SYNTHESIS, REALISM AND CAUSALITY

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I. *Introduction.*

In this paper, I try to show the importance and the possibility of approaching science and methodology in a non-reductionistic and realistic way.

The realistic non-reductionistic interpretation of causality and the indication of its important role in science is a beautiful instance of my claims.

A serious attempt towards this end is found in L. Apostel's «Matière et forme» (L. Apostel 1974). For this reason I shall pay special attention to this book. So I proceed by (a) giving a general survey of this book, (b) sketching a synthesis procedure based on some semantic-pragmatic considerations and showing how and to what extent this procedure can be found in Apostel (1974), (c) treating the problem of determining in a non-arbitrary way the cause of an effect and (d) the relation between knowledge and causality. Finally, (e) I shall discuss the problem of theory change in realism.

II. *A general survey of L. Apostel's «Matière et forme».*

In his comprehensive work «Matière et forme», L. Apostel indicates how central causality is in the search for a solution of today's important epistemological, logical and ontological problems.

What makes this book really exceptional is the awareness of what Piaget called «the more and more interdisciplinary nature of research in every field» (Piaget 1973, p. 26). In this book is brought together a manifold of approaches to causality: temporal logic, the logic of subjunctional conditionals, probability, statitics, axiomatic theory of causal relations, automata theory, algebra, topology, systems theory, mathematical physics, all of hem are brought into the fore.

The relevance of each of them for the understanding of the phenomenon of causality (or vice versa) is discussed at length in the first and most elaborated volume of this work. In the second volume part I, on the results of the first volume, several general epistemological problems are discussed and an epistemic logic is constructed.

The second part (II, II) is devoted to an analysis of the influence of synthetical and factual discoveries and changes in theory on formal logic. Mainly physics and quantum mechanics, in respect of their influence on logic, have been dealt with. In this part the author's choice of the title of his work, «Matiêre et forme», comes most clearly to the fore. His main thesis of this part II, II is very expressive on this account: «Logic and reality — the determination of form by content as exemplified in quantum mechanical logic» (Apostel, part II, p. 233).

In fact the treatment of causality in the first volume must also be seen in this light. It shows how the general structure of reality, represented by causality, imposes restrictions on logic (part II, p. 349).

In the third and last part of the second volume (II, III) the author deals with the problem of explanation. Here, he tries to integrate (a) historical theory of explanation, (b) question logic applied to explanative questions and (c) the deductive-nomologic model. Again he comes to the conclusion that to get the notion of explicative reasoning, one needs to formulate specific conditions on deductive logic.

Looking at these multiple contributions the question to define the implicit or explicit method for synthesizing used by the author, arises.

For this reason, before commenting on some specific topics — it is clear that in this article I cannot exhaustively discuss all the relevant data on the significance of causality for the philosophy of today, as they have been treated in this book (Apostel 1974) — I will try to answer this question. I believe that some interesting remarks and explanations of the success and synthesizing power of the procedure of the author can

be made on the basis of some general semantic-pragmatic considerations.

III. *Some general semantic-pragmatic considerations relevant to the problems of synthesis.*

a. The lexicographer's semantic-pragmatic approach.

In his book on «Problems on the construction of a theory of natural language» (Tartaglia 1972) Tartaglia pointed out that the classical semantic approach is based — implicitly or explicitly — on the distinction between analytical and synthetical expressions. Quine, however, has convincingly shown in a lot of his publications that one has no non-arbitrary methods to differentiate between analytical and synthetical sentences. Quine does not even accept that 'meaning' is a useful theoretical term.

In some papers (Vandamme 1975a, 1975b) I myself have argued that it is possible to reject the distinction 'analytic/synthetic', without rejecting meaning. This means that one can construct a semantic theory, even if it is not possible to differentiate 'analytic' from 'synthetic' expressions.

I here interpret semantics in the sense used by Jasin (1972, p. 40): «Semantik, deren Gegenstand der Inhalt der Mitteilung ist, oder mit anderen Wörtern, die Beziehungen zwischen den Zeichen, die die Gegenstände abbilden, und ihrer Reflexion und Form in Speicher des Organisationssystems».

In this sense, it may be said that in fact semantics embraces the whole field of cultural, subcultural and personal model-building. Meaning then consists of programs relating language expressions to these models (Vandamme 1972, 1975b).

