

# DOES QUANTUM MECHANICS REQUIRE NEW FORMS OF THOUGHT<sup>1</sup> ?

## *Towards a formal epistemology*

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### INTRODUCTION

What makes possible the intellectual background against which is set our knowledge of the order of nature? “There,” said Kant, “solutions and answers are brought to a halt; because we must always go back to (this background) for all answers and all thought of objects”.<sup>2</sup>

At least this setting of limits, typical of transcendental philosophy, points towards that which a formal epistemology *cannot be*. It cannot be the formalism of a standard theory of knowledge which would take the subject-object relation as a second-order natural object, and would then leave unquestioned the grounding of normative presuppositions on which all science, including epistemology itself, depends. Further, a formal epistemology cannot conform to the definition “of a clearly too foolish ambition” which H. Putnam depicts as “[...] a superb theory of the normative grasped in its own terms”<sup>3</sup>; a sort of redoubling of the realm of norms of thought, by which the theory would try to explain itself in objectifying the system of its own principles, without being able, except by an infinite regression, to question itself in return on its use of those very principles. Of course, these remarks are not to deny the current attempts at naturalising epistemology any interest. They are only aimed at pointing out that naturalisation of epistemology can only be a *process* with *no foreseeable completion*; and that at the provisional end of each step of this process there is a set of non-explicit formal norms of investigation which

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<sup>1</sup> This paper was initially published under the title “ FORMAL EPISTEMOLOGY, LOGIC, AND GRAMMAR”. I Thank M. Mugur-Schächter for her remarkable seminar on Formal Epistemology held in Paris between 1994 and 1998. This was the place where this reflection was first presented and discussed.

<sup>2</sup> I. KANT, *Prolegomena zu einer jeden künftigen Metaphysik, die als Wissenschaft wird auftreten können*, 1783, §36, A standard english translation can be found in: I. Kant *Prolegomena to any future metaphysics that will be able to present itself as science*, Manchester university press, 1971. As J. Petitot pointed out, Kant however modified this very strict transcendental standpoint in his *Opus Postumum*. J. Petitot, *La philosophie transcendantale et le problème de l'objectivité*, Osiris, 1991

<sup>3</sup> H. PUTNAM, *Définitions (Pourquoi ne peut-on pas 'naturaliser' la raison)*, Editions de l'Eclat, 1992, p. 41

we can but call the “pragmatico-transcendental background” of the current state of research.

It is of no apparent advantage either to cast formal epistemology in the role of a mathematicised or logicised variant of epistemology in the modest sense traditionally intended in France: that of a multiplicity of critical analyses of the premisses and results of particular sciences. Because in epistemology, as in the sciences, formalisation consists in the abstraction of particular contents of understanding in order to reach universal rules. A formal epistemology must therefore be of value to *any* science, even if it is especially profitable (as we shall see below) when elaborating on the knowledge acquired by certain methodologically advanced sciences.

Having discarded some tentative definitions of formal epistemology it remains to give it a plausible positive characterisation. To that end a comparative rather than a directly constructive strategy will be used. A parallel will be established with the case of logic; the remarkable isomorphisms between logic and what we would expect of a formal epistemology will be underlined; then, at the end of the discussion, the bringing into consideration of some major differences between the two disciplines will allow the formulation of the specific project of formal epistemology. It will thus appear that formal epistemology can be understood as a generalisation of logic; a generalisation of considerable range because it principally consists in recognising the expansion of the form of the sciences beyond the closed domain delimited by the *Logos*, taken in its narrow sense of explaining by means of *discourse consisting in predicative judgments*.

## LOGIC AND FORMAL EPISTEMOLOGY

Let us start from the dualistic prejudice of the theory of knowledge; because it is by way of criticising it that we will most quickly arrive at the point of neutral equilibrium where both logic and formal epistemology stand.

