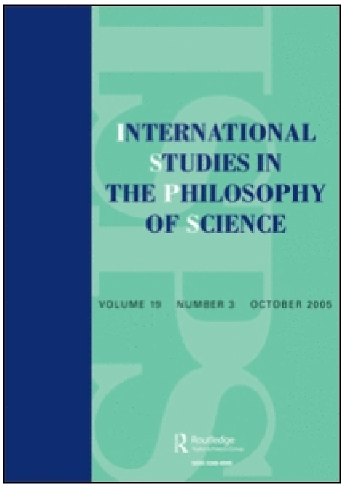

International Studies in the Philosophy of Science
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713427740

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Online Publication Date: 01 October 2009

To cite this Article Arun Murthi, S. K. and Sarukkai, Sundar(2009)'Multisemiosis and Incommensurability',International Studies in the Philosophy of Science,23:3,297 — 311

To link to this Article: DOI: 10.1080/02698590903197773

URL: http://dx.doi.org/10.1080/02698590903197773

International Studies in the Philosophy of Science
Vol. 23, No. 3, October 2009, pp. 297–311

Multisemiosis and Incommensurability

S. K. Arun Murthi and Sundar Sarukkai

Central to Kuhn's notion of incommensurability are the ideas of meaning variance and lexicon, and the impossibility of translation of terms across different theories. Such a notion of incommensurability is based on a particular understanding of what a scientific language is. In this paper we first attempt to understand this notion of scientific language in the context of incommensurability. We consider the consequences of the essential multisemiotic character of scientific theories and show how this leads to even a single theory being potentially 'internally incommensurable'. We then discuss Kuhn's lexicon-based approach to incommensurability and the problems associated with it. Finally we argue that this approach by Kuhn has interesting overlaps with the problem of meaning associated with multisemiosis, particularly the challenge of understanding the process of symbolization in scientific theories.

1. Introduction

The idea of incommensurability, particularly the formulation introduced by Thomas S. Kuhn in his *The Structure of Scientific Revolutions*, has undergone continual conceptual changes (Sankey 1993). Kuhn suggests that the term incommensurability is drawn from mathematics. The hypotenuse of a right isosceles triangle is incommensurable with a side of the triangle as we cannot a find any unit length that can measure both of these an integral number of times. There is said to be no common measure for both. Analogously, Kuhn relates this to the problems in comparing an early scientific theory with a latter one. This lack of common measure, according to him, is due to shift in meanings of certain terms that occur in the older theory and which are not rendered properly from the standpoint of the current theory. Such a situation emerges because there is communication breakdown between what he considers to be two different communities speaking two different languages. Incommensurability is the idea that captures such a communication breakdown and Kuhn develops a philosophical thesis

S. K. Arun Murthi and Sundar Sarukkai are at the School of Humanities, National Institute of Advanced Studies, Bangalore. Correspondence to: School of Humanities, National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore 560 012, India. E-mail: arun_jamadagni@yahoo.co.in, sarukkai1@yahoo.com

ISSN 0269–8595 (print)/ISSN 1469–9281 (online) © 2009 Open Society Foundation
DOI: 10.1080/02698590903197773

on incommensurability that holds between two radically different scientific theories. In essence, he was trying to describe the problems of a common measure between radically different scientific theories. Under many challenges to this idea of incommensurability, Kuhn in his later work equates the lack of common measure with the lack of 'shared lexical structure or taxonomy' between two competing scientific languages (Kuhn 2000b; Wang 2002). Incommensurability became equivalent to untranslatability as both these ideas indicated a sense of communication breakdown. For the later Kuhn, shared lexical structure between two languages made communication possible and the lack of such a shared taxonomic structure results in incommensurability.

Untranslatability arises due to radical variance in meaning and reference. According to Kuhn, the meaning of a scientific term rests within the context of a theory and the term cannot be seen in isolation from the theory. In cases of radical shifts in theory a same term that appears in two different theories could mean or refer to two different things. As Xinli Wang notes, 'the meanings and references of the shared terms in two competing theories (such as "mass" in both Newtonian and relativity theory) would be different when they occur in each theory' (Wang 1998, 293). In fact, Kuhn takes as his illustration the shift from Newtonian mechanics (NM) to Einsteinian mechanics (EM) and claims that terms in these two different theories have different meanings and refer to different things because of a lack of a shared lexical structure. Kuhn illustrates his lexicon-based approach to incommensurability by first examining the lexicon of NM and then arguing for how it is very different from that of EM. In such an approach each term acts as a node of a network. The meanings of these terms are rendered with reference to other terms in the network. Because the terms are part of a lexical network, Kuhn explicates the interrelatedness of scientific concepts in terms of how these are learnt in a holistic fashion. He discusses in detail the process of learning and acquisition of lexicon. In such an acquisition process the entire lexicon of the field is picked up as a whole and this is what he calls a lexical acquisition process. Laws are also part of this process. He takes NM to illustrate his idea of this holistic acquisition process where the laws and the lexicon of NM are acquired together as part of a learning process.