Looking at this semantic model from a functional point of view, one can define several levels. One of the most important functions of the semantic model is to make possible the implicit and explicit behavior of «explaining». Much of the explanatory behavior happens by language. The construction of the semantic model in function of this verbal explanatory behavior is called the language-semantic level (L.S. level).

However, human model-building certainly does not limit itself to this function, but it is also used for the coordination and storage of perceptions (the perceptive level), actions «praxiological level, emotions (emotional level), etc. It is clear that these different functionally defined levels are interrelated. I will not go deeper into this problem here.

Semantics in this view (in other words the models one has) can be very useful in explaining to somebody Y the significatum (S) of a certain term or sequence, or the use of a certain element (T).

One can do that by giving Y a set of constructions {C}, which can be formed out of 'S', in certain contexts (O) in certain ways (W). Depending on the knowledge of Y of the set {C}, and the construction-relations, which {C} has with 'S', Y is able to understand 'S'.

Piaget's dictum «to understand is to invent» (Piaget 1973) is a clear description of what happens. On the basis of the knowledge of {C}, O and W, the interpreter is able to construct: to invent a value x for S, so that (O o W (S) → {C}).

It is important to be aware of the fact that the construction-relation is not an analytical relation at all. This is easy to illustrate. Starting with the stimulus (A), which activates our retina we can, for example, construct the abstraction 'chair' (B). In this case we will not say that (A) implies analytically (B). In fact on the basis of our whole experience, we are able to construct (B) out of the data (A), in certain contexts only. This non-analytical character is shown by the fact that in different contexts we can construct other concepts from the same data. In psychology plenty of examples of this can be found. Of course the construction (B) can itself be regarded as a datum On the basis of (B) we can build up other constructions, say: leg, furniture, etc... Again this does not mean that (B) analytically implies (C) or (D), they are once more just hypothetical constructions from (B), having some cognitive and/or pragmatical value for the understanding and manipulation of the world.

The lexicographer tries to make a model for the verbal explanatory behavior (V·E.B.). He can try to make such a model

relative to a certain individual, a certain group, or a certain culture. Building such a model, we can take into account two types of information: (a) the implicit verbal explanatory behavior of thos people, whose language semantic level we want to reconstruct, and (b) their explicit explanatory behavior.

Most explanatory behavior we meet in every day life is implicit. A new-comer in a certain group is in general taught the signification and meaning of a certain term by being shown a set of constructions which can be built by means of it. The explicit explanatory behavior of a certain group is obtained by asking questions about the definitions of certain terms.

b. Analogies and differences between the model of the lexicographer and of the scientist.

The models of the lexicographer intend to describe and explain some aspects of the use of the terms: the expression of meaning in a certain cultural context.

The scientist tries to describe and explain certain observational events. Both scientist and lexicographer look for the possible constructions which can be made with certain elements. The criteria for the choice of the accepted constructions are, however, different for both.

The lexicographer will choose these constructions C out of S, which are generally accepted in the group he studies, as normal constructions of S. For sure this claim he must scientifically prove.

The scientist's criteria are also dependent on the group he is a member of, but in another way. He will choose these constructions to explain a certain event, which fulffil certain methodological conditions: intersubjective controlability, types of logical coherence, abstractness, generality, and explanatory power, etc.

c. Synthesis and constructive models.

If we have several models (M_1, M_2, ... M_n) (sets of interrelated constructions) and if we are able to interrelate them by constructing, for example, on the basis of central elements of M_1, central elements of M_2, etc., then we get interrelated and coor-

dinated models: a synthesis. The interrelation between the elements of M_1 and M_2 does not need to be logical (deductive relations), but synthetic.

To illustrate what we mean, let us take thermodynamics. Thermodynamics can be described and explained in a model (M_1) of phenomenological terms (heat, cold, temperature, etc.). It can also be described and explained in statistical mechanics (M_2). It has been proved that it is possible to relate central notions of M_2 with M_1 by means of correlative definitions.

In the same way we can link together and coordinate several language models. One can — as Bar-Hillel tried to do — link categorial grammar (Lambec, Montague) with transformational grammar, etc.

Synthesis, described n this way, is clearly different from reductionism. A classic definition of reductionism is the one Kemeny and Oppenheim (1956) introduced. Given two theories T_1 and T_2, T_2 is said to be reduced to T_1 if and only if: (1) the vocabulary of T_2 contains terms which are not present in the vocabulary of T_1; (2) any observational data explainable by T_2 is also explainable by T_2; (3) T_1 is at least as well systemized as T_2 (note 1).