Knowledge, according to Piaget<sup>4</sup>, consists in a certain relation between a subject and an object. It manifests itself by way of *judgment* (which consists of ascribing a predicate to an object) or more generally by way of thought shaped by the structure of judgment. Each science can be said to attain *knowledge*, in the local sphere of objectivity to which it is assigned, if it expresses itself *via* a certain network of judgments whose interdependence and coherence fence off the temptation to systematically

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<sup>4</sup> J. PIAGET, *introduction*, in: *Logique et connaissance scientifique* (Dir. J. Piaget), Pleiade-Gallimard, 1967, p. 3

resort to *ad hoc* explanations. But in that case, logic, which we traditionally present as a general doctrine of judgment and of relations between judgments, is at once “science's doctrine”; logic, as Husserl points out, “[...] aims at bringing to light the essential forms of knowledge [...] as well as the essential presuppositions with which its forms are linked”<sup>5</sup>. In that, at least, the programme of logic covers exactly the programme of a formal epistemology.

In the dualistic framework provisionally adopted, however, logic (and the formal epistemology which matches it) takes on a sort of constitutive ambivalence. Logic and formal epistemology are what Husserl calls “double-sided” disciplines<sup>6</sup>; disciplines having at once a subjective and an objective side. They have a subjective side because they seek to extract the necessary states and regulative principles of a “rational subjectivity in general”<sup>7</sup>. And they have an objective side for two reasons. Firstly, because they engender ideal objective formations, as the product of their work of abstraction and deductive generation; and secondly because, although they situate themselves below the level of the concrete determination of objects and of classes of objects of the particular sciences, they relate to the form of judgments, of which the prime function is to characterise *objects*. It is this last thought which led Husserl to characterise formal logic as “*a priori* formal doctrine of the object”<sup>8</sup>.

The two orientations of logic (subjective and objective) were given privileged roles in turn by the actors of the history of philosophy. But this process only led one to show the inadequacy of each single orientation as a paradoxical result of the attempts to assure it the exclusivity.

Let us consider a first example. In the framework of the critical philosophy of Kant the distinction between the reflexive and objective orientations of a discipline does not rest on an exterior account of the face-to-face subject-object, but rather on an internal analysis of the conditions for the possibility of experience. The “fundamental proposition”<sup>9</sup> of the critical philosophy effectively announces that “The conditions of the *possibility of experience* in general are at the same time conditions of the *possibility of objects of experience*”<sup>10</sup>; so there can be no question of a confrontation between a pre-constituted subject and object, but rather a *co-constitution* of experience and its objects. That being allowed, we notice

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<sup>5</sup> E. HUSSERL, *Formale und Transzendente Logik*, in: *Jahrbuch für Philosophie und phänomenologische Forschung*, X, 1929, §5

<sup>6</sup> *ibid.*, §9.

<sup>7</sup> *ibid.*, §6.

<sup>8</sup> *ibid.*, §27.

<sup>9</sup> M. HEIDEGGER, *Kant und das Problem der Metaphysik*, Klostermann, 1991, §24

<sup>10</sup> I. KANT, *Kritik der reinen Vernunft*, A158, B197. English translation in: I. Kant, *Critique of pure reason*, (new edition, by V. Politis), Everyman's library, 1993.

that Kant's internal analysis gives him two motives for insisting on the *reflexive* orientation of logic. Firstly, logic situates itself entirely on the side of the formal aspect of our knowledge, without any reference to its material and “objective” aspect<sup>11</sup>. Thus, according to Kant, logic somehow situates on the “subjective” side of knowledge. Secondly, logic is freed from any link with the form of the *sensible intuition*, by which “we can perceive objects *a priori*”<sup>12</sup>; it proceeds without consideration of perceived objects, turns on the understanding alone, and consists in announcing the formal laws necessary to the *thought* of any object<sup>13</sup>. It is certainly not subjective according to the *psychological* conception of subjectivity, because it is not content to describe in empirical terms the intellectual mode of functioning of particular subjects; but we can call it “reflexive” in so far as it is linked to the principles which order the thought of the subject in general. Logic relates not to particular subjective facts but to the norms which bear on the intelligent activity of any subject.

In that way, Kant does not just oppose logic to psychology, but also to transcendental philosophy in its entirety. Because if transcendental philosophy *also* deals, like logic, with the *a priori* formal conditions of thought of objects, it does it *via* a very broad perspective in order to elucidate the connection between knowledge and the faculty of knowing in general<sup>14</sup>; on the contrary, logic is supposed to content itself with furnishing a “canon” of agreement of *one* of the constitutive elements of the faculty of knowing (understanding) with itself. “In logic” writes Kant, “the question is uniquely: *how does the understanding know itself?*”<sup>15</sup>.

