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KUHN'S ASSUMPTIONS CONCERNING THE MEANING OF SCIENTIFIC THEORIES

Tihamér MARGITAY

Department of Philosophy
Technical University of Budapest
H–1521 Budapest, Hungary
Phone: + 36 1 463 2156
E-mail: Margitay@tttk2.tttk.bme.hu

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Abstract

In the following paper I will analyse two of Kuhn's assumptions which lay behind his semantical theory leading to the famous meaning-variance thesis. By criticising these two assumptions I will try to show the inadequacy of his semantics thereby attacking the foundations of the problem of meaning-variance.

Keywords: Kuhn, semantics, scientific theories, meaning-variance, incommensurability.

Kuhn's famous meaning incommensurability thesis rests on two interrelated assumptions: a semantical and a pragmatical one. The second backs up the first. As to the first one, the radical meaning variance springs from that the reference of a scientific term is determined by the claims the theory makes about it. Thus when the theory changes so does the meaning, i.e. the reference of its terms. To render this reasoning persuasive, it must be assumed that the theory consists of a pretty well-defined and fairly stable set of claims which determines the meaning of their terms and the change in the theory is marked by the change in this set of claims. One part of my argument will aim to blur the boundaries. I will deny the existence of the meaning of scientific terms determined by a clear-cut set of claims (i.e. by a clear-cut theory). We come across the variety of the presentations of a theory each of which constitutes a meaningful unit for its audience while different presentations consist of highly different sets of claims.

But this argument needs a pragmatical foundation: the relevance of different audiences to the meaning of scientific terms must be shown. This will be done in an argument which attacks Kuhn's second, pragmatic assumption. Kuhn in his theory of meaning proceeds from a use theory. It is the use of a language community which determines the meaning of the words which, in turn, can be described by a semantical theory as it was sketched above. But what community should we observe when we want to describe the meaning of scientific terms? At this point Kuhn, I think, makes an untenable idealization. He assumes, namely, the homogeneity of the scientific community. It will be shown that numerous and highly different social groups use a theory in significantly different ways, and for them substantially different sets of claims constitute the theory.

This reasoning is intended to show that users of a theory do not and cannot share a unique set of beliefs the change of which could result in an all-or-nothing change in the meaning of scientific terms. But on the top of all this, as my final pragmatical argument will point out, even those scientists who may be said to believe more or less the same, use theories in a way that excludes the Kuhnian semantical assumption that the reference of scientific terms is determined by what the theory says about them. My two minor case studies will include an educational example and the problem of identification of particles in an accelerator. If the *use theory* is taken seriously, and we have a closer look at how scientists use theories then the semantical theory on which the meaning incommensurability thesis rests cannot be adequate.

Let us begin with the pragmatical problems as they underlie the semantical ones.

What is to be Studied?

When we come to the question what we should study if we want to study the meaning of theories, explicit answers are rarely given. Three implicit answers seem to me most prevailing among philosophers. First, philosophers tend to view a theory as a mental representation of a particular chunk of the world. The representation has defined and identifiable semantic contents. So when we would like to study the meaning of a theory we need to see what scientists typically have in mind: a standard world-view. The second type of implicit assumption is that there is some paradigmatic version of a theory which comes out of the research process and which can be made available as a standard presentation of the theory. From our purpose, this second is similar to the first without the mentalistic ballast of the first. Both of these two answers assume a reconstructive step. For clearly, no two scientists have exactly the same mental representation, and there is no single presentation of the theory proclaimed to be the paradigmatic version.[1] This being the case, we have to resort to versions of a theory in order to reconstruct the paradigmatic version. But then we should not start the analysis of meaning with the paradigmatic version, but rather with the

[1]Even if there were identical representations in scientists' mind and even if there were an authorized publication including the theory, the task would be there to isolate within the content of the scientists' mind or within the publication what exactly is the theory and what is already not.

versions from which the standard version is to be reconstructed. The third type of implicit answer to the question concerning the evidential basis of the analysis of the meaning of theories is that the 'original contribution' to the research progress is the authentic version of a theory. It is hard to see how to single out those works that contain 'original contribution' to the progress of research, and how this idea could help us to find the subject of inquiry. What presentations should be studied? For instance, in order to study the special theory of relativity as an 'original contribution' shall we study EINSTEIN (1905) or its today's version in a distinguished textbook or perhaps Einstein's highly influential little popular book[2]. They all promote the research progress, they are all different, novel, and original, but only the first would qualify as 'original contribution' on the basis of some retrospective commonsensical value judgement. If we are not willing to take the risk of being led astray by some unfounded value judgement, then we need to consider *all* sorts of meaningful presentations of a theory.