From this definition we see that it is the observational data that form the link between the two theories T_1 and T_2 in reductionism. All observational data explained by T_2 must be explained by T_1. No requirement of interrelation is stated between T_1 and T_2 as far as the theoretical framework is concerned.

Reductionism therefore implies domination of one theory on the other and elimination of theoretical framework. In synthesis on the other hand, we have the coordination of theories on an identical or overlapping domain of facts. These different theories can pragmatically, semantically and syntactically complement each other.

In this way in the practical application of thermodynamics, the statistical mechanical data can be taken into account in the phenomenological model, which is in many cases easier to communicate and easier to coordinate the action of people.

Having examined in general now non-reductionistic synthe-

sis should present itself, let us now look at the first volume of «Matière et Forme in order to describe the type of synthesis applied in its construction:

(1) The author characterizes 'temporal entailment' and 'subjunctive conditionals'. He combines these, in order to construct the causal relation from its elementary conceptual aspects of which it is a combination.

(2) The notion of 'production' gives him a foundation for his general hierarchy of conditions. We should stress that while in (1) the progress goes from more general entailments towards the more specific causal entailment by specification and combination. In (2) progress starts from an intuitive historical and linguistic concept in order to 'explicate and clarify' it by means of structural characteristics. (3) Trends (1) and (2) meet each other, ,yielding a spectrum of possible realizations of the hierarchy, by means of temporal or conditional, or both temporal and conditional characteristics (this multiplicity is especially important for non-reductionistic synthesis).

(4): (1), (2) and (3) taken together, actieve what we might call purely ontological characterization of causation. The central problem then is: how can causation be discovered ? Once more, the author starts with more general concepts: «correlation» here plays the role performed in (1) by 'temporal entailment'. Specific types of correlations are sought and in general specific types of probability relations that would confirm the existence of causal relations. What had been defined on the object side to begin with, is now defined on the subject side.

(5) But this epistemological characterization, following the ontological one, is again shown not to be self-sufficient. The author then attacks the causal relation as an undivided whole to be defined by its structure. This happens in two different ways: (a) the causal relation is described as a specific type of 'causal implication' in a system of propositional logic and (b) as a specific type of operator on an algebra. (5) is in clear contrast with the two former trends: the object of the study is no longer to be approached from below or from above in the ontological plane, nor from the outside on the epistemological plane, but as a self-contained structure (in the first place, as a proposi-

tional structure; in the second place as a purely algebraical structure).

(6) Once this level of extreme abstraction is reached, the author (in a move that seems characteristic of his method) turns to a radically different approach: his general structure has to be realized in specific relations between automata first, and between general systems (abstracted) from concrete automata) secondly. The «point-counterpoint» method of the book is clearly in evidence here.

(7) The study ends by noting the terms brought together by the causal relation by means of the structure of the space, in which it can or must be embedded. This last method of approach could again be called (as the statistical or probabilistic one) an extrinisic approach (this time, it does not refer to the methods to be used to know the existence of the relation, but rather to its conceptual environment).

The aim of this remark is to make the reader and possibly also the author (who could not simultaneously write the book and study his own method of composition) aware of the rationale of his procedure.

In general we can say that in order to characterize a relation (the causal relation):

(a) more elementary relations are sought by the combination of which it can be defined.

(b) more general and more precise relations are sought of which it is a specification and an explication.

(c) Relations between the relation studied and the knowing subject are used to define the relation by means of its conditions of verification.

(d) The intrinsic combinatorial structure of the relation is presented.

(e) Systems, more or less general (automata: recursive systems or general systems), are looked for the interactions of which mirror the relation studied.

(f) The relation is embedded in more or less structured sets (different spaces) and the properties of these sets are used to characterize it.

The non-reductionistic character of the synthesis is shown

by the fact that none of the levels mentioned in (a) to (f) is basic. All of them are needed, all of them are related but none of them is dominant.