The notion of incommensurability is based on the understanding of what a scientific language is. We, therefore, first attempt to understand this idea and also the distinction between sub-language and natural language that Howard Sankey (1991) makes in this context. We address the issue of meaning that is so central to incommensurability. This problem has not been adequately addressed and as Nancy J. Nersessian comments, 'The "linguistic turn" in philosophy has wrongly made responses to the problem of meaning in science parasitic on developments in the philosophy of language, and has thus led philosophy of science away from the subject of its study: science' (Nersessian 1984, 4). As she correctly observes, meaning in scientific theories should be grounded in scientific practices. Multisemiosis offers one such grounding of scientific practice. Since a scientific theory is essentially multisemiotic it leads to the problem of potential incommensurability even within a single theory—what we refer to as 'internal incommensurability'. The fact that such incommensurability is not present indicates the way to tackle the claims of incommensurability between theories. We then discuss the later Kuhn's lexicon-based approach to incommensurability and the problems associated with it. Finally, we point to interesting relations between meaning in multisemiotic texts and the theory of lexicons and lexical structures. We also suggest that Kuhn was actually on the way to articulating a theory of meaning of multisemiotic texts but would have been unable to complete the project because of his problematical understanding of symbols and their meaning.

2. Language of Scientific Theory

The translational approach to incommensurability brings the issue of language to the fore. When, therefore, one invokes the idea of language in the context of incommensurability the question that arises is: What does one understand by the 'language of a theory', in particular the language of a scientific theory or, in general, scientific language? This question has not been sufficiently addressed by Kuhn. It appears from Kuhn that the language of Aristotelian mechanics is different from Newtonian mechanics and this again is different from Einsteinian mechanics. According to Kuhn, the language of NM cannot be rendered in the language of EM and there is no common language into which they can be translated. What exactly are these languages? Does scientific theory have a special language? If yes, then how does it differ from natural language? Sankey (1991) makes a tangential reference to this point in two different contexts. In the first context he discusses the idea that translation failure does not entail that theories cannot be compared. Here he makes a distinction between the 'special terminology' and 'sublanguage' embedded within a natural language. Again in another context where he distinguishes understanding and translation, he points out a difference between these two languages. The two differ in terms of language learning in that the theoretical sub-language learning is a localized activity occurring within a background natural language. He reveals the difference between these two languages in terms of their learnability. However, this description is not clear, because these differences are made known by using phrases like 'monumental undertaking', 'localized activity', and 'embedding within a background language.' Natural language learning is a monumental exercise for Sankey whereas theoretical sub-language learning is a localized activity.

Sankey does not also clarify the nature of the relation between the background natural language and language of the theory. He writes, 'The key here is to distinguish the special terminology or sub-language employed by a theory from the background natural language in which it is embedded' (Sankey 1991, 415). And later on: '… there is a fundamental difference between learning the everyday language of middle-sized physical objects and learning the technical vocabulary of laboratory and theory' (Sankey 1991, 419). These terms, according to Sankey, are learned by a special process within the background language. Background language, which is a natural language, is somehow necessary. However, we do not have an independent conceptual fix of what this direct learning of untranslatable language means. That this is the case is pointed out subsequently by Sankey when he brings up a likely objection to the shared background natural language of rival theories: 'Given a shared natural language anything expressible in one theory but not in rival theory might be expressed in some portion of the encompassing natural language' (Sankey 1991, 420). There are certain specialized terms which a particular discipline uses. These terms can very well be described within the natural language. Is this activity of explaining the terms by the natural language all that is there to what Sankey calls 'local activity'? Then in which case how is it different from other similar activities in which language is employed to explain something? Even our every day thoughts and ideas are communicated through language. Is the relation that language has to these thoughts any different from the relation of theoretical sub-languages to natural language?