The adequate theory of meaning should account for the meaningful presentations as they appear in scientific discourse, namely, for those when the theory is presented in articles, conference papers, experimental reports, monographs, university and high school textbooks, popular science books, in historical overviews, applications for research grants, expertise for politicians and R&D managers, etc. Each of these presentations is a meaningful version of a particular theory but consisting of different claims. How could it be determined which of the claims define the reference of the terms? Perhaps we could assume that the presentations are different but the background knowledge, the claims in the readers' mind are the same. But this is not the case – at least this will be argued below.

Theories in Contexts

Philosophers who have drawn sociological aspects into philosophy of science and epistemology insist that scientific research is integrated into the social structure which bears not only on the scientific activity, but also on the outcome of that activity, namely on scientific knowledge.[3] According to this view, we should say that theories provide us with knowledge in a social context and they play their cognitive roles in a social context, too. This brings us to an external view-point. Scientific research is embedded in a broader social and cultural framework. Other social activities and cultural products initiate, support and interact with a particular scientific research. A particular scientific theory emerges as a result of this

[2] EINSTEIN (1916).

[3] See MANNHEIM (1929), KUHN (1970), BLOOR (1976), BARNES and BLOOR (1982)

research. Kuhn argued convincingly that the *cognitive value*, the *knowledge claims* of a theory so developed should be assessed in the light of all these interactions. But his conception of theories still remains internal in a sense. He wants to understand scientific theories, and hence, the semantics of scientific theories from an internal analysis of a particular scientific research community and their activity. He persists in seeing theories as means to the cognitive ends of that community adding only that a theory has an extra sociological role to organize the particular research community and activity.[4] What a theory means is thought by the Weltanschauung approach (as well as by the formalists), to be given independent of how the rest of the world is and in what other social or cultural contexts the theory is used *outside the particular research* group developing that theory. Everything that is necessary to understand the theory, and not involved in the presentation is carried by the scientific community's world-view (the research community's metaphysical assumptions, epistemological values, methodological prescriptions, etc.). The assumption is that it is enough to observe the research group working on a particular field – the group on its own – it is enough to study what they do and believe in order to understand their theories and in order to see what their theories mean. This assumption should be reconsidered if externalism is taken seriously. For, clearly, science is not a self-contained and self-sustaining cultural enterprise. Theories appear in various social and cultural contexts.

Kuhn has strong implicit assumptions also concerning this research community in normal science. He assumes the identity of the metaphysical assumptions, the homogeneity of the methods and values of the research community. He also supposes that this community uses the paradigmatical theory exactly in the same sense and the meaning of this theory derives only from this unanimous use. In other words, he assumes an ideally homogeneous group as to the world-view of the members of this group and as to the use of a particular theory. These are clearly untenable idealizations as far as the analysis of meaning is concerned. It is easy to find quantum physicists with the diversity of metaphysical assumptions. Some of them are formalists , others adopt a sort of Coppenhagian view and yet others entertain some sorts of Wignerian thoughts.[5]

Even if we were lucky to select an ideal homogeneous group of the 'top ten' theoretical physicists working in the same and restricted field, we should bear in mind that not only they develop the theory, not only they use

[4]Needless to say that formalists are also internalists, but usually in a far stronger sense of the word.

[5]I venture that the diversity of the metaphysical background is not a XXth century phenomenon. Imagine XVIIIth century physicists, one infected with Newton's metaphysics, another educated in Leibniz's metaphysics. etc..

it, and they do not only use it to discuss it among themselves. For example, they have to teach the theory to the next generation of 'top ten' physicists. Teaching has its own peculiar cognitive aims, values and methods, and what is also important, teaching of a particular theory has its own didactic exemplars and applications. The meaning of the terms of a theory in a high school or university textbook differs from the meaning of that theory found in a state-of-the-art report published, e.g. in the Physics Review Letters, if reference is determined by the claims that were made. The two kinds of presentations are clearly different kinds of interpretation of the same theory involving different claims and relying on different background knowledges (i.e. background statements) on the part of their intended readers.

The meaning of theories can only be analysed, I think, in terms of the whole social context of their use and of their cultural interactions, rather than in a parochial way within an unwarrantedly isolated, self-contained, and self-sustaining scientific discourse. Many different and highly inhomogeneous social groups use a theory, influence its development and contribute to it. Such variety of uses brings theories into various connections with other theories and with various social activities. These social activities have different cognitive aims, methods, they are governed by different cognitive values, and they apply a theory variously by virtue of different background knowledges. It is hard to see, how could there be a set of claims (beliefs) which is in charge to determine the reference of terms and which is (and must be) common to all who deal with the theory.