Even if this is the case, one can still state that one's preoccupation is present everywhere: the book is an attempt to show that David Hume's reduction of causality to legality is not necessary, by showing that the 'production — causality' of philosophical tradition and every day language can be attributed a specific, formally clear structure, so that Hume's negative argument about its unclarity has to be discarded. Has the author reached this aim, and is this aim to be pursued ? I do not wish to discuss this central question in these pages, because I want to attract attention to other features of the work also worthwhile and of more interest to the author of the present paper. I should stress, however, that the first volume should finally be judged by what it has been able to contribute to this topic.

Can this type of synthesis also be found in the other parts of this attempt towards a realistic epistemology ? The answer is clearly affirmative. He approaches knowledge in the same way:
(1) He tries to characterize knowledge on the basis of more elementary relations as there are: assertions (II, p. 44) and in terms of a causal relation between systems (II, p. 57).
(2) He studies the knowledge relation between the subject and the object and its properties (II, p. 44).
(3) He looks also at it as a processus. .In this framework he tries to find in what way the following theories are related to knowledge (II, pp. 57-76): theory of problems, of hypotheses, of argumentation, of constructions, of observations, of experimentation, of proof, of classification, etc.
(4) An epistemic logic is introduced.
In (1) we have the analysis of knowledge in more elementary relations. In (2) the subjective side of knowledge is studied. In (3) we have the study of more general relations of which knowledge is a specification and an explication. In (4) we have the intrinsic combinatorial structure of the knowledge relation which is presented.

We get the same approach (II, pp. 373-401) on explication. The relations between explanation and prediction, probability,

question logic, surprises, deductive logic, historicism, etc. are thoroughly analyzed and a global set of constructions which interrelate the different theories are brought forward.

Obviously the author wants to bring about an extensive non-reductionistic synthesis between a large number of approaches and disciplines, all needed in the study of causality.

IV. The determination of causes and consequences.

L. Apostel has characterized the causal relation (a) by an implication of which the antecedent as well as its consequence have certain spatio-temporal characteristics;

(b) by an implcation that also represents a subjunctive conditional. Stalnaker's and Lewis' theories about Kripke-models for subjunctive conditionals are used and specific new conditions for causal accessibility are proposed;

(c) as a third move the temporal and subjunctive necessary conditions are hierarchized and a method aiming to give an exact simulation of the 'production' relation is proposed, yielding 'cause' as a privileged context-element (note 2).

He remarks that in practical cases, we have sets of elements, spatio-temporal relations and subjunctive conditionals among them and hierarchies among these. The question arises how to choose the appropriate context. Once it is chosen, the cause can be selected by the methods proposed. But the context must be delimited.

According to the author, the way of doing this splitting up of reality, of determining context, is not psychologically, sociologically, nor conventionalistically determined. As always, he takes a realistic standpoint. He argues that the splitting up is determined by differentiations which preexist in reality and by practical aims: «Le genre de découpage que nous faisons subir à la réalité n'est donc pas arbitraire mais nous choisissons pour des buts pratiques les niveaux dont nous voulons nous occuper et qui préexistent à notre attention» (Apostel I, p. 218).

This approach differs from Heider's approach to causality

in his «The psychology of interpersonal relations» not so much with respect to the idea of introducing a hierarchy (although Heider does not give a logical analysis of the hierarchy and does not stress Apostel's main point: the many levelled realizations of the hierarchy by means of time, space, change and physical modalities), as by the reasons and methods for introducing the type of partition in the set. In Heider's approach the way of splitting up the set is strongly determinated by sociopsychological elements. Apostel's practic-ontological reasons and the formal apparatus he uses to express them, have brought I believe, some progress in the understanding of causality. Nevertheless we can ask ourselves the question if this approach is entirely adequate.

Let us look at the following assertion «Tobacco is the cause of smoking». In general, I believe, nobody will accept this to be true. We can ask how this assertion will do in Apostel's work.

Te be sure there is a spatio-temporal vicinity between tobacco and the phenomenon of smoking. Tobacco is also a necessary condition for it (if objects can be necessary conditions of events).

To get rid of tobacco as a possible cause, one could require that the cause and the effect are homogeneous. Of course, in this case the problem of determining homogeneity arises. As far as the type of elements which can be cause or effect is concerned, Apostel follows Scriven. In this respect he quotes Scriven as follows: «A cause or effect may be at least a state, an event, a relation, a configuration, a process, a thing, a possibility, a thought, or the absence of any of these» (Apostel I, p. 165).

