are different from the ordinary conditions of our living. The standards of objectivity and universality it requires have been challenged by a number of scientists, given the complex and chaotic patterns of certain parameters when they are pushed beyond certain limits. Rescher recognizes that:

> Objectivity will have to take context into account, seeing that different individuals and groups confront very different objective situations. Rationality is universal, but it is circumstantially universal – and objectivity with it.[5]

The recognition of the importance of the context and the knower challenges the scientific predilection for abstraction. Abstraction distorts reality and renders knowledge inaccessible and sometimes even useless. This view is emphasized by Prigogine and Stengers when they point out that:

> The progress of science has often been described in terms of rupture, as a shift from concrete experience towards a level of abstraction that is increasingly difficult to grasp. We believe that this kind of interpretation is only a reflection, at the epistemological level, of the historical situation in which classical science found itself, a consequence of its inability to include in its theoretical frame vast areas of the relationship between man and his environment.[6]

Among these "vast areas of the relationship between man and his environment" is the informational component of reality. The cybernetics model that we have adopted has proved that we live in a world where natural phenomena, human behavior, organizational methods, cultural values, social structures, and various living and non-living organisms can be considered as huge information processors, given the interaction of their components and their interaction with their environments. These objects and systems are capable of creating meaning and value through the production, storage and transformation of information. From this perspective, the universe can be conceived as a bundle of information rather than as an aggregate of atoms. In addition to the mechanistic, materialistic, and deterministic view promoted by classical science, there is room for the exploration of an information model that recognizes that atoms are not only material entities in motion, but that, owing to the electronic configuration that determines the way they assemble and disassemble, they do not only collide, but they also exchange information in terms of electrons.

Likewise, small and big organisms can be understood as information systems by virtue of genetic information, which is inherited from generation to generation, and by virtue of various types of information that are stored in form of beliefs, memories, challenges, opportunities, expectations, fears, hopes, and illusions. In this way both the universe and the human person can be considered as information systems. The universe, for instance, can be portrayed as a huge analog (not digital) computer while the human person can, in addition to older metaphors such as "social animal" or "thinking substance" can be understood as "being [a] digital animal".[7] Not all the disciplines reduce information to the fundamental level of binary digits. However, across disciplines, information has been receiving unprecedented attention. For instance, in business schools, "Management

Information Systems" is a compulsory subject and in various companies the post of information technology manager is highly respected and brings significant financial and social benefits. In microbiology, genetic transmission has been considered as a transmission of fundamental particles – genes – that yield an invariable chemical composition. However, this area of human life is more and more understood as a transmission of information from one generation to another. In fact, one genetic "outlook" or "composition" is called a "genetic code". As Rose has noted, "to continue the linguistic, information theory metaphor within which genetic theory was now to be formulated, the directed synthesis of RNA on DNA was termed *transcription*, and the synthesis of protein on the RNA was *translation*"[8]. Therefore, an info-computionalist model of reality, knowledge, mind, and consciousness is possible because as Bynum and Moor have noted:

> Computing provides philosophy with such a set of simple, but incredibly fertile, notions, new and evolving *subject matters*, *methods*, and *models* for philosophical inquiry. Computing brings new opportunities and challenges to traditional activities. As a result, computing is changing the professional activities of philosophers, including how they do research, how they cooperate with each other, and how they teach their courses. More importantly, computing is changing the way philosophers understand foundational concepts in philosophy, such as mind, consciousness, experience, reasoning, truth, ethics and creativity. This trend in philosophical inquiry that incorporates computing in terms of a subject matter, a method, or a model has been gaining momentum steadily.[9]

In other words, by bringing new subject matters, methods, and models into philosophy, computing creates in philosophy, what Thomas Kuhn in his famous *The Structure of Scientific Revolutions*[10] calls, a paradigm shift.

ENDNOTES

[1] Terrel Ward Bynum & James H. Moor, "How Computers are Changing Philosophy" in Terrel Ward Bynum & James H. Moor (ed.), *The Digital Phoenix: How Computers are Changing Philosophy*, revised edition (Oxford: Blackwell, 1998), p. 1.

[2] Nicholas Negroponte, *Being Digital* (New York: Vintage Books, 1995).

[3] Heinz Pagels, *The Dreams of Reason: The Computer and the Rise of the Sciences of Complexity* (New York: Simon and Schuter, 1988), p. 38.

[4] Ilya Prigogine & Isabelle Stengers. *Order out of Chaos: Man's New Dialogue with Nature*. Toronto: Bentam Books, 1984), pp. 23-30.

[5] Nicholas. Rescher, *Objectivity: The Obligations of Impersonal Reason* (Notre Dame: University of Notre Dame Press, 1997), p. 3.

[6] Prigogine & Stengers, p. 19.

[7] Nicholas Negroponte, *Being Digital* (New York: Vintage Books, 1995) and its French version *L'Homme Numérique*, trans. by Michèle Garène (Paris: Robert Laffont, 1995).

[8] Steven Rose, *Lifelines: Biology, Freedom, Determinism* (London: Penguin, 1997), p. 120.

[9] Bynum & Moor, ibid.

[10] Thomas Kuhn, *The Structures of Scientific Revolutions*, 2nd ed. (Chicago: The University of Chicago Press, 1970).

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APPENDIX

DANIEL BELL'S DESCRIPTION OF THE POST-INDUSTRIAL SOCIETY

TABLE 1

The Post-Industrial Society: A Comparative Scheme

	PRE-INDUSTRIAL	INDUSTRIAL	POST-INDUSTRIAL		
Mode of production	Extractive	Fabrication	Processing, information		
Economic sector	*Primary*	*Secondary*	*Services*		
	Agriculture Mining Fishing Timber Oil and gas	Goods producing Manufacturing Durables Nondurables Heavy construction	*Tertiary* Transportation Utilities	*Quarternary* Trade Finance Insurance Real estate	*Quinary* Health, education Research, governement Recreation, entertainment
Transforming resource	Natural power: wind, water, draft, animal, human muscle	Created energy: oil, gas, nuclear power	Inforamtion and knowledge: programming and algorithms, computer and data-transmission		
Strategic resource	Raw materials	Financial captial	Human capital		
Technology	Craft	Machine technology	Intellectual technology		
Skilled base	Artisan, manual worker, farmer	Engineer, semi-skilled worker	Scientist; technical and professional occupations		
Mode of work	Physical labor	Division of labor	Networking		
Methodology	Commonsense, trial and error, experience	Empiricism experimentation	Models, simulations, decision theory, systems analysis		
Time perspective	Orientation to the past	Ad-hoc adaptiveness, experimentation	Future orientation: forecasting and planning		
Design	Game against nature	Game against fabricated nature	Game between persons		
Axial principle	Traditionalism	Productivity	Codification of theoretical knowledge		

lxxxv

Source: DanielBell, *The Coming of the Post-Industrial Society: Foreword 1999.* New York: Basic Books, 1999, p. p. lxxxv.