ON ONTOLOGICAL ASSUMPTIONS OF IDEALIZATIONAL THEORY

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Today it is almost conventional wisdom to claim that scientific theories are based on philosophical assumptions of a kind. This generality is, as it happens more than often to all generalities, both true and non-informative. Indeed, nothing is simpler than to confirm such a claim with numerous examples from science and/or its history. Such illustrations tell us, however, usually very little about the mechanism of theory-formation and the role philosophy plays in it. They certainly contribute to history of culture but not to philosophy of science. For a philosopher of science the problem of the philosophical background of scientific theory becomes more interesting when "theory" is understood in the sense explicated in a given methodological approach, that is, in a definite manner. In this text I would like to consider what kind of philosophical assumptions are adopted by theoretical science, if the latter is understood in terms of the idealizational conception of science.

Assumptions

Recently, the central role of idealizations in science is admitted in various methodological approaches to science, e.g., Barr [1971, 1974], Suppe [1972a], Wojcicki [1974, 1979], Cartwright [1983, 1989], Niiniluoto [1990]; notably, the structuralist philosophy of science seems to have made an important contribution to the study of idealization and approximation [cf. e.g., Moulines 1976, Kuipers 1985, Kuokkanen 1988, Hamminga 1992, Kuokkanen and Tuomivaara 1992, Ibarra and Mormann 1994]. However different these may be, both in their philosophical ideas and methodological implications, all of them claim that the role of idealization in science is not negligible and belongs to the core of theory-formation [cf. a review of different recent approaches to idealization in Niiniluoto 1990].

According to one of these approaches which is presupposed here [cf. my 1971a-b, 1972, 1980], scientific theory is basically a deformation of phenomena. It is neither an "abbreviated record" of observables nor a body of factual hypotheses referring to unobservable phenomena that still pertain to actual objects. A scientific theory resembles much more the logical structure of a caricature than that of registration or reconstruction. Indeed, it is difficult to imagine so far-reaching a caricature as the mass-point commonly in use in physics. The crucial point for a proper understanding of idealization involved in caricature is that it differs fundamentally from the abstraction involved in registration or (factualist) reconstruction. Abstraction as the omission of properties leads from individuals, to sets of individuals and from sets of

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individuals to families of sets, etc. Idealization does not do this. The omission of the dimensions of physical bodies does not yield any set of physical bodies but the mass-point. Abstraction is generalization. Idealization is not.

From this point of view, the scientific method can be summarised as follows:

(*Idealization*) The pure ideal of a given type of phenomena is formed by depriving them of some of features, those which are considered to be secondary. What remains contains merely the principal properties of the empirical original. If some simple formulae connecting them (idealizational laws) are valid, it is for the ideal alone.

(*Essentiality*) A magnitude *A* is termed essential for a magnitude *B*, if the fact that *B* takes on arbitrary of its values excludes the fact that *A* could take on some of its values on (the set of values thus excluded is labeled the range of influence of *B* magnitude upon *A*). That *B* is more significant for *A* than *C* means that the cardinality of the range of influence of *B* upon *A* is greater than the cardinality of the range of influence of *C* upon *A*[1]. The principal factors are the magnitudes which are most significant for a given magnitude; the secondary factors are all the remaining magnitudes essential for it; the order of essential magnitudes for the given magnitude is termed its essential structure.

(*Concretization*) The ideal is concretized by gradually admitting the previously neglected secondary properties and modifying the initial formulas. The laws become more and more complicated and therefore ever closer to the empirical reality, and the body of them becomes greater in subsequent models of increasing realism. This procedure continues until the most realistic model becomes a sufficient approximation of the given system in a certain stage of its historical development. Only experience will decide whether this is the case, or not.

(*Theory*) The structure of a scientific theory *t* is thus given by a sequence of models M^k, M^{k-1}, ..., M^i, AM^i, where M^k is the most abstract model equipped with *k* idealizing conditions, M^{k-1} ...M^i being its subsequent concretizations. Finally, AM^i is an approximation of the least abstract of these models M^i to the empirical reality.

