Note. Le texte qui suit est le manuscrit de l'introduction générale à un livre collectif – *Proposals in Epistemology : Quantum Mechanics, Cognition and Action*, Mioara Pugur Schächter and Alwyn van der Merwe, eds. (Kluwer Academic, 2002). Le contenu de cette introduction se superpose en grande partie à celui de l'article *Les leçons de la Mécanique Quantique : vers une Epitémologie Formalisée*, publié dans Le Débat, No 94, 1997, Gallimard. Mais tandis que ce dernier annonçait un but l'introduction qui suit annonce une réalisation : le lancement d'une nouvelle discipline. En outre, vers sa fin cette introduction contient des spécifications importantes concernant l'adjectif « formalisée » utilisé pour qualifier une épistémologie.

GENERAL INTRODUCTION

The aim of this book is to initiate a new discipline, namely *a formalized epistemological method* drawn from the cognitive strategies practised in the main modern sciences, and from the philosophical thinking. This will be attempted by general discussions concerning the concept itself, by constructive attempts, and by informative-critical explorations. This aim has been triggered by the following considerations.

Everywhere on the frontiers of the nowadays scientific thought one can watch how absolute assertions and absolute separations that seemed unshakeable, are fading away.

In logic and mathematics the belief in the possibility of an uninterrupted progression of unlimited purely formal developments, which dominated the beginning of the last century, has collapsed. It has become clear that any definite domain of exclusively formal action is confined, even if in principle it can always be extended, while the process of extension itself escapes formalization, like also, quite radically, the process of creation of a domain of formal operationality.

For living systems, the definition of what is called the system raises non trivial problems. The biologists have been led to introduce notions like «self-organization» and «organizational closure» in order to point toward the way in which a living system constantly re-constructs its own matter, forms and functions, by processes where the feed-back upon the system, of its interactions with the «environment», is as important as the characters of the system itself.

As soon as life is involved, the concept of cause withstands any attempt at a clear distinction from the concept of aim. For living beings as well as for these meta(living beings) called social organizations, the importance of pragmatic models induced by aims placed in the future but which shape the actions displayed now in order to reach the aims, becomes decisive. The aims – tied with belief and anticipation – act back upon the action that brings nearer to the aims, whereas this action, while it develops, changes the aims. This entails a dynamic which depends on its history and its context, and of which the characterization requires a cognitivistic and evolutionary approach.

The theory of (communication of) information represents the transmission of messages by making use of a probabilistic representation of a peculiar sort, according to which any received message unavoidably depends, not exclusively on the sent message, but also on the «channel» through which this message has travelled. So the received message is quite fundamentally relative to the way in which it has become perceptible to the receiver. Therefore the possibility to reconstruct the sent message, out of the received one, has to be studied explicitly as a function of the modalities of transmission, and the conditions required for a reconstruction are highly non trivial.

The investigators of «chaos» have dissolved a millenary confusion by elaborating abstract mathematical examples, on the one hand, and on the other hand simulations, which prove that determinism does not entail predictability : side by side, the deterministic modelizations, and the full recognition of the randomness of the facts such as they are directly perceived by us, accede to mutual independence. The factitious belief that a choice has to be made, evaporates, and a world of new questions arises concerning a pertinent representation of the relations between perceptual randomness and deterministic models of the physical processes.

In the approaches concerning the treatment of «complex» systems or processes, the «agents», their «environment» and «actions», and the feed-backs of these, compose inextricably imbricated hierarchies of matter, situations, conscious aims and behaviours, knowledges, social organizations, devices. What is named how, what is treated how, becomes a matter of method much more than a matter of fact. The frontiers between categories with fixed inner content fade away, and instead *rôles* step in.

And so on. This enumeration could be much prolonged. Everywhere the contours of separations that seemed obvious, clear cut and absolute, become covered by tremblings and cracks. And these superficial symptoms make us feel that we are in presence of changes which, though in surface they seem to be mutually isolated, are tied beneath. We also feel that the implications of these changes go down very deep, that they touch and modify the slopes of the very first layer of our conceptualization, that one where the general structure of our nowadays way of thinking and speaking has forged itself. But the nature of changes of this sort – precisely because they concern the established manner of thinking and speaking – is very difficult to grasp by putting to work the established manner of thinking and speaking. So the existence of such changes becomes manifest by its effects long before we become able to discern and express of what they consist themselves.