In the evolution of the Kantian project after Kant, the joining of form with the subjective side of knowledge, the stratification of the sensible and intellectual and the limitation of logic to a task of self-validation of the operations of the understanding, have been regarded as the weakest and least indispensable aspects of the project's completion. With the impetus of Cassirer and the many protagonists of the “linguistic turn”, the integrated forms of symbolic expression have replaced the hierarchical forms of the faculty of knowing in the role of preconditions of objectivity. Since then, as G. G. Granger points out, the opposition between logic and transcendental philosophy has had no *raison d'être* : “logic can [...] appear to be the most elementary and the most radical aspect of the

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<sup>11</sup> I. KANT, *Introduction to logic*, (ed. T.K. Abbott) New-York, 1963, VII

<sup>12</sup> I. KANT, *Prolegomena zu einer jeden künftigen Metaphysik, die als Wissenschaft wird auftreten können*, op. cit. §10

<sup>13</sup> I. KANT, *Introduction to logic*, op. cit., I

<sup>14</sup> I. KANT, *Prolegomena zu einer jeden künftigen Metaphysik, die als Wissenschaft wird auftreten können*, op. cit. §13, III

<sup>15</sup> I. KANT, *Introduction to logic*, op. cit., I

transcendental”<sup>16</sup>. “Logic is transcendental”<sup>17</sup>, writes the early Wittgenstein, and, in the intention which it shares with logic, formal epistemology is too.

In opposition to this process of abstraction and identification of the Kantian *a priori* forms with the symbolic, another current of thought has tended to put them into relation with the concrete turning points of the phylogenesis and ontogenesis of the human subject. A psychogenetic reinterpretation of the Kantian hierarchy of the constituents of the faculty of knowing has been proposed by Piaget, for example. According to Piaget, the underlying structures of natural thought issue from the stepwise coördination of the diverse operational activities of the subject in the world. But contrary to physics, which partially takes its information from the manipulated objects, by way of perceptual or experimental phenomena which are supposed to open access to objects, logic proceeds from the exclusive coördination of the *actions* which impinge *on* these objects and transform them<sup>18</sup>. To the Kantian duplex of sensibility and understanding there corresponds here a duplex of sensible receptivity and structured motor activity of which only the second term concerns logic. According to Piaget, “That which is axiomatised by formal logic is certainly an *activity of the subject*”<sup>19</sup>. More precisely, it is a systematic activity of the subject whose psychogenetic evolution has passed an essential stage: the conquest of the *reversibility* of operations, which allows their formalised outcome to constitute an ensemble of timeless and necessary connections<sup>20</sup>.

But doesn't exclusive concern with an ideal and isolated *subject* in evolution keep us within a framework too narrow to yield reasons for the emergence of the norms of thought? Does it not mask other genetic components which are indispensable to the shaping of a logic? These additional components are not denied by Piaget, but they do not constitute, in his work, the material of systematic development. They concern just as much the social interaction *between subjects* as that which is presupposed by them *regarding objects*.

On the one hand, although it is true that the construction of logic is in the first place, according to Piaget, the work of a subject in activity, its operational structures require “the collective contribution” of other

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<sup>16</sup> G.G. GRANGER, *Formes, opérations, objets*, Vrin, 1994, p. 75

<sup>17</sup> L. WITTGENSTEIN, *Tractatus logico-philosophicus*, Routledge & Kegan Paul, 1963, 6.13

<sup>18</sup> J. PIAGET «Epistémologie de la logique», in: *Logique et connaissance scientifique* (Dir. J. Piaget), op. cit., p. 385

<sup>19</sup> *ibid.* p. 383; see J. Piaget, *Introduction à l'épistémologie génétique, I/ La pensée mathématique*, P.U.F. 1973.