(*Testing*) An idealizational theory is tested by concretization and approximation. In the case of falsification it is not rejected but improved by continuing the process of concretization. It is finally rejected at the point where no concretization proves to be able to cover the discrepancies between the theoretical, predicted outcomes and the actual data. The data also undergo the procedure of purification which is the introduction of idealizing conditions of a certain sort in order to remove errors contained in them [Kupracz 1990].

(*Dialectical correspondence*) It might happen that an old theory is falsified by giving too great discrepancies with the empirical data. If new secondary factors responsible for the deviations of *t* from the data are discovered, then a new corrected version *t'* of the theory *t* is formed. *t'* is composed of models M^n, M^{n-1}, ..., M'^k,..., M'^i, AM'^i, where $n > k$ (the new secondary factors that have been discovered) but the formulas of the model M^k continue to appear in M^n, and the further models from M'^k onwards differ from those of *t* due to corrections introduced which account for the working of the newly discovered secondary factors. This connection between *t'* and *t* is termed the dialectical correspondence [Nowakowa 1975a-b, 1994]. It consists in correcting the initial theory as the previous view on the principal factors (the "essence") of the explained phenomena holds unchanged; what changes and becomes expressed in the new theory t' is the view of how the same essence is manifested in the phenomena.

(*Dialectical refutation*) Dialectical refutation consists in rejecting the previous view of what is principal. What changes in the new theory t'' are formulae from the initial model; the old formulae are to appear as components of the derivative models of the new theory t'' [Nowakowa 1982, Paprzycka 1990].

In summary, the presupposed view of the scientific method is that knowledge is discovered with the aid of idealization and concretization, and expressed in idealizational theories. Corrections of the theories take the form of new theories dialectically corresponding to the old ones. Refutations of the old theories take the form of new proposals dialectically refuting the former.

The above claims constitute what may be called the core of the idealizational approach to science. There are also many more special approach variants based on some derivative constructions: *ceteris paribus* [Patryas 1975a, 1982], proto-idealizing [Brzezinski 1978, 1985], stabilizing [Chwalisz 1979, Zielinska 1981], para-idealizing [Maruszewski 1983], aggregating [Lastowski 1990], normalizing [my 1991], etc. A rough outline of these may be found in my [1992].

The problem

It may be noticed that the outlined approach does not do justice to the role of philosophical assumptions in making science. The goal of this paper is, first, to make the nature of the philosophical assumptions of the idealizational theory a bit more comprehensible than it is now, and, second, to derive from that certain methodological conclusions to correct the core of the idealizational approach to science.

A conjecture

If we assume the above outlined picture of the scientific method, the question arises as to what makes a researcher distinguish particular factors as essential for a given magnitude and to stratify of a set of those factors into more and less essential ones. It is exactly at this point, I suppose, that the dominant role is played by the philosophical assumptions that the scientist adopts. Those assumptions usually do not determine some particular essentialist structures for the magnitudes investigated because they play only the role of general principles of essentialist stratification. They tell us what kinds of magnitudes are essential, or more essential than magnitudes of some other kind, to factors of such and such a kind; these are the positive rules of essentialist stratification. They also tell us what kind of magnitudes are inessential to factors of a given kind; these are the negative rules of essentialist stratification. In other words, philosophical assumptions do not fix particular essential structures for factors the researcher is considering, but fixes families of such structures.

The principles of essentialist stratification seem to be empirically testable. They are not tested directly, but indirectly by means of the verification of theories based upon those principles. On the one hand, if a theory based upon given principles of essentialist stratification is confirmed by experience, then this indirectly testifies to the truthfulness of those principles. It also testifies to the fact that factors of a given kind, that are being determined in them, actually do exert influence upon magnitudes investigated in the theory. On the other hand, a failure to build theories based upon given principles of stratification testifies indirectly against them. That is the way the development of science confirms or refutes philosophical views, never definitively, of course. Thus, for instance, a failure to build deterministic, satisfactory theories of micro-world may be interpreted as an argument against determinism. The latter can be recognized as the principle of stratification by saying that a relationship of the factors being investigated to the main factors are always of a univocal nature. In consequence, deterministic statements are to appear in the first model of a(n adequate) theory, whereas statistical ones may appear only in derivative models of it. According to this view, an adequate theory may contain statistical statements only as an expression of the technical inability to show an exact relationship of given magnitudes with all the secondary magnitudes. The principle of stratification: "all the principal factors influence physical magnitudes deterministically" has actually been put into question by the appearance of quantum mechanics which makes reference to statistical dependencies, not in derivative models, but already in the basic models of physical reality.