The very existence of these changes - as such - before having tried to explicate the contents, already raises questions. The conceptualization by man, of what he calls «reality», is itself an element of «reality». Is it then not subjected to some *laws*, to some *in*-variances ? This should be so, in some sense, but in which sense, exactly ? What does change, and what stays the same ? How could we infiltrate our sight deep enough, and how should we proceed in order to be certain to fully seize and to fix in the expressed the essential contents of the transmutation which is developing, as well as the stable structure which meanwhile persists ? Without permitting decades to sweep away while the process is accomplished implicitly, by osmotic assimilation of random additions of disparate small knowledges and interactions between small knowledges, without generating a perceivable contour ?

It would be of crucial utility to succeed. Only what is explicitly known acquires a definite form, perceptible from «outside». And only if this has happened becomes it then possible to detach what has been formed, to optimize it with respect to definite purposes, to make a genuine instrument out of it, which can be deliberately made use of and can be indefinitely improved.

At the beginning of the last century the theory of special relativity has reduced the structure of the concept of space-time which underlies the descriptions of physical phenomena, in the sense in which the fracture of a bone is reduced by a surgeon. And later, starting from 1924, quantum mechanics has cut out conceptual-operational-formal channels which enable human mind to apply itself directly upon the unobservable and to construct concerning it observable predictions that realize with disconcerting precision. Of course, these are confidential revolutions which so far have penetrated the thinking of only a minute amount of people. Moreover they are as yet unachieved revolutions. But the philosophers, helped by a small number of physicists, have generated a process of communication by which – osmotically – certain essences of the views of modern physics has more or less infused many minds. The germs of the new approaches that are developing in various domains of scientific investigation, have encountered this modified ground, which has nourished their development.

I make now the following assertion, possibly surprising, which I hold to be crucial.

*Quantum mechanics, like a diver, can take us down to the level of the **very first** actions of our conceptualization of reality. And starting from there, it can induce an **explicit** understanding of certain fundamental features of the new scientific thinking.*

The following remarks can give a first notion of the content of this assertion. Our way of conceiving the «object», that what we separate from the «rest» in order to become able to perform definite examinations of it and to reason on it, marks our whole thinking as well as all our actions. Now, intuitively, the word «object» is still quasi unanimously felt to be essentially tied with in-variance – material, morphological and functional –, so with what could be called an «intrinsic objectity», independent of observation, pre-existing such as it is perceived. More or less implicitly, the whole current language, the whole classical logical and probabilistic thinking, are founded on this presupposition. But quantum mechanics opposes a direct, radical and definitive *veto* to this presupposition. The quantum mechanical formalism, if the cognitive strategy involved by it is fully decrypted and conveniently generalized, acts like a strong lens under which the static contour of the classical concept of object dissolves into a complex *process* inextricably tied with human cognitive actions, most usually reflex actions, but often also deliberate ones ; and in any case, the result of this process is indelibly marked by *relativities* to all these involved cognitive actions. In its essence this conclusion is well known since a long time. But the specific way in which quantum mechanics conveys this old conclusion, is new, and it amounts potentially to an overt grabbing by *physics*, of the basic metaphysical question of realism. Thereby physics merges with philosophy, in a basic, massive way, and it injects into philosophy a flux of innovation which springs directly into epistemology :

> *Quantum mechanics has captured and represented – for the particular case of microstates and in an implicit, cryptic way but for the first time in the history of human thought and directly in mathematical terms – certain* ***universal*** *features of the* ***very first stage*** *of the processes by which man extracts chains of communicable knowledge, from the physical reality where he is immersed and of which he partakes*.