<sup>20</sup> J. PIAGET, «Epistémologie de la logique», in: *Logique et connaissance scientifique* (Dir. J. Piaget), op. cit., p. 388

communicating subjects in order to be “reinforced and multiplied”<sup>21</sup>. “Reinforcement” ends in the stabilisation of norms by means of the symbols used to communicate them. And “multiplication” could well refer to the construction of non-classical logics which, not contenting themselves with stating the normed forms of the *effective* operational activity of subjects, formalise many *possible* operational activities by exploiting the supplementary free space which is offered by symbolism. The orientation towards a theory of communicational intersubjectivity, favoured by contemporary German philosophers such as Apel and Habermas<sup>22</sup>, is thus able to complete and enrich the focus on this work of “inquiry” of a generic subject which, before the work of Piaget, already formed the principal theme of many currents of American pragmatism of the beginning of the 20<sup>th</sup> century.<sup>23</sup>

On the other hand, the throwing back of the Piagetian problematic of the normed activity onto the *subject(s)*, its liberation in regard to the object, calls at least to be nuanced. Activity is certainly, in the first instance, that of the subject, but what about its regulatory forms which alone concern logic? Piaget admits that it is “[...] impossible to know in advance if (these forms) belong to the subject, to the object, to both, or solely to their relation”<sup>24</sup>. It must not be forgotten that activity consists in operations-of-the-subject-on-objects. Even if it is indispensable to remove from the description of this activity any mention of the particular features of the handled objects, it must be recognised that the activity and its formal sediment rest on two suppositions which bear on the objects in general: the supposition of the *permanence* of objects and that of a *minimal degree of stability* in their properties.

Let us dwell a moment on these two elementary suppositions of operational activity, because they will have particular importance in the rest of this paper. What must be noted about them from now on is that they correspond term for term with those which the very use of the proposition implies (by way, respectively, of the two fundamental acts of *reference* and *predication*). For that reason, the formal kernel of the coördination of the operations of the subject in the world corresponds closely to the formal kernel of *language*. And so we understand that the axiomatisation of the motor activities of the subject, on which Piaget focuses, converges at once towards an axiomatisation of discursive activities to constitute that which can be called a *Logic*. Nevertheless, one must bear in mind that the circumstances which allow this remarkable convergence between the norm

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<sup>21</sup> *ibid.* p. 397

<sup>22</sup> J. HABERMAS, *Zur Logik der Sozialwissenschaften*, Suhrkamp Verlag, 1982

<sup>23</sup> See for example, J. DEWEY, *Logic: The theory of enquiry*, Henry Holt & Co., 1938

<sup>24</sup> J. PIAGET, *Introduction*, in: *Logique et connaissance scientifique* (Dir. J. Piaget), op. cit., p. 4

of the activity and the norm of linguistic activity, are very peculiar. They are linked to everyday life and speech. This urges us to introduce a reservation from now on: nothing guarantees the durability of the relation obtained between the domain of activity and the domain of discourse when we pass from a gestural activity exercised at the heart of the everyday environment to an experimental activity aimed at exploring its limits.

## LOGIC, GRAMMAR AND FORMAL EPISTEMOLOGY

On the other side of the dualistic demarcation, to wit according to the philosophers who have privileged the *objective* side of logic, symmetrical difficulties have provoked a swing of the pendulum back towards the same point of equilibrium.

For the Wittgenstein of the *Tractatus*, the status of logic is that of a representational framework. Logic, he writes, is a picture which reflects the world<sup>25</sup>, its propositions represent the scaffolding of the world<sup>26</sup>; “logical pictures can depict the world”<sup>27</sup>. Accordingly, logic merges with the limit of the world. Indeed, the form of representation cannot for its part be represented in the logical picture; it can only be *shown* by it<sup>28</sup>. This remark, directed against the possibility of an *authentic* meta-representation, justifies in its turn the crucial distinction which Wittgenstein makes between *concepts* and *formal concepts*<sup>29</sup>. We can *say* (with the help of a proposition) that something falls under a concept, but we can only *show* that something falls under a formal concept. “Object” and “property” are such formal concepts. That something is subsumed under them is not claimed but shows itself by way of the type of sign which is used to denote it, or by means of the position of that sign in the propositional network. The formal concepts of object and property are, so to speak, *structurally presupposed* by language.