Apart from determining what may be counted as principal magnitudes for the explained domain, it is a matter of ontological assumptions of science to determine the universe on which all the magnitudes are defined. According to the classical approach [e.g., Hempel 1960, Ajdukiewicz 1965], a magnitude is a family of classes of abstraction determined by the given equivalence defined on a certain universe. The question arises, then, as to what kind of objects are to constitute the universe of a given theory. It is the presupposed ontology which defines it. In trivial cases, the universe of discourse of a given theory is taken from natural language, that is, from the current ontology that is presupposed already by the language we normally employ; usually, it is the standard substantivist ontology of things and properties. Sometimes, however, scientific theories presuppose non-standard ontologies.

An idealizational theory presupposing principles of ontological conceptualization and essential stratication is said to be based upon the ontological frame. The conjecture that I would like to put forward is the following: the role of philosophy for the special sciences is to provide theories built in those sciences with ontological frames. If this conjecture were correct, philosophy would indirectly determine the structure of empirical theories, or, at least, fundamental theories presupposed by all the more specific theories. It might account for the fact that great researchers are always interested in the philosophical background of their solutions as well as often referring to particular philosophical traditions.

Let me add one reservation here. I do not claim that it is the whole task of philosophy to establish the principles of essentialist stratification for the special sciences. I am not discussing the subject of what philosophy is actually doing at all.

What I suppose is only that whatever philosophy is dealing with, there are profits for the special sciences from its activity as they derive the principles of ontological conceptualization and essentialist stratification from it.

An illustration

At this point I would like to show that some arguments supporting the above conjecture can be found in the assumptions of Noam Chomsky's linguistic theory.

It is structuralist distributivism in the linguistic theory which is both philosophically and theoretically criticized by Chomsky. For the main representative of the theory, Z.S. Harris, the initial subject of the linguistic enquiry is a concrete utterance, an idiolect and the initial linquistic operation is a segmentation of the idiolect into silmutaneous and successive fragments, independent of one another within this utterance[2]. The main theoretical method of linguistics are the observation of the idiolect and inductive generalization of the results.

Chomsky maintains that observation, classification and induction are unable to separate the factors significant for the linguist and therefore they cannot serve properly as a means to build a genuine linguistic theory. Traditional linguistics is associated with a methodological conception according to which genuine linguistic science must only be of the character of a pre-Darwinian taxonomy dealing with the collection and classification of innumerable specimen, i.e. linguistic acts. Meanwhile, Chomsky goes on to say, these acts are performed under the influence of countless factors. If the factors are not differentiated, then one can achieve what is actually provided by the taxonomical theory of language: descriptions of innumerable acts of the usage of language (which not always is correct). The description of language as a set of "linguistic habits" or as "a set of actual dispositions to linguistic behaviour" (Quine) is incorrect. The competence in one's language, Chomsky claims, does not express itself indirectly in habits and linguistic dispositions and, obviously, people speaking the same language can differ considerably in dispositions towards the verbal reply, depending upon their personalities, beliefs and other countless extralinguistic factors [1966, p.30, note 2].

Thus we can see what Chomsky reproaches taxonomists for simply describing what can be observed in linguistic behaviour. Instead, they should be distinguishing the principal factors, neglecting all the secondary ones and building a theory that would enable us to understand how language is dependent upon principal factors alone. The linguistic competence of a subject is a factor that is claimed by Chomsky principal for linguistic performance. The problem of a linguistic theory is to examine general properties of any system of rules which can serve as the basis for human language, that is to say, which is assumed *a priori* in each possible realization of any particular natural language. Obviously, not only linguistic competence decides which linguistic activities are actually being realized. It is only in ideal conditions, Chomsky continues to say, that performance of an act is a direct reflection of competence. A registered fragment of natural speech will manifest numerable gaps, deviations from rules, shifts of the aim planned etc. The task of the linguistic theory is to provide a characterization of the correct (ideal) linguistic activity undertaken under the influence of the competence of a speaker and in the absence of all the remaining factors [1968, p.10]. Hence the description provided by grammar is not to be confused with the description of an actually potential performance. The very usage of language comprises the complicated mutual influence of many incompatible factors, grammatical processes being merely one of them [1965, p.4]. The linguistic theory is to refer to the ideal speaker-receiver in an entirely homogeneous language community who knows perfectly his/her language and who is not at all affected by grammatically insignificant circumstances [Chomsky 1965, p.3]. If we abstract from all these secondary circumstances, we are in a position to reconstruct the ideal speaker-receiver's language competence. However, this is only the starting point of it. Having reconstructed the competence of the ideal user of language, the linguistic theory has to explain the actual language performance.