The Simultaneous Use of Incompatible Theories

First, consider an experiment. An experiment needs a cluster of assumptions about how the idealized system of the theory is influenced by factors neglected by the theory at issue. These factors are taken into consideration by other theories (perhaps, by *ceteris paribus* assumptions). In order to apply a theory in an experiment subsidiary theories are necessary controlling the experimental devices, supplying the data, etc.[6] These theories add to the description of the same objects, properties. That is to say these subsidiary theories characterize the same system that is described by the theory at issue.

Think, for example, of a scattering experiment. The motion of a particle beam in the accelerator is described by the classical relativistic (or Newtonian) dynamics and Maxwell's theory.[7] Then these particles reach the target and scatter on it. The scattering, however, is described by quantum mechanics.

Both at the end of the acceleration process and at the 'beginning' of the scattering, the experimentalist has to identify a particular physical system, which, imagine for the sake of simplicity, consists of one particle with certain quantities. A purely semantical problem arises: what is the reference of the terms of the two theories and how the experimentalist identifies them. At the end of the acceleration she will have a particle which is a classical object with certain classical quantities, for she identified it as a model of a classical theory (relativistic electrodynamics). As the particle hits the target, she identifies the particle of the scattering as a quantum object with quantized quantities, as a model of a quantum theory.

The whole experiment is senseless if the particles accelerated classically are not the same as the particles interacting quantum mechanically, if the momentum generated classically is not the same as the initial state of the particle interacting quantum mechanically, etc. The (interpreted) classical formulae should supply exactly the initial state of the interacting particles. The output of the classical formulae should be exactly the input of the quantum formulae. The same particle and the same physical properties are, on one occasion, described by a classical theory (relativistic electrodynamics) then, on another occasion, by the quantum theory. The theory of relativistic electrodynamics refers to the physical system which is the same as the one quantum theory refers to. Obviously, the assumption underlying the experiment is that there is one system described by two different theories in different stages of the process. If the difference in the theories

[6] Cf SUPPES (1962).

[7] See SIMONYI (1978).

brought about difference in the meaning of the terms, i.e. difference in the reference of these terms, then it would be impossible to carry out observations of objects and perform measurements of the measured parameters on the basis of another theory. This would entail that it would be impossible to relate a theory to the data produced by other theories consisting of *incompatible* claims.

This example is remarkable for two reasons. The two theories, the relativistic electrodynamics and the quantum theory, respectively, have no common model in logical sense, they are logically incompatible. Still the classical relativistic electrodynamics interprets the quantum theory, by means of the model (physical system) which has the specified parameters. The other remarkable feature of this example is that we believe that there is a solid physical system which satisfies the description supplied by the two theories, but there exists no satisfactory independent description of that physical system. The physical system, the reference can be identified only by means of the theories at issue.[8] There is no third, neutral description to determine the reference for both theories, and the two descriptions, the two theories are incompatible. Still their references are compatible, in fact, they are regarded to be identical.

Semantically this means that the reference of terms of the two theories cannot be identified only by the descriptions given by the theories.

Notice that the Ehrenfest theorems or any other approximative relation between the classical theories and the quantum theory is not even mentioned. Nor could it be. Imagine an acceleration process in a synchrocyclotron. The frequency of the accelerating voltage is modulated to take into account the increase of the relativistic mass of the particle as it reaches high energies. The control of the process of accelerating a particle into the relativistic domain derives from considerations about the position and path of the particle and the change of its momentum during the process. (SIMONYI (1978), pp. 113–118.) This picture of the synchrocyclotron–particle system is irremediably classical.

Opponents could claim that the classical system is just an approximation of the quantum mechanical system. It is an approximation only in a very weak sense. There is no quantum mechanical model of the system to which the approximation could be compared. It is an approximation only

[8] This is really important here. The identification of the reference in this example would be difficult for a Kripke-Putnam type causal theory. For in this case, unlike in our second example (see below), there is no 'direct' ostension, observation, manipulation, etc. by which the particles in the tunnel can be followed. Also the causal connection between the experimentalist and the objects can only be created by virtue of the classical theory. The existence of the causal link depends on the successful identification of the particle by the classical theory.