Without discussing the points in detail, we would like to make one relevant observation here. The role of natural language within scientific theory is indeed problematical. In fact, one could argue that the shift towards mathematics in scientific theories is a response to the perceived problems of natural language as far as the activity of science is concerned. One interesting reflection of this bias against natural language is to be found in the problem—or the lack of a problem—in translating scientific texts. In translation studies, there has been sustained work on the problems of translating a text to another. Some of these problems are indeed very challenging. However, in translating scientific texts these worries about 'proper' translation rarely occur. It is remarkable that completely new disciplines such as relativity theory and quantum mechanics were translated into English from German and French, for example, without any comments about the potential pitfalls of translation (Montgomery 1996). The dominant reasons for this neglect of the problem of translation are the beliefs (1) that translation is primarily a problem of natural languages and (2) that the natural language component of scientific theories does not carry any of the 'essential' meaning of these theories. Concomitant to these beliefs is the view that mathematical expressions capture all the significant elements of a theory, and since mathematics, in principle, does not exhibit the problems of translation of natural languages, there indeed is no significant problem in translating a scientific text from German to English. Such a belief is visually enshrined in the similarity of the equations in translated scientific texts. That is, the equations in a German text remain the same in the translated English text, and since these equations are what are epistemologically significant there is no 'loss' or 'modification' in the activity of translation. Ironically, this practice of translating scientific texts is a worthwhile challenge to the incommensurability thesis, and if Kuhn had perhaps looked at this practice carefully he might have recognized that even incommensurable theories carry the same semiotic structures and thus in principle are always translatable.

Wang wants to make a clear distinction between scientific theory and scientific language as he feels that this lack of clarity has led to 'many confusions in the discussion of the issue of incommensurability' (Wang 2007, 18). According to him scientific theories are 'formulated in a theoretical language with a special lexicon (such as Kuhn's lexical structure), syntax and logic'. The sentences are attributed a certain truth value or degree of belief. He thus adopts a semantic approach to theories. In such an approach any language including natural language can be used for the formulation of theories. Wang concludes that 'all accompanying languages of scientific theories are scientific languages' (Wang 2007, 19–20).

As seems apparent, the question of what constitutes scientific language is not only ambiguous but also central to the claims of incommensurability. First of all, splitting scientific language into a natural language component and a 'localized' language is not very helpful. If a scientific theory is a coherent 'text', as indeed scientific texts are, then how do the natural language terms and those of the localized language cohere? What is the model that explains how the different 'languages' in the same theory work together in order to create coherent meaning? Furthermore, why is there no acknowledgement that the localized language is largely mathematical—particularly so in the cases of physics that Kuhn and others discuss? What is the relationship between mathematics and the localized language in a theory? Invoking mathematics creates a new set of problems since mathematics in principle does not seem to have a theory of meaning that allows claims of incommensurability. There are at least two important reasons for this which would underlie such a claim: one is that a theory of meaning of mathematical terms (as used in science) is significantly different from that of natural language terms, and the other is that the problems of translation that lie at the heart of incommensurability thesis again seem to be negated in the case of mathematics. The relation between mathematics and translation is indeed very interesting, but we will not discuss this point here and instead refer the reader to Sarukkai (2001b). Finally, incommensurable theories seem to use very similar mathematical terms, symbols, structures, and functions. This, perhaps more than anything else, challenges any simple reading of incommensurability.

The problem of how natural language terms and the localized language cohere needs an explication. The view that the background language does not contribute epistemologically to a theory and hence is not significant would be wrong on many counts. In fact, it would be quite impossible to construct a scientific theory without using natural language. Localized language terms very often have a prior reference to natural language. This is very clearly seen even in the case of 'pure' mathematical terms. Even if mathematics is exclusively seen as a symbolic system with special rules it is still essentially related to natural language. One way this occurs is through prior reference—symbols, first and foremost, refer to natural language terms. Even in the context of calculations the presence of natural language is crucial, as Ludwig Wittgenstein well understood (see, for example, Shanker 1987 and Sarukkai 2001a).

Scientific theories are special in that they are *necessarily* multisemiotic, that is, they use many semiotic systems in a given theory. For example, a scientific text uses graphs, figures, diagrams, natural language, symbols, mathematical terms, and equations (Lemke 1998; see also Martin and Veel 1998; Halliday and Martin 1993). In fact, the defining mark of a scientific text is this multisemiotic character. What is remarkable is that such a multisemiotic text creates unified meaning. This is remarkable particularly because even a single language is potentially open to semantic plurality and thus one would expect a combination of 'languages' to be semantically uncontrolled. However, the reverse seems to be the case. There is actually a 'convergence' of meaning made possible by the use of multisemiosis in scientific texts.

First of all, how does one put all these different semiotic systems together? How is meaning transferred from one semiotic system to another—so effortlessly, if we may add? How do we move from the meaning we make of a graph to natural language terms to mathematical symbols so effortlessly? Mathematics is already the first example of a multisemiotic system. The primary model of meaning making in scientific theory must give us a coherent account of meaning making in multisemiotic systems. Interestingly, one of the more useful ways to understand this process of meaning making in such systems invokes the idea of translation. However, this approach needs a much more nuanced idea of translation than often used in discussions on incommensurability. These refined models of translation are available in contemporary theories of translation (see, for example, Gentzler 1993). One such model which is useful to understand the creation of meaning in multisemiotic systems is that of free translation (Sarukkai 2002).