As can be seen, Chomsky assumes an essential structure for the process of language acquisition in which as the main factor is termed linguistic competence and all other factors *de facto* influencing the usage of language are secondary ones. We might ask why linguistic competence has been put forward as a fundamental determinant of the usage of language rather than, for instance, dispositions to particular verbal reactions to particular impulses? It is in Chomsky's philosophical conceptions that an answer to that question can be found. He is a firm adversary of positivistic empiricism and makes a recourse to the rationalistic tradition of the 17th century because this tradition contains the idea of the priority of the inner knowledge of language compared with observables of linguistic usage.

Chomsky's linguistical approach can be summarised by saying that his rationalism constitutes the ontological frame for his linguistic theory. Let us now consider his theory in itself.

Chomsky's theory is based upon at least the following idealizing assumptions:

(*a*) the speaker-receiver forms sentences of its simpler components alone,
(*aa*) the speaker-receiver does not impose the phonetic shape upon his/her grammatical creatures.

Strictly speaking, these are quasi-idealizing assumptions as the part of sentences formulated in the normal communication process do satisfy conditions (*a*)-(*aa*) [cf. Chomsky, Miller 1963, p.299].

Under these assumptions the basic domain of Chomsky's theory is a structure:

$$G^g = (V, c, \text{-->}, V^T, S, \#)$$

where

1. V is a finite set of symbols (vocabulary); sequences of symbols of V are formed by the relation of concatenation c.
2. V^T is the final vocabulary; the complement of V^T to V is the auxiliary vocabulary marked as V^N.

3. --> is a two-argument, anti-reflexive and anti-symmetric relation defined on seqences built of members of V; it is read "is rewritten as"; a pair (R, r) such that R --> r is termed a grammatical rule of the grammar G^g.
4. If $A \in V$, then $A \in V^N$ iff there exist sequences R, r, q such that RAr --> Rqr.
5. $\# \in V^T$, $S \in V^N$, $e \in V^T$; # is a limiting symbol that serves to mark the beginning and the end of expressions; S is an initial symbol read as "sentence"; e is the identity symbol such that $eR = R = Re$, for every R.

G^g assigns to each sentence a structural description which determines the elements of which the sentence is composed, their order, organization and mutual connections [Chomsky, Miller 1963, p. 285].

The basic grammar G^g does not suffice to reconstruct the full linguistic competence. Some sentences such as those in the passive form, questions etc. cannot be naturally and economically generated by this grammer, but they are systematically connected with the sentences of a simpler form. The rules of transformation express connections between simple sentences and more complex ones already generated within the grammar G^g .

In other words, in order to pass to a more realistic approach, the condition (*a*) is removed and a more comprehensive grammar (termed transformational) is put forward:

$$G^{g\text{-}t} = (V,\ c,\ \text{-->},\ V^T,\ S,\ \#,\ F^M,\ \text{==>},\ K)$$

where:

0. The first six symbols have the same meaning as explained above.
1. F^M is the set of phrase-markers univocally attached to each sequence of V^T.
2. ==> is a relation whose domain is the Cartesian product over F^M and its counter-domain is F^M itself; n 1-tuple $(a^1 \cdots a^n, a^s)$ of elements of the set F^M such that $(a^1 \cdots a^n)$ ==> a^s is termed a grammatical transformation.
3. K is the sum of V^T and K^T; $x \in K^T$ iff there is $a \in F^M$ univocally attached to x.