This is what the epistemological universality of quantum mechanics consists of. By no means does it consist, as it is often asserted, of the fact that any material system is made of microsystems : this is a physical circumstance, not an epistemological one. The feeling of essentiality conveyed by the quantum mechanical formalism to those who can read it, does not stem from this physical circumstance, it stems exclusively from the universal character of *the peculiar cognitive situation* dealt with in quantum mechanics. And, while reflections of it are encrypted in the general features of the formalism considered as a whole, this cognitive situation marks also directly the specific formal features that are pointed toward by the

expressions «quantum probabilities» and «quantum logic». These simply are not intelligible in terms of what is classically called probabilities and logic : this manifests strikingly that the *general* epistemological consequences of the quantum mechanical formalism, if elaborated, modify the structure of our classical representations of probabilities and of logic, the two most basic and worked out representations of domains of our everyday thinking and acting. Indeed, when the universal representation of the very first stage of our processes of conceptualization, drawn by generalization from quantum mechanics, is injected into classical probabilities and classical logic, these undergo a sort of spectral decomposition, and this brings into evidence that, far down beneath language, the probabilistic and the logical conceptualization merge into one unified probabilistic-logical structure. This entails deep conceptual clarifications as well as corresponding formal modifications. No other theory of a domain of reality, not even Einstein's relativity, has ever triggered an outflow of a comparable ampleness, so deep set and so powerfully innovating.

This, however, though variously felt and much discussed and analyzed since more than 70 years, often with remarkable penetration, nevertheless is still very far from being fully known and understood. The general epistemological implications of quantum mechanics are still cryptic, even for most physicists, and even for many who manipulate the formalism currently, often in a masterly manner. *A fortiori* quantum mechanics is very superficially and feebly connected to the development of other new scientific approaches. This is a *huge* lacuna. It hinders a free, rapid, maximal development of the revolution of the basic concept of object, implicitly started by quantum mechanics, but the pressure of which manifests itself also – otherwise – in biology, systemics, information theory, etc. So it also hinders the perception and full elaboration of the consequences of this revolution upon logic and probabilities, which guide our everyday thinking. Thereby it stays in the way of a now *possible* radical progress in our knowledge of our manner of producing knowledge. Which furthermore hinders a now possible radical improvement of an explicit and deliberate domination of our epistemological behaviour, so also of our actions.

One of the main aims of this book is to fill this lacuna.

This aim meets with a still larger one which stems from the postulate that *any* big theory of a domain of reality, fixes in the concepts and the structures defined by it, certain essential features of the epistemological processes by which human mind generates representations of what we call reality. But, as it happens in the special case of quantum mechanics, these features tend always to remain more or less implicit in the descriptional substance that has incorporated

them. This entails that their universal value remains unused. *A fortiori*, the different epistemological innovations involved by different scientific approaches, in general remain non referred to one another, which blocks the emergence of an integration.

For instance, the theory of information obviously involves a certain epistemological universality. Any process of «transmission of knowledge» – even if in fact it is a natural, non intentional process of just *acquisition* of knowledge, or a scientifically normed process of measurement i.e. of deliberately organized transmission of data from an object of study to the mind of an investigator, etc. – can be cast in the canonical mould of the theory of information, according to which there always exists a «source of information» which issues «messages», a «channel» for the transmission of information which can introduce various types of alterations of the messages sent through it, and a «receiver» who tries to restore the original message out of the received one. This remarkable generality entails a tendency to apply the informational representation (initially imagined concerning the engineering of communication devices) to the most diverse domains, in biology, in the theory of physical measurements, in linguistics, and so on. Therefore it would certainly be fertile to explicate thoroughly the general epistemological presuppositions of the formalism of the theory of information, and to confront them systematically to those involved in other approaches. The theory of quantum mechanical measurements would certainly offer opportunity for a particularly interesting confrontation. Indeed this theory concentrates in it the whole essence of fundamental quantum mechanics *and* it concerns quite essentially an informational problem. Nevertheless *the formalism of the theory of quantum mechanical measurements possesses certain formal features which are essentially* ***different*** *from those of the informational formalism.* It would by interesting to establish why, what facts, assumptions, methodological choices, lay at the source of this unexpected difference. This, while it might lead to a deeper understanding of the general concept of «information» – so central –, could perhaps furthermore lead to a reformulation of the theory of information in terms of Hilbert mathematics [1], which probably would be a formulation much deeper and more precise and general than the present one. While in return, the attempt at a re-expression in terms of Hilbert mathematics, of the theorems from the information theory (especially the second theorem of Shannon), could draw the famous question of hidden parameters into an organized and mathematical framework, and furthermore it should permit

[1] I do not write Hilbert *vectors* because certainly a principle of superposition permitting a pertinent use of vector spaces, does *not* hold for any sort of transmissions of information.

important clarifications concerning the concept of physical superposition, as well as supplementary clarifications concerning the concept of object.