Consider a text written in more than one natural language. How is meaning created in such texts? A reader should first of all be multilingual. Moreover, there is a constant movement from the universe of one language to another in moving from one language to another. A multisemiotic system is analogous in the sense that making sense of such expressions involves moving from one semiotic system to another through translation understood in a most general sense. The scientist as the reader of scientific texts is thus primarily a translator but a translator who heeds this sentiment: 'Since languages express cultures, translators should be bicultural, not bilingual' (Lefevere and Bassnett 1990, 11; for a more detailed discussion, see Sarukkai 2001a, 2001b, 2002).

The consequence of a more complex understanding of translation is that certain claims of language and translation present in discussions on incommensurability with respect to scientific theories need to be modified. Primary among these is the very definition of incommensurability as indicating some mismatch between different theories. Given that scientific theories (by and large, particularly in the examples often discussed in incommensurability) are multisemiotic implies that the notion of incommensurability is already present in a given theory—different semiotic systems are incommensurable if the traditional accounts of incommensurability hold. Thus, this leads us to consider the possibility of 'internal incommensurability' which is present in any given theory at a particular time.

This implies that it is not only radically different theories that might have very different meanings of some terms. Such changes in meaning might occur across the space of a single theoretical framework. Such a possibility is often catalysed by multisemiosis. This claim can be illustrated by considering how physics describes phenomena. For example, consider the oscillation of a simple pendulum. The scientific description of this process often begins by first picturing this event in a simple way. Most commonly, this will consist of a drawing of a line with a bob at its end and the oscillation indicated by the angle of displacement. This description is a semiotic world of its own. It has certain strengths and also certain limitations. On this picture one then encodes other terms such as force, weight, angle, and so on. Once this symbolization happens, a different linguistic world is open for description, which includes the use of the language of geometry and trigonometry, and subsequently the language of algebra. Thus, the description of a physical process needs many such semiotic moves for a complete description. In such a process, the question of meaning is completely different from that of traditional theories of the meanings of terms.

We will illustrate this creative engagement with meaning—one that is characteristic of science, and most definitely of physics—by considering one scientific term, 'coordinate'. In the earliest definition of coordinates, they were fundamentally a quantification of space and basically measures of distance. So one could specify an object in two dimensions by two coordinates x and y. However, there were also other possible descriptions of this scenario. The coordinate description (x, y) could be replaced by (r, θ), where r is the radial distance; and θ is the angle. Now, θ is not a length like x and y are, but is still a coordinate. In higher dimensions, the spherical coordinates have two angle terms and one length term as coordinates. In moving to higher dimensions, we lose the possibility of pictorially representing these dimensions as we can do in the case of two dimensions. This necessitates a shift into algebraic modes of describing coordinates. When geometrical coordinates are algebraized, something interesting happens. The original meaning of length and angles do not have the same meanings. The generalized coordinates are not constrained by any meaning associated with spatial length or even angle.

For example, in phase space, momentum itself functions as a coordinate. In classical accounts of meaning, one would obviously say that position and momentum are completely different kinds of concepts. Once these are both seen as 'coordinates', then that implies that both these terms have a common characteristic related to the idea of 'coordinates'. This reformulation of meaning is accomplished not because of any experimental results but due to the primacy of multisemiosis in the activity of scientific theorizing. When position and momentum are seen as coordinates then there are other interesting consequences. Since one set of coordinates can be transformed into another, 'the *distinction* between position and momentum, in this co-ordinate disguise, is no longer tenable and they can now be transformed into each other' (Sarukkai 2002, 68). As a physics book notes, through appropriate transformations we can 'generate a rather trivial but yet canonical transformation in which the new co-ordinates become the old momenta and vice versa' (Taylor 1976, 60). The point to be noted here is that even in the space of a single theoretical framework the original meaning of coordinates becomes radically different. It is in this sense that if Kuhnian ideas of incommensurability are accepted then we will be forced to consider the possibility that even a single theory is 'internally incommensurable'.

Multisemiosis is a way by which science offers different layers of description of a phenomenon (and even entities). A pendulum's 'meaning' is actually a set of multilayered descriptions ranging from the physical description of a mass at the end of a string to that of a simple harmonic oscillator. So what is the 'real' meaning of a phenomenon in such a multilayered description? Which of the meanings of these different layers should be seen as the meaning which is open to comparison between incommensurable theories?