to the effect that the quantum mechanical effects can be ignored for particles 'sufficiently' separated if the interaction with their own field is weak, etc. But the answers to the question whether the particles are indeed 'sufficiently' separated, etc. ultimately come from the fact that the accelerator works by virtue of the classical description. The proper legitimacy of the approximation should rest on the accurate theory and the theory of approximation, i.e. on the relation of the accurate theory to the approximative theory. This needs that the system be described by the two theories. In contrast, the approximation in our case works on the other way round. The system is not identified by a quantum model plus a model of approximation but it is identified with the help of the descriptive content of the classical theories. At most, the existence of the particular model of approximation is postulated on the basis of the efficiency of the device, the classical description of the system, and the postulate concerning the sameness of the physical system. If opponents manage to manufacture a theory of approximation which, augmented with a quantum theoretical model, would identify the reference, well then I would increase the complexity of the system (by including, say, the power plant) until it cannot be accounted for in terms of quantum and approximation theory. By this trick we always will reach a point where the legitimacy of the approximation will rest on the assumption about the identity of the system despite of the two different descriptions.[9]

The idea may come to mind that the common, theory-independent description may be an informal one which interprets both formal theories, relativistic electrodynamics and the quantum theory. This informal description consists in the informal description of the experimental setup.[10] But this informal description of the particle is far not enough to identify the object in the accelerator. The informal description on its own does not supply the identifying information of the reference for the terms of quantum theory. The references of the terms of quantum theory, the input, cannot be identified without the descriptive content of the theory of relativistic electrodynamics.

The experimentalist says that the particle was accelerated in such and such a way and the particle scattered on the target in such and such a way. It is the reference of the 'particle' which remains constant and which links the 'particle-in-relativistic-electrodynamics' and the 'particle-in-quantum-theory'. Thus the experimentalist applies the incompatible theories to the common physical system.

[9] In this argument I did not make use of the macro apparatus – micro system duality which may supply further theoretical support (beyond the pragmatical point I made here) for alternative and incompatible descriptions of the very same physical system.

[10] Something like this: a particle is flying in the tunnel of the accelerator while its velocity is increasing due to the right timing of the change of electromagnetic field, etc.

To be sure a Kuhnian philosopher of science is ready with the objection that our experimentalist was, all the time, thinking of the quantum world and she approximately identified the quantum particle as a classical one. But the question is unfortunately not that what she is thinking of, rather how she identifies it. Let alone the formidable conceptual problem of the 'approximative identification' of an individual, this move does not work for the following reason. What the Kuhnian opponent claims is that the experimentalist did not identify the quantum particle but something near to it. Nevertheless, she puts the quantities she determined on the basis of the classical theory into the quantum-theoretical equations because she can do nothing else. Saying that *this* is the particle, but *this* is not *the real one* does not identify the real one. She equates the reference of the terms of the classical theory with the reference of the terms of the quantum theory. She may have a quantum particle in mind, but she does 'put' a classical one into the quantum equations. The system she identifies during the acceleration process is a classical one. She is causally linked with the particle described as a classical particle and the causal link is also controlled by, and judged according to classical effects.

My example was not extreme, the list of the interpretations of similar kind is endless. In experiments, scientists wish to control the experimental device and they pay less attention to secure the formally clear semantical links between the theories. Chemists first identify the mass of a component of a reaction by means of an equal arm balance based on Newtonian statics, then they claim that the mass so determined is the mass the substance has in some theory of chemical reactions. (The theory of the chemical reaction may be a quantum chemical theory, too.) They check very rarely, if at all, whether the two descriptions of mass supplied by the two theories, are logically compatible. What guarantees their semantic compatibility without logical compatibility is that they are interpreted by the same informal terms referring to the same physical properties of the same substance. Here of course they have direct recourse to the causal and pretheoretical determination of the reference. This brings us to our second example for the interpretation of different theories by the same interpreting theory.

Secondly, take an educational example. EINSTEIN's (1921) famous On the *Special and General Theory of Relativity* and most of the introductory books to the Theory of Relativity use the example of a train (rocket or some other vehicles) with passengers (observers) on it and people (observers) standing outside of it pitching balls (firing bullets, sending sound signals, etc.) and sending light signals to each other.[11]The example of this system has a double function. It introduces both the Galilean and the Ein-

[11]E.g. NORWOOD (1981), TAYLOR & WHEELER (1966).

steinian Principle of Relativity. In the first case the train, the balls, and the light signals are described as Newtonian particles while in the second case, they are described as relativistic particles. The contrast between the two relativity principles is made on the basis of the distinct results supplied by the distinct descriptions of the same system. This can happen only if the train–ball–light signal system interpreting the two theories remains the same on the occasion of the interpretations of the two theories. The identification of the train–ball–light signal system does not require either of the theories. If it did, it would be an inapt example from a didactic point of view. Clearly the descriptions provided by the Newtonian particle theory and the theory of relativity are semantically negligible with respect to the identification of the train–ball–light signal system. It is a pretheoretical system. Fixed by the everyday description, the train–ball–light signal system is firm in place to help the apprentice to break into the Newtonian theory, then, by returning to the same system she can jump into relativity theory. It is to be underscored that she can return to the same everyday train–ball–light signal system which is the springboard for both theories.