But as it is well known, that statics of mimesis typical of the *Tractatus* is exactly one of the principal targets of the Wittgenstein of the *Philosophical Investigations*<sup>30</sup>. The meaning of a proposition no longer establishes itself in a projective relation to the world, but in a lateral relation to its use in a “language game” or to its being put to work as a moment of a “form of life”. The dynamic of this use appear to be constrained to a body of rules which we call *grammar* in a wide sense; but

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<sup>25</sup> L. WITTGENSTEIN, *Tractatus logico-philosophicus*, op. cit., 6.13

<sup>26</sup> *ibid.* 6.124

<sup>27</sup> *ibid.* 2.19

<sup>28</sup> *ibid.* 2.171

<sup>29</sup> *ibid.* 4.126

<sup>30</sup> L. WITTGENSTEIN, *Philosophical Investigations*, B. Blackwell, 1958

it must not be believed, Wittgenstein insists, that those who speak and act in conformity with those rules are *guided* by them. Grammar is only the formalised residue of the practice of language-games. In order to identify this formalised residue, one can rely on the so-called “hinge” propositions of language. These propositions are “[...] devoid of content because they do not admit of a negation endowed with meaning”<sup>31</sup>. In other terms, they are devoid of content because they constitute the minimal basis of tacitly accepted affirmations in relation to which the affirmation or negation of all other propositions makes sense.

At this stage, if we would situate the thesis of the *Philosophical Investigations* in terms of the dualism in the theory of knowledge, we would need to ask ourselves some second-order questions: from what emerges the symbolic practice with which that thesis deals? Is it imposed by the subject or the world? The later Wittgenstein turned at length around these questions, but it was more to denounce their double lack of relevance than to answer them. Even though practices are proper to the subject, they do not reduce to series of arbitrary gesticulations and vocalisations. And even though the grammar of practice is constrained by some “reality”, it does not constitute a *copy* of this reality<sup>32</sup>. To paraphrase a remark of J. Bouveresse's<sup>33</sup> concerning arithmetic, we should say that *the connection which exists between grammar and reality is something which can only be shown in the application of grammar, and so it must not be described in terms of correspondence with the facts accessible from a point of view exterior to the practice of language-game*. Just like logic in the *Tractatus*, or formal epistemology according to the sketch which we have traced, grammar in the *Investigations* is thus transcendental. It simply is so in a quite particular way; not in the rigid style of Kantian *a priori* or the pictorial skeleton of the *Tractatus*, but in the mobile manner of the functional *a priori* of Dewey, qualified as *quasi- a priori* by Putnam<sup>34</sup>.

Furthermore, grammar retains a feature which we have so far reckoned as characteristic of *logic* : the merging of presuppositions of discourse and of action. “I act with complete certainty”<sup>35</sup> in accordance with the norms which underpin the forms of life in which I participate; I speak in complete confidence within the framework of rules of language of which I make use; and I hold as unquestionable that background of propositions “against which I distinguish between true and false”<sup>36</sup>. Forms

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<sup>31</sup> J. BOUVERESSE, *Wittgenstein, la rime et la raison*, Editions de Minuit, 1973, p. 67

<sup>32</sup> L. WITTGENSTEIN, *Philosophical Investigations*, op. cit. II, XII,.

<sup>33</sup> J. BOUVERESSE, *La force de la règle*, Editions de Minuit, 1987, p. 142

<sup>34</sup> H. PUTNAM, *Définitions (Pourquoi ne peut-on pas ‘naturaliser’ la raison)*, op. cit. p. 71

<sup>35</sup> L. WITTGENSTEIN, *On Certainty*, B. Blackwell, 1969, §174

<sup>36</sup> *ibid.*, §94

of life, background of “beliefs”, and rules of use of language, constitute for the later Wittgenstein a coherent and undivided communal basis.

It is now possible to clarify the project of a formal epistemology by means of a detailed play of similarities and differences between it and logic and “grammar” in the sense of the later Wittgenstein.