In fact, if there is a lesson in the art of scientific theorizing it is this: the questions of meaning do not regulate the possible descriptions of a phenomenon or object. Strictly, meaning is bracketed in the act of constructing a theory. (Bracketing is used in the same sense Edmund Husserl used it—the question of meaning is not relevant to the process of creating scientific narratives, just as the question of reality is bracketed in phenomenologically analysing experience.) The preoccupation with meaning comes after the job of creating surplus meanings through different layers of description by using multisemiosis. The problematical relation between meaning and theorizing can be seen in the very act of symbolization, which is the first step towards mathematization. Symbols, in their essence, are meaningless. The replacement of a word by a symbol first of all removes meaning from the word and replaces it by a meaningless symbol. Once this is done, operations can be performed on the symbol without worrying about the meaning of such operations on the word or concept. Given that this shift to meaninglessness is an integral part of scientific theorizing, how can incommensurability—dominantly concerned with radically different meanings of terms—be of any consequence in scientific theories? In fact, as is well known, radically different theories carry over similar symbolic structures such as the example of energy equation in classical mechanics and its counterpart, the Schrödinger equation, in quantum mechanics.

Consider another example, that of mass. In a given theory mass may be used as a concept; when it comes to symbolic expression, *m* may be used instead of the word 'mass'. How are we confident that moving from 'mass' to *m* does not duplicate the problem of incommensurability that apparently arises when we move from one theory to another 'different' theory? We do not have this guarantee but only work on a belief that the use of different semiotic systems to describe a particular term does not run into the problems of incommensurability. In the language of translation, symbolization is one particular kind of translation. Roman Jakobson (1966, 232–239) suggests three types of translation in his influential work on translation. One is intralingual, which is translation within one language itself—synonyms, for example, are also translations. The second type is interlingual, which is the usual translation from one language to another. The third is intersemiotic translation, which is the translation from one semiotic system to another, including 'translation' of verbal terms with nonverbal ones. For scientific theories, intersemiotic translation is the most important. In fact, we should look at this model of intersemiotic translation (whereby we move from one semiotic system to another in the space of a single theory) as that which negates the problem of incommensurability. In other words, although a given theory is already potentially 'internally incommensurable' there seems to be no apparent problem of incommensurability in that theory. One can thus argue that the problem of incommensurability is 'eliminated' by the process of intersemiotic translation. Thus, this model of negating internal incommensurability gives us a particular way of understanding how incommensurability is actually handled when we move from one theory to a radically different one.

The Kuhnian response to this might be as follows: one, multisemiosis is not a problem for incommensurability; and two, the notions of lexicon and lexical structures developed by the later Kuhn offer a different view of incommensurability. As for the first response, multisemiosis is indeed a problem for the thesis of incommensurability because it challenges the very idea of how meanings accrue to terms in a scientific theory. Paradoxically, meaning accrues by first making terms meaningless and then taking these meaningless terms into a different semiotic universe. As for lexicons and lexical structures, there are two responses that can be given: one is that the shift to lexical structures is actually related to certain aspects of multisemiosis and hence in principle cannot sustain the claims of incommensurability. The other problem is that Kuhn talks of lexical structures by drawing upon the idea of network of lexical items that attach to nature but he is unable to specify what these lexical structures are. Moreover, it could be argued that the shift to the vocabulary of lexicons dilutes the force of the earlier incommensurability thesis. The emphasis on lexicon cannot handle the problem of incommensurability in itself since the process of meaning generation in scientific theory is not sufficiently well described by this mechanism. By keeping aside the role of mathematical terms in scientific theories as well as ignoring the multi-semiotic character of these theories, the very meaning of incommensurability has come under question. We will consider the later Kuhn's argument for incommensurability based on lexical networks and analyse how in this formulation there is a tacit acceptance of multisemiosis, thereby suggesting that there is a canonical critique of incommensurability available within Kuhn's later formalism.

3. Lexicons and Lexical Structures

Lexical items, as defined by Kuhn, are terms or concepts that attach themselves to nature through certain criteria (Kuhn 2000c). The lexicon is a structured vocabulary that gives one access to different sets of possible worlds. Kuhn uses the picture of network of nodes to explicate his notion of lexical network. These lexical items form a network of nodes where each node is connected to the other by labels of identifying criteria. Some of the nodes are thus closely tied together, and this forms a structure that reflects some aspects of the structure of the world. This structure of lexical network is laid on the world to adequately describe the world. The limitation of this lexical network also is the limitation of the description of the world. Members of the same language community share a homologous lexical structure (Sankey 1998). The communication breakdown between two different language communities results due to different homologous structures. What is required for translation between one language and the other is a shared lexical taxonomy. Translation failure occurs when the lexical structures of the respective language communities are different.