But he adds to it: «Nous sommes d'autre part convaincus que dans la mesure où la cause et l'effet sont décrits comme appartenant à l'un des types logiques mentionnés, nous imposons aux pôles correspondants des conditions qui en restreignent la variabilité» (Apostel I, p. 165).

Could the requirement of homogeneity be such a restriction ? In any way, I believe that much interesting work has to be done yet about the type of conditions which restrict the variability of the causes relative to a certain type of effect.

I also want to draw attention to the analogy of the problem, Apostel treats here (viz. how to choose in the net of subjunctive temporal implications we have, an element as the cause of another) with the problem of explaining. In paragraph III, I introduced the set of constructions {C} which can be made out or with the significatum (S) of (I) to explain to somebody Y the element T. Dependent on the context, one has to choose one element, or a peculiar subset of {C}, in order to explain successfully S to Y. Here too the problem of making a hierarchy in {C}, and of splitting up {C} is important. Here too one can argue that the way of splitting up {C} is dependent on pragmatical considerations and on the reality on which {C} is dependent.

V. Knowledge and causality.

As I have already mentioned in his approach Apostel links knowledge to causality. The following quotation is interesting in this respect: «Si x connaît p, il existe une chaîne causale émanant de p en atteignant x à un moment antérieur au moment où Kxp: ce n'est parce qu'une transformation émanant de p modifie x, qu'une information concernant p peut être transmise à x. Cette remarque n'est as complètement formalisée, parce que nous devons plutôt écrire qu'une implication causale existe entre p d'une part et d'autre part une proposition qui comporte au moins un nom ou un description de x comme constituante. Nous pourrions d'ailleurs également affirmer que 'Kxp' implique pour au moins un des objets y mentionnés dans p, l'existence d'une fonction g, telle que g(y) est liée à f(x) par une chaîne causale (pour au moins une fonction f de x).

Nous soulignons que cette condition n'est pas une condition suffisante pour l'existence d'une connaissance, mais seulement une condition nécessaire. Nous ajoutons que la chaîne qui mène de p à f(x) peut être très longue et indirecte...» (Apostel II, p. 3).

So Apostel argues that there is a causal relation between what is known and the person who knows. This is without doubt true in many cases. However, if mathematics is taken

into account and abstract sciences in general, I believe that this claim must be weakened.

Apostel's point of view may be expressed as follows:
(1) $Kxp \rightarrow (Ey)\ (y' \text{ occurs in } p) \,.\, g(y) \rightarrow_c f(x))$
viz. x knows p, implies that there is a causal relation between a function of an object y, which is designated in p and a function f of x. I have difficulties, however, with the requirement that y has to be designated in p.

Be p the statement $2 + 2 = 4$. In Apostel's formulation, there must be a causal relation between one of the constituents of p and a function of x. I think that as a matter of fact, the following expression is more plausible:
(2) $Kxp \rightarrow ((Ey)\ ((g(y) \rightarrow_c f(x)) \,.\, (h(y) \rightarrow p))$
In other words, if a person x knows p, then there exists something, a function of which is causally related to x, but also a function of it for example an abstraction operator is related (perhaps also causally) to the expression p.

Coming back to my example of arithmetics, viz. $2 + 2 = 4$, this means that there is, for example, a certain structure y in reality a function of which is causally related to a certain function of the knower x, but at the same time by another function on y (fore example abstraction) p is generated or produced.

VI. Realism and science.

In his discussion on the relation between knowledge and causality, Apostel — as we have seen — takes a rather strong realistic stand. However, in his discussion on science, empiricism and methodology, he seems to weaken his realism considerably, under the influence of Peircian, Hansonian and Chomskian types of epistemology and perhaps under the influence of the general tendency to psychosocial relativation of science.

For this reason, I want to have a look at Apostel's points of view on retroduction, empiricism and sociology of science. Apostel attacks rather vehemently empiricism in the following terms: «Contrairement à l'empiriste pur qui vaudra collectionner un grand nombre de «case studies» en histoire des scien-

ces, avant d'oser arriver à une généralisation prudente quant à la loi de développement de ces mêmes sciences, nous croyons au contraire qu'il faut commencer par faire une hypothèse profonde et audacieuse, quant au développement de la science, pour essayer d'expliquer par après son développement en détail à partir de cette hypothèse audacieuse ...» (Apostel II, p. 124).