To begin with, we have said that logic, “grammar” and formal epistemology are all transcendental. That is to say, they tend to reveal the formal conditions of possibility for a state of knowledge (or a practical and verbal orientation in the world). From that standpoint, they constitute second-order disciplines, as against the first-order disciplines which are the sciences. But they are not, for all that, meta-sciences or meta-theories relative to the theories of particular domains of objects. They take as their object of investigation neither the sciences nor knowledge-gaining activity as a whole. They content themselves with codifying a symbolising procedure, and thus are able to *make manifest* the structures usually implicit in knowledge-gaining activity. They say nothing; they show. They do not represent; they present. They are typical examples of what G. G. Granger very appropriately calls *non-meta-theoretic meta-disciplines*<sup>37</sup>; examples of disciplines which in coming *after* a discipline do not establish between them and the discipline a distancing relation as between a science and its objects.

Further, we have underlined a considerable difference between logic in the sense of the *Tractatus* and “grammar” in the sense of the *Investigations*. The former has the rigid and hierarchical character of a structure which presents itself as *grounded* in the giving of a world of which it exhibits the “scaffolding”. “Grammar” has the mobility of a system of rules following the lines of force of an interlacing of operational and linguistic practices which is certainly constrained in some way by the real “other”, but which has the elasticity to modify both the mode of expression of this constraint and its mode of response. If we want formal epistemology to be able to meet the challenge of scientific revolutions with a sure hand it must resemble the “grammar” of the later Wittgenstein in its elasticity. It must, like “grammar”, belong to the class of evolutionary and non-foundational meta-disciplines.

Finally, there is a common feature of logic and “grammar” which we are inclined *not* to ascribe to formal epistemology; it is the presupposed certainty of a concordance between the form of discursive practice and the form of operational practices. This additional degree of freedom should allow formal epistemology to take care of a situation like that which confronts quantum mechanics, in which there is no obvious agreement between the formal coördination of operational activities and the structure

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<sup>37</sup> G.G. GRANGER, *Formes, opérations, objets*, op. cit. p. 113.

of language. It justifies in every way our calling formal epistemology *an evolutionary meta-discipline leaving in suspense the linguistico-operational concordance*. And it also justifies the expression “formal epistemology” when one attempts to display the formal structure of a physical theory, as opposed to Y. Gauthier’s expression “internal logic”.

We can sum up these thoughts in the following table:

Meta-disciplines	Logic	“Grammar”	Formal Epistemology
evolutionary		“Grammar”	Formal Epistemology
Lacking linguistico-operational concordance			Formal Epistemology

## TO ACT BEFORE PREDICATING

The idea of a meta-discipline leaving in suspense the linguistico-operational concordance is not entirely new. It is brought out very well, albeit in negative relief, in a critique which Husserl addresses at formal logic. Formal logic, Husserl explains, is of value for “ [...] a real world thought of as already given beforehand”. In traditional logic, the predicative structure of judgment, together with the presupposition of the permanent existence of that of which something is predicated, “ [...] was self-evident and was never examined”<sup>38</sup>. This constitutive pre-judged is equally brought to light by M. Mugur-Schächter when she emphasises that language, logic and the classical theory of probability rest on the common postulate of an “ [...] *intrinsic* ‘objectivity’ which would preëxist all acts of observation and conceptualisation”<sup>39</sup>.

In contrast, Husserl proposes to go below the categorical structures of language, below the form of judgment and below the formal concepts of object, property or relation. In *Formal and Transcendental Logic*, and more systematically in *Experience and Judgment*, he undertakes to put “[...] in question their innate *production* and their *springing up* in the lower stage of knowledge”<sup>40</sup>. Husserl calls this lower stage of knowledge “ante-predicative experience”; and he shows page after page, with all the refinement of his specific analyses, how from this can emerge the characteristic moments of predicative judgment. The emergence of the substratum of predication and that of the predicate arises respectively by way of two modes of ante-predicative experience: the “identificatory

<sup>38</sup> E. HUSSERL, *Formale und Transzendente Logik*, op. cit. §92

<sup>39</sup> M. MUGUR-SCHÄCHTER, «Space-time quantum probabilities, relativized descriptions, and Popperian propensities» I et II, *Foundations of Physics*, 21, 1387-1449, 1991; 22, 235-312, 1992

<sup>40</sup> E. HUSSERL, *Erfahrung und Urteil*, Glaassen & Goverts, 1954, §47

aiming” and the “explanatory experience”<sup>41</sup>. The identificatory aiming synthetically unites the multiplicity of perspectives, of profiles or of aspects presented by perception in an open experience of *same* and constitutes the precondition of the act of *reference* to an *identified* object. As for the explanatory experience, with its anticipatory tension, with its way of projecting interest towards the aspects which we *expect* to find if we modify our point of view on one and the same object, it is at the basis of *predication*. An anticipation attested and confirmed by the reproduction of a phenomenon when a certain perspectival situation is reiterated can, in effect, translate into a *predicate* assigned to the object aimed at.