The importance of language in a theory lies in the lexical structure or the lexicon that is first developed and thus the meaning of these terms assumes importance. Therefore, for Kuhn, to understand a past scientific text in a particular domain, one must acquire the lexicon of the past theory which systematically differs from the present one. He elaborates this claim as follows: The failure to understand past scientific texts and dismiss them as products of ignorance is due to the failure to acquire the lexicon of the older theory and in our efforts to understand the older text by the current lexicon. He illustrates this claim with the example of the interrelated terms 'mass', 'force', and 'weight' in Newtonian mechanics. Kuhn tries to explain the notion of scientific language in this illustration. In this he draws upon the notion of holism. Meaning holism forms a significant part of Kuhn's account of meaning acquisition. According to him there are certain terms in the theory whose meaning cannot be acquired in isolation. There are sets of these terms whose concepts are related and as such their meaning is acquired together. Kuhn claims that there is a small subgroup of these terms in a theory whose meaning is acquired holistically. 'Mass', 'force', and 'weight' are elements of such a subgroup in Newtonian mechanics according to Kuhn (2000a). However, in this analysis it is also important to note another dimension of holism. It is also his claim that these terms are *acquired* together with the theory. The acquisition of the concepts and the theory is a holistic activity. He describes how one learns the concept along with the theory and suggests five aspects of this learning activity of these Newtonian terms (Kuhn 2000a, 66). In this he makes clear that definitions play a negligible role (second aspect) and in the third aspect explicates how concept learning takes place when the terms are applied to certain situations along with certain law statements in which these terms appear. These situations are exemplary for Kuhn in the sense that without these it is not possible to acquire the terms of the Newtonian lexicon. He focuses on the idea of the acquisition of these terms that are essentially quantitative in NM.

There are already some significant problems present in such an account of lexical networks. First, in the context of translation, it becomes problematical to reduce the possibility of translation from one language to another to having a shared lexical taxonomy. This idea of translation is highly restrictive and is not one that is applicable to scientific theories as discussed earlier in the context of intersemiotic translation.

Secondly, in the context of scientific theories, it does not make sense to reduce the problem of meaning to the lexical domain alone. In the space of a single theory a lexical term—say, mass—will be represented differently in the different semiotic systems. The meaning that accrues to the lexical terms is the 'sum' total of all the semantic expressions in the theory. For example, metaphoric meaning is one important way in which scientific terms get meaning (Boyd 1979; Sarukkai 2002). While it may be argued that Kuhn's loose invocation of holism might hold metaphorical meaning, it is not clear that the richness of metaphoric meaning is actually encapsulated by the idea of holism that Kuhn invokes. But to understand this further, let us look at how meaning is acquired in a lexicon.

4. Learning and Meaning

How do the terms in a lexicon get meaning? Kuhn's theory of lexicon has an account of meaning but one that seems to be incomplete. From the discussion above, we can see that the meanings of terms arise through their relation to a set of interrelated terms. For Kuhn, meaning and the activity of learning have an intimate relation. For example, 'mass', 'force', and 'weight' are considered as a set of interrelated terms or lexical items of the Newtonian mechanics that need to be learned. For learning this terminology, there are already certain other terms as part of lexicon with which one is familiar (first aspect). However it is Kuhn's contention that one can learn the above mentioned three terms along with the acquisition of the Newtonian theory. The use of these Newtonian terms essentially reveals a quantitative nature. There are different routes through which one learns the use of Newtonian terms. Kuhn shows two routes that can be employed in this particular illustration. The difference in the way the laws figure in these two routes lies in the epistemic status attached to these laws. What is significant in these routes is the exposure to certain examples that serve as necessary conditions for acquiring the term. In the elucidation of how terms like 'mass' and 'weight' are learnt he presents Newton's second law as a description of how moving bodies behave. It is here that Kuhn describes how laws are bound by language through his idea of stipulative description and how laws form part of his lexical acquisition process.

What is this 'stipulative description'? Kuhn disregards the fact that definitions play any role in this process of learning but focuses on concept as that which is acquired by exposure to exemplary situations. The actual use of the concept is revealed when the concept is *applied* to that situation. There is an ostensive element in this. The exemplary situation can be given by a description and the second law is presented as how the moving bodies behave. In such a process one stipulates how the term is to be used as well as how the world should behave. This is the idea of simultaneous stipulation that he endorses. What is it that is stipulated? The stipulation is both about how the term is to be used as well as the way the world should behave. This idea can be elaborated as follows. If one structures the world of moving bodies with an evolved lexicon such as mass and force then the law related to moving bodies describes, in terms of these concepts, how they should behave. Corresponding to these concepts there are things in the world of moving bodies whose behaviour matches that of the law and they relate themselves in the way the laws describe them. This is made possible, according to Kuhn, when an exemplary situation is juxtaposed along with laws. By placing the law side by side with the exemplary situation, one is exposed to the terms that appear in the law. But in this process one also stipulates the way the world behaves if it is described through these terms. Such is the claim of double stipulation of Kuhn. Therefore when the laws are juxtaposed with situations to which they apply, there is a double role that is being played, the role of simultaneous stipulation. It is in this way that the laws are simultaneously stipulated. Such a stipulation is warranted according to Kuhn, in order to learn the Newtonian terms. These laws in Kuhn's conception become conditions that are laid down as part of an arrangement to learn those concepts. It is in this sense that laws are said to be bound by language. This law is formulated as force = mass × acceleration.[1] Mass in this formulation, for Kuhn, is an 'incompletely established term' (Kuhn 2000a, 70). The term that is embedded in the law and the presentation of the law as a description of the way nature behaves both together constitute an aspect of the lexical acquisition process for Kuhn. It is in this way that laws of nature form part of the lexical acquisition process.