Considerations of a similar nature could be made concerning many other modern disciplines, in particular concerning the various computational approaches, concerning molecular and genetic biology, and – quite specially – concerning the modern cognitivistic approaches.

But the preceding considerations suffice already for conveying the following conclusion.

> What is lacking in order to improve our knowledge and domination of our ways of producing communicable knowledge, thoroughly and rapidly and with precision and detail, is a systematic research inside the mutually isolated special languages of the major modern scientific approaches, of the epistemological essence incorporated in each one of them, and a systematic reference to one another of the explicated results.

Indeed, in its own space of representation, each approach traces a certain specific direction of conceptualization. But what are the angles between these directions ? What are the contents of their projections on each other ? What a new *metawhole* can be pertinently drawn from such comparisons ?

This conclusion and the questions which surround it, point toward an aim : from the most profound and performing modern scientific disciplines, to induce an explicit and formalized *method of conceptualization*, basic enough to be able ***(a)*** to enclose in a unifying and *optimizing* structure the main specific procedures for generating knowledge employed in all these disciplines ; ***(b)*** to assign there a definite location to each one of these procedures ; and ***(c)*** to generate comparability between these specific procedures and between their results.

This, I hold, is an important aim. The following specifications will permit to understand it better.

So, from the start on, what is desired is the construction of a method, not of a neutral description of the processes of conceptualization such as they do spontaneously emerge or such as they can be identified here or there. A perfectly neutral description, in fact, would not be a possible purpose, and even if it were it would be devoid of a definite and immediate pragmatic interest.

As for the requirement of a «formalized» method, it can be explained as follows. Any methodology involves subjection to some system of aims. A minimal finality that seems imperative when a method of conceptualization is planned, is to offer general algorithms for

excluding the emergence of false problems and of paradoxes while insuring rapid progressions, without hindering thereby a fully free exercise of the own curiosities of the conceptualizing mind. This, however, if it can be achieved at all, can be achieved only by *extraction* of the method from the current language. The most radical extraction would be achieved by the definition of a «formal» method where exclusively non-verbal symbols, well-formed sequences of such symbols, and transformation laws of these, are put to work. But this is ***not*** the aim proposed here, because significance, semantics, is primordially essential when one conceptualizes. So, instead of «formal», I prefer to make use of the term «formalized» which involves that *something to be formalized has been formed before*, independently (like, for instance, in the case of a mathematized theory of a domain of physical reality, say, the Faraday-Ampère-Biot-Savart-Laplace-etc. system of descriptions which Maxwell has then re-expressed in mathematical terms) [2]. Hence in our case, the first stage should consist of the explicit construction of a general system of posits, definitions and procedures, constituting a self-consistent net of routes for directed and safe conceptualization, inaccessible to the innumerable and unpredictable obstacles inherent in the tortuous paths of conceptualization which each one of us cuts out for himself accordingly to his own ability and to the way of thinking induced in his mind by the usual language. Of course, a system of this kind has to be expressed by words.