But what would be the result if the phenomenological circumstances of this twin stabilisation, of predicate as well as substratum of predication, were not realised? What would happen in circumstances of the total disorder of “ante-predicative experience”? Nothing less than this would result: the disappearance of the conditions of an objectifying discourse making use of predicative judgment; and consequently the equivocation of the means of *saying* what this would amount to.

This *aporia* of the inexpressible can nevertheless be defused on two conditions (which are not mutually exclusive):

1) If the disorder of the experience is only *partial* and not total; because in that case the failure of the anticipations associated with aiming at an object could simply point towards the opportunity to change the type of object or quite profoundly modify the mode of aiming towards it.

2) If, in response to the disorder, we can limit ourselves to a calling into question of the lower levels of a logic which be *less universal* than that which Husserl proposes.

The restricted calling into question which we propose is certainly superficial when compared to the programme of genesis and foundation which the creator of phenomenology formulated; but it is sufficient to deal with the difficulties of contemporary physics. Instead of opposing, like Husserl, the pre-logical circumscription of ante-predicative experience to the domain where (predicative) logic is to be established, we would oppose the combined domain of everyday life and instrumental operations, where the validity of logic remains unquestioned, to the domain of the putative objects of experimental investigation, in which the relevance of logical structures remains an open question<sup>42</sup>. If we proceed in this way, the loss of the conditions for an objective mode of expression using predicative judgments within the particular domain aimed at by experimental investigation does not have as a consequence a global slide into the

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<sup>41</sup> *ibid.* §8

<sup>42</sup> M. BITBOL, *Mécanique quantique: Une introduction philosophique*, Flammarion, 1996

inexpressible, but only the restriction of the sphere of relevance of the forms of discourse to the description of instrumental operations.

## QUANTUM MECHANICS AND FORMAL EPISTEMOLOGY

In quantum mechanics we are exactly at this point. On the one hand the traditional forms of discourse using predicative judgments remain valid in the domain of instrumental operations; better, they *must* remain so in as much as they are the bearers of the preconditions of an intersubjectively shared experimental knowledge<sup>43</sup>. But on the other hand, the *expectations* which are induced by the aiming at a traditional type of object (corpuscular bearers of properties) *beyond* the experimental apparatus, are generally confounded. The expectation of being able to re-identify a corpuscular object founders on the impossibility of experimentally following its trajectory continuously, and on the indirect consequences of this impossibility (i.e. combinatorial and statistical consequences). The expectation of seeing a phenomenon reproduce itself is for its part systematically confounded in certain well-documented cases: a value of a variable is not reproducible if, between two occurrences of its measurement, we insert a measurement of a variable called “incompatible” or “conjugate” (e.g. position and momentum).

So none of the phenomenological criteria for reference to a corpuscular type of object, and for the predication of determinations to that type of object, are satisfied in the experimental domain of microscopic physics. We are left in the presence of something which *prima facie* resembles an isolated flux of singular experimental results, indissolubly dependent on the experimental conditions which have given rise to them. In effect, these results do not have a sufficient degree of invariance with changing experimental sequences for us to be able to detach them from the instrumental context of their occurrence and to treat them *as if* they were evidence of a determination which an object would possess. In short, the events of microscopic physics are essentially *contextual*, or again, as M. Mugur-Schächter says, they arise from a “*descriptive relativity*”.