We would like to point out how Kuhn, in invoking these ideas of description and the role of laws, is actually working with a preliminary idea of multisemiosis. This problem of meaning in multisemiotic systems is actually implicit not only in his attempts to describe how one learns the meaning of these lexical terms but also explicit in a comment he makes about symbols. First of all, the idea of multiple descriptions is an important indicator that a theory of meaning in scientific theories needs to invoke multiple semantic levels. The stipulative descriptions are, among other things, descriptions which involve multiple descriptions of the same phenomenon.

A careful reading of Kuhn's understanding of lexicons and lexical structures actually indicates something interesting. His description of the process of meaning making through lexicon (Kuhn 2000a) seems to suggest that he is actually trying to come up with a theory of meaning of multisemiotic texts. In the beginning of this paper, he notes the similarities in the problem of translating a literary text and scientific text. From this he goes on to articulate a theory of meaning (in a loose sense of the phrase) and to isolate two aspects of such a theory. The first equates knowing a word with 'knowing how to use it for communication' (Kuhn 2000a, 62) and the second aspect is related to meaning generation through the use of common structures or what he later calls as interrelated terms.

How does this theory of meaning function in practice? Kuhn repeatedly invokes the idea of learning as an integral aspect of learning. So when he talks of the lexicon of Newtonian physics he describes the process entirely through a particular process of learning. According to this picture, first a student must have the 'significant portions' of the lexicon in place. And then Kuhn suggests that onto this 'they must have grafted a mathematical vocabulary rich enough' to generate other kinds of descriptions (Kuhn 2000a, 66). The invocation of the mathematical vocabulary already signals a shift to multisemiosis and the generation of multiple levels of description that is necessary for scientific texts.

But how do these scientific terms get meaning? Kuhn isolates five ways by which the meanings of these terms are *learned*. The first two ways have a 'stipulative element: terms are taught through the exhibit, direct or by description, of situations to which they apply' (Kuhn 2000a, 66). The consequence of this is that what is learnt is not 'about words alone but equally about the world in which they function'. Here is where Kuhn comes close to accepting the multisemiotic character of the scientific imagination but does not follow through the consequences. Instead, he reduces this act to a traditional theory of meaning which, however, cannot explain the richness of this act. Kuhn makes an initial move towards a multisemiotic theory of meaning when he notes that stipulations are 'simultaneously and inseparably about both the substance and the vocabulary of science, about both the world and the language' (Kuhn 2000a, 67). This line captures in principle the shift into a theory of meaning which, for scientific terms, makes a necessary reference not just to the world but also to language. But which language is Kuhn talking about here? It is not natural language like English alone but also the mathematical vocabulary which he refers to earlier. In other words, he is talking about a multisemiotic universe of scientific articulations.

A theory of meaning that invokes reference to both the world and language is what characterizes the nature of meaning making in multisemiosis. While one can understand stipulations in reference to the world what does the relation of stipulations to language mean? The third and fourth ways of learning do not clarify this relation to language although they are primarily about language and structure. The third aspect of learning is related to learning through laws of nature and here again he makes an implicit connection to language by saying that laws of nature are types of statements. The fourth process is a structural connection between terms.

One can try and make sense of the importance of the idea that meaning is in some sense about world and language by considering the example he gives of how the meaning of force is learnt. Kuhn asks how can a student learn the meaning of force-free motion, since this can be exhibited (and pointed to) only in outer space. Even though teachers try to teach this through ingenious methods, Kuhn points out that for most students the meaning is from the use of the term force in Newton's first law of motion. This Kuhn sees as exhibiting, 'by description, the motions that require no "force"' (Kuhn 2000a, 68). This analysis is indeed surprising if classical accounts of meaning are taken into account. However, it makes sense if we understand that the shift to linguistic expressions and structures generates the meanings of terms in science and this is what is captured by the idea of meaning in multisemiotic systems.