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[2] From onecontribution to this volume, to the other one, the reader will remark oscillations between the terms «formalized» and «formal». In this connection, in a recent letter, Hervé Barreau wrote to me:
«…..As for the essence, we are in agreement, since for all of us, and especially for you and me, it is quite obvious that the sort of epistemology we want to construct presupposes that we conserve the (often very complex) semantic of the involved terms, upon which we shall try to impose constraints of «form» in order to stabilize invariants of meaning which in the usual language in general get lost. Initially, for me, «formal epistemology» meant precisely this submission to formal constraints of a basic semantic which has to be kept. What rejected me in the expression «formalized epistemology» , was that it might be understood accordingly to the opposition between «formal logic» and «formalized logic». The formal logic, of which the classical example is Aristotle's logic, conserves in it a basic semantic which permits to produce counter-examples in order to exclude a possibility that is allowed by the criteria of pure form: for instance, when he wants to exclude certain syllogistic modes relative to some given «figure», Aristotle gives proofs by *ecthesis*, that is, by specification of a counter-exemple (this procedure is still current, in particular, in modal logic). While on the contrary, formalized logic makes abstraction of any content. This is not the case in Frege's first presentation of his logic, but this is the case in the axiomatization of his logic. This is equally the case in Wittgenstein's «semantic tables» where the only «semantic» notations kept (namely «true» and «false») finally are indifferent since the tautologies, the formal laws, are valid inependently of the truth-values of the involved statements. So the formalized logic concerns exclusively statements and not propositions (statements asserted to be true or false). In a similar way, for the formalists mathematics is a formalized knowledge that is independent of the semantic content, not only a formal science. This is the distinction which I had learned in the school books of logic and mathematics. But the explanation you gave last Thursday assign an opposite significance to this opposition, and it raised no objections….. ».
This quotation shows clearly that (a) throughout this volume it is admitted by all the contributors that the semantic contents are an essential element in the researched epistemology; (b) those who use the word «formalized» refer to the paradigmatic example of a mathematical theory of a domain of physical facts, while those who make use of the term «formal» refer implicitly to certain traditional expressions concerning logic (though nowadays «formal logic» is considered to deal with purely syntactical systems).

But nonetheless, as a *system,* as a self-consistent whole, it is already extracted out of current language, the imperviousness with respect to an uncontrolled inflow of harmonics of significance triggered by the words, depending on the density of the structure the system has been endowed with. The second stage, then, should consist of a ***formalization*** of the methodological system constructed in the first stage (or several formalizations), mathematical or not, the initial outline being left present as a nourishing ground. Thereby, without loss of nuances, the precision and efficiency of the processes of general conceptualization achievable by use of the method would become comparable to those which logic has attained for the particular aim of combining and transporting truth-values of propositions, or to those which a mathematical theory of a domain of physical reality insures for the representation of physical phenomena, under constraints of inter-subjective consensus and of predictability.

A methodology of the kind indicated above is what we call ***a formalized epistemology****.*

By the nature of its aim, a formalized epistemology should emerge much more general and nevertheless by far less abstract than the representations built in metamathematics or in the logical theories of hierarchical languages.

The project sketched out above should not be identified to a transdisciplinary or a pluridisciplinary project. Such projects are formed in order to offer to non specialists, access to *information*, to results obtained inside specialized disciplines, as well as a certain understanding of these results ; while a method of conceptualization should endow with an *instrument* for conceptualizing in whatever domain and direction one might choose. Furthermore the method planned here should not be assimilated either with an approach belonging to the modern cognitive sciences which try to establish as neutrally as possible descriptions of how the human body-and-mind work spontaneously when knowledge is generated ; while a method of conceptualization should establish what conceptual-operational deliberate procedures have to be applied in order to represent and to achieve processes of generation of knowledge optimized accordingly to definite aims.

However it seems clear that a method of conceptualization of the sort defined above would possess common features with the transdisciplinary or pluridisciplinary approaches as well as with the cognitive ones (as well as, furthermore, with a theory of a domain of facts).

Now, is a formalized epistemology possible at all ? The tentative purpose of this volume is to bring about agreement on a positive answer.

The volume is organized in three parts.

The first part offers various perspectives concerning the aim proposed in this introduction : its historical roots, its present conceptual environment, estimations of its possible content and of its pragmatic value, the difficulties entailed by it, and its *a priori* chances to succeed. These preliminaries seemed necessary in order to deepen the intuition of what is desired, and also for creating a background for the constructive attempts to be referred to.

The second part contains three constructive approaches. These form the hard core of the volume.

The third part contains critical-constructive explorations concerning the present stage in several different domains of investigation (philosophy of time, physics, logic-mathematics-computation, linguistic, complexity), each one more or less explicitly related with the concept of a formalized epistemology. Thereby, around the constructive approaches from the second part, new ground is cleared for future constructive developments.

The whole, I think, offers a rather exact account of the synthesizing dynamics conducted inside the ***CeSEF***.

Mioara Mugur-Schächter