What is to be done in facing this critical situation, in which the corroborated theoretical anticipations of the results of operational activity do *not* satisfy the presuppositions of discourse reflected by traditional logic? The first strategy, urgent and clarificatory, consists in *showing*, in *manifesting*, the coördinated structure of these anticipations as it is extracted by the formalism of quantum mechanics in a rigorous but not

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<sup>43</sup> N. BOHR, *Physique atomique et connaissance humaine*, Introduction et annotations par C. Chevalley, Folio-Gallimard (1991); F. Lurçat, *Niels Bohr*, Criterion, 1990

very explicit way. It consists in capturing the *meta-contextual* structure which P. Heelan spoke of<sup>44</sup>, or the *algebra of observation* which S. Watanabe developed<sup>45</sup>, or the ordered system of *relativising glances* in the sense of M. Mugur-Schächter<sup>46</sup>. In sum, the strategy amounts to extensively utilising the resources of a meta-discipline freed of the constraint of an isomorphism between language and operations. A meta-discipline which answers exactly to the definition which we have given to *formal epistemology*.

As a second strategy, we could always ask ourselves if it is not possible to go back to the golden age of the linguistico-operational concordance in changing logic (“quantum” logics), in choosing a new partitioning of the world into objects having nothing in common with the material bodies which bear localised properties (e.g. the referents of state vectors, as according to Schrödinger<sup>47</sup>), or in assuming (as in hidden variable theories) that the properties of corpuscular objects are instantly influenced by the instrumental or environmental conditions of their manifestation<sup>48</sup>.

But none of these second-level endeavours will be able to ignore the lesson to be drawn from the first-level analysis brought to fruition by formal epistemology. Quantum logicians face considerable difficulties in defining what they mean by “property of an object” without conceding too much to contextuality; the new ways of partitioning the world (i.e. the “new ontologies”) remain reliant on a level of discourse where a tacit “natural ontology” operates; and hidden variable theories must have recourse to the artifice consisting in substituting “contextualism” for contextuality: that is to say, invoking a holistic influence of experimental circumstances on the underlying intrinsic processes, rather than drawing directly the consequences of the co-definition of the phenomenon and the conditions of its manifestation.

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<sup>44</sup> P. HEELAN «Quantum and classical logic: their respective roles», *Synthese*, 21, 2-33, 1970; also: M. Bitbol, *Mécanique quantique: Une introduction philosophique*, Flammarion, 1996

<sup>45</sup> S. WATANABE, «The algebra of observation», *Suppl. Prog. Theor. Phys.*, 37&38, 350-367, 1966

<sup>46</sup> M. MUGUR-SCHÄCHTER, «From quantum mechanics to universal structures of conceptualization and feedback on quantum mechanics», *Foundations of physics*, 23, 37-122, 1993

<sup>47</sup> E. SCHRÖDINGER, *The interpretation of quantum mechanics*, Edited and with introduction by M. Bitbol, Ox Bow Press, 1995; M. Bitbol, *Schrödinger's philosophy of quantum mechanics*, Boston Studies in the Philosophy of Science, Kluwer 1996

<sup>48</sup> For a comparative analysis of these diverse approaches see M. Bitbol, *Mécanique quantique: Une introduction philosophique*, op. cit.; M. Bitbol, «Quasi-réalisme et pensée physique», *Critique*, n°564, 340-361; M. Bitbol, «L'aveuglante proximité du réel», *Critique*, n°576, 359-383

## EPILOGUE

In the manner of the Euclidean geometers of Michel Serres, the physicist of the classical epoch “ [...] hopped on the moving train, at a moment when everything was already worked out, when the concepts were a thousand times over-determined”<sup>49</sup>. Then, without clearly understanding what he was doing or why he was doing it the physicist of the 20<sup>th</sup> century adopted the path of a radical reëxamination of the previously unquestioned articulation between the operational and discursive domains. To that extent he put himself in the predicament of the modern mathematician who, in a paradoxical development, “ [...] steers himself towards his unforeseeable horizon and his starting point”<sup>50</sup>; a mathematician who, to put it differently, approaches more and more the *performative origins* of his science whereas he thinks he gets closer and closer to his *object*. The meta-disciplinary analysis of his science in the framework of a *formal epistemology* is apt to make the contemporary physicist conscious of this reflective task which he has undertaken in the wake of the mathematician, so clearly that nothing can ever force him to fall back into forgetfulness.

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<sup>49</sup> M. SERRES, *Les origines de la géométrie*, Flammarion, 1993, p. 21

<sup>50</sup> *ibid.* p. 27