From the context of multisemiosis, we can understand what Kuhn means when he says that meaning refers back to the world and language. In the act of multisemiosis a given term is represented not just by its natural language term but succeedingly by a variety of symbolic terms which are all related to different semiotic systems to which they belong. Thus—as far as *meaning of the term is concerned*—force refers not just to a characteristic world but also to its placement in a series of symbolic phrases, including its placement in statements of laws. If laws for Kuhn (in the text we are discussing here) are statements and meaning is acquired through these laws then we can see how the meaning of a term is fixed, not by reference to the world, but by its use in other linguistic structures. For example, Kuhn points out how both Newton's third law as well as Hooke's law are used in learning the quantitative meaning of force (Kuhn 2000a, 69).

The multisemiosis inherent in scientific descriptions can now be seen—following Kuhnian language—to be different language-learning routes (towards the same phenomenon). Kuhn discusses the possibility of learning about mass and weight through two different learning routes—'one that stipulates the second law and finds the law of gravity empirically; another that stipulates the law of gravity and discovers the second law empirically' (Kuhn 2000a, 71). Different semiotic descriptions, what we referred to earlier as multiple-level descriptions, are in principle different routes towards learning a theory. And the main consequence of this is that the richness of scientific descriptions is possible only because of invoking a theory of meaning which refers to different linguistic systems. In fact, not just learning but also research in science is made possible by the implicit shift to multisemiosis.

However, there are two aspects where this Kuhnian description differs from that of our account given earlier. One has to do with the indifference to meaning which is a hallmark of the process of scientific theorizing. Kuhn is concerned about how we learn to compare theories and thus his emphasis is on language learning since, as he notes in the beginning of his text, translatability is closely associated with language learning. But in this paper we are also concerned about the role of meaning in the process of creation of theories. In this act, there is often a bracketing of meaning. Theoretical activity in science proceeds not with the constraining presence of the question 'What does this mean?' at every step but with a studied indifference towards the question of meaning. Multisemiosis exhibits this bracketing of meaning in the process of theorizing.

The second aspect where Kuhn differs from our analysis has to do with his understanding of the nature of symbols. Kuhn talks about symbols and meaning in a way that is quite problematical. Kuhn considers the possibility that 'incommensurable' lexicons may be mistakenly seen to be similar because 'one can write down strings of symbols that *look like* revised versions of the second law and the law of gravity' (Kuhn 2000a, 73). He goes on to add that the 'resemblance is deceptive, because some symbols in the new strings attach to nature differently from the corresponding symbols in the old thus distinguishing between situations which, in the antecedently available vocabulary, were the same'. Following from this he notes that when two lexicons give access to two possible worlds then translation between these worlds is impossible. Here is where Kuhn misses the point about the importance of multisemiosis and the bracketing of meaning in the process of scientific theorizing. First of all, the belief that symbols 'attach to nature' is a very problematic one. It is not even a new idea that symbols are in principle meaningless and it is their meaninglessness that makes the shift to the symbolic so potent in science. Leibniz was well aware of this character of the symbol when he introduced his idea of the 'characteristica universalis', a move that had profound influence in the creation of modern mathematics and symbolic logic (for a discussion on related themes, see Sarukkai 2005). The advantage of using symbols is that the question of meaning is deferred and one can manipulate them without worrying about the change in meaning under certain actions. So, symbols do not attach to nature; they, if one insists, attach to other linguistic terms. It is this character of multiple referencing—both of the world and language, as Kuhn has it, or to different semiotic systems, as we have described earlier—that best captures the uniqueness of scientific descriptions in the theoretical mode. In these moves, the question of meaning is constantly deferred.

Therefore, one can reasonably argue that Kuhn's later views on incommensurability actually reflect an attempt to understand the nature of meaning in a multisemiotic discourse. Unfortunately, he was writing under the influence of views on language and symbols which were not sufficiently rich to capture this character of scientific texts. He also seems to have been unaware of seminal work in translation studies which would not have allowed him to suggest that the translation of metaphorical terms is 'impossible' (Kuhn 2000a, 75). Nevertheless, we believe that it is important to recognize the change implicit in Kuhn's incommensurability thesis which brings him closer to an analysis of meaning in multisemiotic descriptions of the world.

Acknowledgements

An earlier version of this paper was presented at the International Seminar on the Incommensurability Thesis organized by the Department of Philosophy, University of Hyderabad, India. We are grateful to Howard Sankey for his critical comments as well as insightful suggestions on the paper, both during and after the seminar. We also thank S. G. Kulkarni and Prajit Basu for their helpful comments on the paper. Detailed critical responses by two anonymous referees as well as the editor of this journal helped us considerably strengthen the paper. We are particularly grateful to them for taking the trouble to do this. Our thanks are also due to the librarian at National Institute of Advanced Studies, Hamsa Kalyani, for making available the needed references in time.

Note

[1] This explicit expression is not to be found in Newton's *Principia*. The earliest expression of the well-known formula force = mass × acceleration is to be found in Euler (Jammer 1961, 89).

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