The two sets of interpreted systems, the set of the train–ball–light signal-as-Newtonian-systems and the set of the train–ball–light signal-as-relativistic-systems are disjoint. In other words, the Newtonian theory interpreted by the informal description of the train–ball–light signal system is incompatible with the relativity theory which is interpreted by the same informally described system. The common informal descriptions are to secure the fulfilment of the hidden ontological commitment. After all there is only one physical system consisting of a train, a ball and some light signals. We did not double the system just because we used this physical system to interpret two different theories. These theories provide only alternative descriptions of one and the same physical system.

These two examples show that physicists feel relaxed to use different sets of claims to identify one and the same system. Therefore, a semantical theory that is to be consistent with this practice, cannot assume that the difference in the sets of claims, i.e. the difference in theory results in the difference of the reference of their terms.

Meaning-Variance

A pragmatic objection which is usually brought up against Kuhn's meaning variance thesis is that scientists believing different theories live in the same world in their everyday life so the semantical content of their language cannot be completely different from each other to block understanding. This position justly (though not profoundly enough) emphasises, on the one hand, that Kuhn ignores the everyday world when he makes his claim – however metaphorical it is – that scientists accepting different paradigmatic theories live in different worlds. On the other hand, this critique does not really threaten Kuhn's position. Because he may reply that he has described how scientists do research and this description does not make recourse to anything outside the world of the paradigmatic theory. To make the critique more cogent we need to show that Kuhn's description is incomplete and makes use of unwarranted idealizations. The researchers' world somehow rests on, intimately linked up with, and partly determined by the world outside the paradigmatic theory. Therefore, the semantical content and the use of scientific theories (paradigmatic theory included) cannot be understood from 'inside' in isolation from the wider social context of research. In addition, it is an unwarranted idealization that users of a theory form a homogeneous group. The pragmatic cluster of my arguments against the meaning variance thesis relies on a socially contextualized view of scientific theories.

If we notice the variety of incompatible theories which are used synchronically, and if theories are seen as used by many different people knowing different theories and methodologies, believing in different metaphysical assumptions, then a theory cannot be seen as a nice homogeneous world-view. The smooth communications between scientists knowing different theories and methodologies, believing in different ontologies indicate that a particular theory alone cannot be credited with the responsibility to determine the meaning of its terms.

I think one of the roots of the meaning-variance problem is that historically oriented philosophers applied different measures. They emphasised the difference between the views of scientists of the consecutive historical periods, while underestimated the differences of the contemporary social groups who collaborate on doing normal science.

Historians are also users of theories. Advocates of radical meaning-variance tend to forget about this fact. For example, Kuhn gives an account of why scientists accepting two different paradigmatic theories cannot understand each other, while Kuhn tacitly assumes that he can understand scientists of both paradigms. Kuhn and Feyerabend claim that they understand Aristotle's physics in historical context while deprive people accepting the Newtonian paradigm of the capability of understanding Aristotelian physics. They have nothing to say what is miraculous about historians or philosophers compared to scientists.

They fail to notice that their own historical arguments rest on the precondition that they, namely historians can understand scientists of different paradigm. Kuhn admits that he as a historian can understand former scientists, and it should be emphasised, he does it on the basis of texts, by semantical means. He cannot, say, observe the ancients life, at least primarily not such observations give him the data to understand Aristotle. A historian goes on with mainly linguistic evidence (books, inscriptions) much more so than we do when understanding our contemporaries. A historian's understanding involves the understanding of theories, values, metaphysical commitments and the exemplars of scientists working in various paradigm. By virtue of such understanding they intend to show that two scientists accepting different paradigms do not succeed in understanding each other.

In sum, if scientific theories are seen in their complex social use, then it should be clear that the change in meaning caused by the change in a theory cannot be so radical and threatening as advocates of the thesis of meaning-variance maintain. Theories may not have a semantics which endorses such radical changes.

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