Neither the generative nor generative-transformative grammars explain how the spoken language is possible, that is, how the syntactic structures take the forms of speech. In other words, the simplification (*aa*) must be removed and the grammar expanded to contain the syntactical and phonetical components. The latter does not play any role in forming new sentences but merely attaches to them an appropriate phonetic shape [Chomsky, Miller 1963, p. 306]. Therefore, the generative-transformative-phonetical grammar may be expressed by the system:

$$G^{g\text{-}t\text{-}ph} = (V,\ c,\ \text{-->},\ V^T,\ S,\ \#,\ F^M,\ \text{==>},\ K,\ D,\ \equiv\equiv\equiv>)$$

where:

0. The first nine symbols have the meaning explained above.
1. D is a set of acoustic symbols defined in physical terms.
2. $\equiv\equiv\equiv>$ is a two-argument relation whose domain is the set K and the counter-domain is the set D; a pair (R, r), such that $R \equiv\equiv\equiv> r$ ($R \in K$ and $r \in D$) will be termed a phonetical rule.

As can be seen, it is a more compound scheme than the previous one and it resembles more real languages. It is, obviously, an ideal type of natural language, although a more realistic one than the previous two. What is omitted here, though, is the semantic aspect of language about which in Chomsky's view little can be said at the moment. What is also omitted are circumstances disturbing processes of normal linguistic communication. Nevertheless, it can be thought that the sequence of grammars G^{g}, $G^{g\text{-}t}$, $G^{g\text{-}t\text{-}ph}$ is an ever more realistic approach to the language phenomena. One may thus conjecture that the sequence of models of the generative, generative-transformative and generative-transformative-phonological grammars constitute an idealizational theory of natural language.

If so, then one may claim that linguistics, like physics, theoretical biology, theoretical economics etc. applies the method of idealization. Descriptive work in this domain plays the same role as in physics or economics: it collects the material for theoretical explanation by, and for the testing of, idealizational theories.

Some applications

I shall now discuss the changes in the idealizational approach to science that seem to follow from the ideas outlined in this paper.

An idealizational theory may be accepted either realistically or instrumentally. It is accepted realistically on the condition that apart from the theory itself its ontological frame also is accepted. The theory is accepted instrumentally, if it is not.

It follows that to understand a phenomenon and to explain it is not the same thing. To explain a phenomenon means, in the idealizational approach, to refer to such an idealizational law (being an element of the initial model of the accepted theory) from which the empirical description of the phenomenon can be obtained via concretization. In other words, to explain the given empirical phenomenon means to establish a chain of concretizations whose first element belongs to the initial model of the accepted theory, the second element belongs to the second model of the theory, etc, until a(n approximate) description of the phenomenon is reached. The theory which is the basis of the explanation may be thus accepted either realistically or instrumentally. To understand a fact means to explain it with the aid of the realistically accepted theory. In other words, explanation presupposes merely the acceptance of the appropriate theory, understanding presupposes the acceptance of both the theory and its ontological frame.

The problem of how science evolves has been already analyzed in the idealizational approach to the effect that its history falls under the following scheme [cf. Nowakowa 1975a-b, 1994, my 1980, Chap.13]:

(*) *d-cor...d-cor* **d-ref** *d-cor ...*

That is, each theory is first corrected and only then, if the modifications do not remove the persistent deviations from experience, it is replaced by a new theory, dialectically refuting the old one, and the new theory is again modified until the new theory dialectically refutes it, etc. The point is, however, that this picture does not take into account the philosophical framework of all the theories involved. And this is of some importance to it.

Let us call all the theories of a given domain that are based upon one and the same ontological frame a theoretical orientation. Within a theoretical orientation the philosophically-grounded differences between subsequent theories may be omitted as all of them presuppose the same principles of ontological conceptualization and essentialist stratification. Therefore, within one and the same theoretical orientation the scheme (*) can be kept. Let us, however, admit that more than one theoretical orientation appears. For simplicity's sake, it is assumed that theoretical orientations do not appear in paralell.