This same idea he repeats later on in the following way: «Il est faux que la connaissance se construit par une méthode inductive et statistique. On ne prend pas des échantillons, pour les observer et puis par après à l'aide d'un canon de règles rationelles de logique inductive, généraliser pour des univers plus vastes les propriétés réalisées dans les échantillons. Cette description est fausse parce que les échantillons sont toujours extrêmement petits par rapport à l'univers, les tentatives de les élargir sont très modestes et les généralisations ne vont pas dans le sens d'une universalisation de propriétés observées mais d'une construction des objets et propriétés observées à partir d'autres propriétés non observées et en général inobservables» (note 3) (Apostel II, p. 165).

With this last remark Apostel opens the way to idealism. An analogical point of view is taken by Chomsky (1968). It is only a small step now to claim that the non-observable properties at the basis of all hypotheses and constructions are chosen from a set of synthetic apriori data, as was, among others, argued by Sneeds at the Vth International Congress of Logic, Methodology and Philosophy of Science. This means we get a weak Kantian outlook on science; weak in this sense that the only function of reality is to force upon us a choice between alternative synthetic apriori's.

It is important to look now at his characterizaton of retroduction — as he calls his alternative for the inductive and hypothetico-deductive methods — and see if it brings some information of how to avoid the idealistic consequences of the attack on the empirists.

Apostel describes retroduction as follows: «Le mécanisme de création de nouvelles théories est le suivant: a) une théorie précédente comporte une structure algébrique telle que par

spécialisation ou généralisation (relâchement ou intensification de restrictions) typique pour la dynamique des systèmes, d'écrite auparavant, on peut obtenir un nouveau système algébrique comportant à la fois des propriétés simples et riches, des symmétries et invariants reliés aux symmétries et invariants des théories précédentes d'une façon régulière et b) l'acte constructif de perception d'un certain domaine de faits comporte lui aussi une organisation intérieure typique, une certaine fermeture qu'il est possible de saisir par la construction d'une forme générale. Hanson appelle «retroduction» cet acte de saisie d'une forme organisationelle dans les faits et nous ajoutons que cette «pattern recognition» également reconnue comme l'essentiel de la construction d'un paradigme par le commentateur le plus profond de Kuhn, Margaret Masterman, est encore une inconnue sur laquelle d'innombrables travaux se font mais qui est certainement fonction d'une collaboration de la structure réelle du domaine perçu et de le structure active (note 3) de l'acte de perception construisant le percept de ce domaine. A la suite de la saisie de cette forme, nous charactérisons le domaine par de grandes propriétés qualitatives, c) une nouvelle théorie se crée si les deux développements que nous venons d'indiquer: l'acte de saisie d'une organisation perceptive d'une part, et l'acte de création d'une nouvelle structure algébrique d'autre part se rencontrent (Apostel II, p. 166).

Aftr discussing Sneed's «Dynamics of theories» (Sneed 1971) and generalizing Roman Susko's «Diachronic logic» (Suszko 1968), Apostel proposes a semantic-pragmatic model for sequences of theories to be found in the history of science. This is an important part of his volume II.

In his characterization of retroduction we see certain important affinities with Sneed's formal theory of theory change (Sneed 1971, Sneed: to appear, and Vandamme: to appear).

Sneed argues that the changes in theories are of twwo types: (Sa) specilization or generalization of the core of the theory to get new applications or (Sb) a more detailed theory of a certain application or of the core itself.
In the type Sa, Apostel's feature (a) is most dominant, while in the type Sb, Apostel's feature (b) seems most important. As well

Apostel as Sneed stresses the algebraic relation between succeeding theories.

Sneed, however, sees the epistemological and ontological status of the core rather in a platonic fashion and, as already mentioned, he argues that the statements in the core are synthetic apriori, with however this important non-Kantian feature that there are sets of alternative synthetic apriori statements.

In this approach, close to Pierce's and Chomsky's epistemology, the role reality can play through observation, control, falsification, etc. is to be found in the choice of alternative sets of apriori hypotheses.

Now, we may wonder if Apostel too has such a minimal interpretation in mind of the function of reality in the formation of an organization form, when he writes that organization form is a function of a collaboration between the structure of reality of the observed domain and mind (la structure active). Taking into account his remarks on empiricism — quoted above — and on logic (note 4), I think one could get the impression that here Apostel takes a minimal realistic point of view. Although certain results Apostel got on quantum mechanics and logic would justify — I believe — a much stronger realism.

I would rather like to defend a strong realistic point of view. I believe that reality not only plays a role in the elimination of hypotheses, of certain alternatives, but that theoretical structures are constructively functional dependent on reality.

After reading Apostel's book, one can say (a) that the perperceptual field is constructed by an interaction between reality and the perceiver, both being active; (b) that the apriori's are constructed by genetic features of the organism, sociological features of the group of scientist and laws of the dynamics of scientific systems, (c) that knowledge is reached by the interaction between these two interactions, in which no element plays the role of a passive partner. If this view is taken, the danger of idealism is avoided, but it is my impression that the author in his methodological theory has not elaborated upon

this important problem in a sufficiently clear way

I understand the difficulties met in inductive logic, confirmation theory, perception theory, have led many people to pessimism about the possibility of explaining scientific activities along these terms, without a strong idealistic apriori basis. But in a certain sense, I believe that this idealistic and apriori approach is not an explanation either, for it introduces as a 'deus ex machina' the very thing one has to explain. I think that an answer to the immense problems met in the inductive logic, confirmation theory, etc. must be sought in the Winograd results (note 5).

In artificial intelligent experiments, Winograd (1972, 1973) proved to get very good results on a question-answering problem by using a partial syntax, a partial semantics and a partial model of the world and the strategy that from the moment one got too many problems (too much, for example: ambiguity) at one level (for example: syntax) one shifts to another level (note 6) (e.g. semantics).

It seems to me promising to investigate the formal aspects of this strategy and to examine if the same approach could not be very efficient to explain the theory changes in science. Is the scientist not working in the same way with a partial inductive logic, a partial deductive logic, a partial confirmation theory, a partial observation theory and interrelating all of them following one or another strategy.

The fact that inductive logic, confirmation theories, etc. all by themselves did not help us much for a better understanding of the scientific activity, is perhaps not due to its theoretical failures, but rather to the non-interdisciplinary approach of science-methodology.

As Winograd indicates for language, so for science too, we have to take into account the mixing of methodological strategies and levels.

I would like to critizise for the same reason Apostel's stress on the importance of sociology of groups of scientists for epistemology (note 7). I agree that adequate knowledge of the sociology of scientific groups is important and that sociopsychological features influence the changes in the theory, but I

believe that these influences are only one of the elements which determine scientific structures, and, moreover, that their influences are restricted within certain borders determined by logical and methodological features of the existent theories, and so by reality (see about this Sneed: to appear and Vandamme: to appear).

I must, however, acknowledge that if an independent formal theory of theory dynamics (as Apostel tries to construct as a development and modification of Suszko's diachronic logic) is persued no unilateral determination of theory development and modification of Suszko's diachronic logic) is persued no unilateral determination of theory development by the internal structure of the scientific group can be feared. Once more only bilateral interaction can be aimed at.

VI. Conclusion

Much has already been written on ontology, epistemology and causality by lots of people, philosophers and others. Nowadays a new consciousness of the importance of all this for the better understanding of science, man and his world, is growing. In this short article, I hope that I have somewhat stressed the importance of making an attempt at a non-reductionistic synthesis of all knowledge we have on this domain, however imperfect it may be. With Winograd in mind we can argue that the synthesis of a set of imperfect theories can be of an immense practical value. I believe that for any future attempt for synthesis in this field, Apostel's work «Matière et Forme» is an important starting point.

(1) For a more extensive discussion on the relation between synthesis and reductionism, see F. Vandamme (1974): «Synthesis against reductionism».

(2) «Nous disons alors que sont appelées causes dans une histoire partielle, les éléments distingués par le découpage, qui sont par rapport à un ordre O défini par rapport à une relation R, des maxima dans le sens que nous venons de définir ...» (Apostel I, p. 170).

(3) Italics are mine.

(4) «Dans notre livre I, nous avons vu comment le structure générale du réel, représentée par la causalité, imposant des *conditions contraignantes* à la logique ...» (Apostel II, p. 349).

(5) M. De Mey brought these results of Winograd to my attention.

(6) M. De Mey also told me that in automatic reading one gets the same results. With no single approach one gets an adequate result; by combination of different approaches one gets the task done practically and efficiently.

(7) Apostel writes: «La théorie de la connaissance *doit* se fonder sur la sociologie des groupes scientifiques» (Apostel II, p. 51).

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