A new theory which belongs to a new theoretical orientation possesses an ontological frame which is different from the one that the old theory is based upon. Therefore, the theories differ not with respect to the repertory of essential factors of a given type but with respect to the type of essential factors and/or with respect to the universe of objects their variables range over. In consequence, no dialectical refutation, not to mention the relation of dialectical correspondence, can hold between these two theories. An ontologically innovative theory *t'* may stand to its predecessor *t* from the old theoretical orientation in a much weaker relation: *t'* explains all the empirical facts which are explained by *t*, but not the reverse; *t'* is then termed empirically stronger than *t*. Notice that this notion complies with the standard formulations of the principle of correspondence of the physicists themselves[3]. Notice also that although the body of empirical knowledge explained by the most sophisticated theory of the old theoretical orientation may be explained on the ground of theories belonging to the new orientation as well, the old explanation cannot be understood in terms of the new theoretical orientation.

Now, in the case considered the image (*) of the development of science is transformed into the following one:

(*') *d-cor...d-cor* **d-ref** *d-cor ...d-cor* **E-STR** *d-cor...d-cor* **d-ref** *d-cor* ...

That is, within a given theoretical orientation each theory is first corrected and only then, if the modifications do not remove the persistent deviations from experience, it is replaced by a new theory, dialectically refuting the old one. Then the new theory is again modified, etc. If the deviations from the experience, in spite of inner changes of the given theoretical orientation, persistently remain, a new theoretical orientation appears generating a theory which proves to be empirically stronger than the most sophisticated theory of the old orientation; and the theories in the new orientation undergo the same scheme of development (*); etc.

On the one hand, the notions of dialectical correspondence and/or refutation imply the comparability of the methodological structure of the theories involved. On the other hand, if one theory is empirically stronger than another, the lack of conceptual comparability (i.e. incommensurability in Kuhn's sense) seems to be admitted. Accordingly, one could say that theories from one and the same theoretical orientations are "commensurable" whereas those from different orientations are "incommensurable". Even if such a paraphrase were admissible, the consequences that follow differ from those attached to the Kuhnian philosophy of science.

First and foremost, the fact that some theories are "incommensurable" does not exclude that they may be methodologically compared in relation to a third instance, e.g. empirical knowledge. One theory may presuppose, e.g., substantivist ontology, the other may be based on eventist ontology but still one can be said to cope better with the empirical data (paraphrased either substantivistically or eventistically) than the other. That is, one of them may prove to be empirically stronger than the other.

Moreover, one should distinguish two types of scientific revolutions: those of the first type take place within a given theoretical orientation and consist in dialectical refutations of the old theories and those of the second type are connected with a change of theoretical orientations. Only revolutions of the second type may involve "incommensurability". And they are less common than Kuhn claims they are. For instance, the special theory of relativity seems to presuppose the same ontological frame as classical mechanics. Hence they both belong to one and the same "classical" orientation which differs from the orientation opened by quantum mechanics.

If the picture outlined above is correct, then one of the most embarassing properties of philosophy, viz. its discouraging undecidability, becomes perhaps more comprehensive. First of all, it is of cognitive importance for science that there is such a domain of thinking which in advance elaborates ontological frames to be filled in on appropriate occasions in science itself. Since nobody can say in advance which ontological frame will be of use for future theories, the optimal strategy is easily imaginable: to multiply as many ontological frames as possible. And that strategy is applied in philosophy. It is of cognitive advantage for science, then, that there is a domain which is not oriented towards the reduction of the number of conceptions at work, as science itself is, but is oriented towards the multiplication of them. Whether philosophy is science or not is a matter of terminological convention. That philosophy as it is known in our culture, including its undecidability, is indispensable for science is a matter of fact.

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Notes

[1] This is a changed formulation of my (1987) definition. I owe some improvements to the criticisms of Kuokkanen and Tuomivaara (1992) and to Paprzycki and Paprzycka (1992).

[2] What follows is an interpretation of Harris's distributivism which is presented in more detail in Kmita and Nowak (1968), pp.186*ff*.

[3] It is the idea of Kemeny and Oppenheim (1956) to define the relation of correspondence with the aid of the notion of the empirical strength of a theory. Nowakowa (1975a, 1994) argues that the principle of correspondence based on this notion does not generally work in the history of science. However, in a more limited form it may be of some use.