A Companion to the Philosophy of Science, ed. W.H. Newton-Smith (Oxford: Blackwell, 2000).

27

Incommensurability

MUHAMMAD ALI KHALIDI

Along with "paradigm" and "scientific revolution," "incommensurability" is one of the three most influential expressions associated with the "new philosophy of science" first articulated in the early 1960s by Thomas Kuhn and Paul Feyerabend (see KUHN and FEYERABEND). But, despite the fact that it has been widely discussed, opinions still differ widely as to the content and significance of the claim of incommensurability. What is uncontroversial is that the term "incommensurability" was borrowed from mathematics, where it can be used, for example, to apply to the relation between the side of a square and its diagonal. Since the side of a square is measured by a rational number, and its diagonal by an irrational number, and since an irrational number cannot be represented by a point on the rational number line, the two quantities are said to have no common measure; they are literally *incommensurable*. Kuhn and Feyerabend adapted this term and applied it to some pairs of rival scientific theories, to indicate that such theories also had no common measure, or, in some sense to be determined, could not be compared directly. Both Kuhn and Feyerabend agree that they hit upon the term independently and used it in print for the first time in 1962, in *The Structure of Scientific Revolutions* and "Explanation, reduction, and empiricism," respectively. But the two writers explicate the claim and argue for it rather differently. After tackling the concept of incommensurability as it appears in the works of each of these authors in turn, some reactions and responses will be sampled.

Kuhn's notion of incommensurability

One common and natural interpretation of the idea that there is no common measure among rival scientific theories is that they cannot be phrased in a common set of linguistic terms, or, to put it more simply, that they cannot both be translated into a single language. That is, the claim of incommensurability can be taken to be about the impossibility of the linguistic mode of comparison in the first instance. This interpretation is confirmed by some, though by no means all, of Kuhn's early articulations of the concept. In *The Structure of Scientific Revolutions* Kuhn often puts incommensurability in terms of change of meaning, but he sometimes suggests that translation *is* possible between two incommensurable theories or paradigms. He writes that "the physical referents of these Einsteinian concepts [space, time, and mass] are by no means identical with those of the Newtonian concepts that bear the same name" (1970a, p. 102). He continues: "This need to change the meaning of established and familiar concepts is central to the revolutionary impact of Einstein's theory" (ibid.). Kuhn refers to this revolutionary change from classical to relativistic mechanics as a "displacement of the

conceptual network" (ibid.). In the "Postscript" to the text, he reiterates the view that incommensurability involves differences in meaning between two agents espousing incommensurable theories: "Two men who perceive the same situation differently but nevertheless employ the same vocabulary in its discussion must be using words differently. They speak, that is, from what I have called incommensurable viewpoints" (1970a, p. 200). However, he then goes on to say that "what the participants in a communication breakdown can do is recognize each other as members of different language communities and then become translators," resorting to "shared everyday vocabularies" in doing so (1970a, p. 202). If this is carried out successfully, Kuhn thinks, then "Each will have learned to translate the other's theory and its consequences into his own language and simultaneously to describe in his language the world to which that theory applies. This is what the historian of science regularly does (or should [do]) when dealing with out-of-date scientific theories" (ibid.).

Since Kuhn sometimes suggests that translation is indeed possible between two incommensurable scientific theories, how are we to understand the claim of incommensurability? At some points in the "Postscript," he hints that it is a claim about the impossibility of a more general assessment of two scientific theories. This second construal of the notion of incommensurability – that it precludes a neutral way of appraising scientific theories – seems to rest on a different claim: namely, that scientific theories or paradigms contain within themselves their own standards for success or criteria of appraisal. Not only do scientific paradigms differ "about the population of the universe and about that population's behavior"; Kuhn writes that they are also "the source of the methods, problem-field, and standards of solution accepted by any mature scientific community at any given time" (1970a, p. 103). These "non-substantive differences" are an integral part of incommensurability, which is demonstrated by the fact that adherents of two scientific paradigms "will inevitably talk through each other when debating the relative merits of their respective paradigms," since "each paradigm will be shown to satisfy more or less the criteria that it dictates for itself and to fall short of a few of those dictated by its opponent" (1970a, pp. 109–10).

However, in later developments of Kuhn's view, less emphasis is placed on what might be called "evaluative incommensurability," and more on "linguistic incommensurability." Indeed, by 1983, Kuhn appeared to have moved away from evaluative incommensurability entirely, by saying that speaking of differences in "methods, problem-field, and standards" is "something I would no longer do except to the considerable extent that the latter differences are necessary consequences of the language-learning process" (1983, p. 684, n. 3). And in a 1990 article, Kuhn states quite baldly: "Incommensurability thus equals untranslatability" (p. 299). In a footnote, he writes: "My original discussion described nonlinguistic as well as linguistic forms of incommensurability. That I now take to have been an overextension resulting from my failure to recognize how large a part of the apparently nonlinguistic component was acquired with language during the learning process" (1990, p. 315, n. 4). Not only does Kuhn in his later work take incommensurability to be more explicitly the denial of translatability, he also states that this version of the claim is the same as the "original version" of the incommensurability thesis, which he characterized as follows: "The claim that two theories are incommensurable is then the claim that

there is no language, neutral or otherwise, into which both theories, conceived as sets of sentences, can be translated without residue or loss" (1983, p. 670). Therefore, if incommensurability equals untranslatability, what is it about scientific paradigms that precludes translation into a single common language, so that their claims can be set side by side and their points of agreement and disagreement isolated? Moreover, how does this claim square with Kuhn's earlier claim (in the "Postscript") that historians of science can and do translate out-of-date scientific theories? (Some commentators on Kuhn have regarded this as the supreme irony of his work, that he denies translatability while at the same time serving as an articulate expositor of historical scientific theories.)

The resolution of this tension lies in what Kuhn says after equating incommensurability with untranslatability: "what incommensurability bars is not quite the activity of professional translators. Rather, it is a quasi-mechanical activity governed in full by a manual that specifies, as a function of context, which string in one language may, *salva veritate*, be substituted for a given string in the other" (1990, p. 299). Such a quasi-mechanical translation cannot be effected because of certain concrete problems posed by the translation of a scientific theory by a translator who does not share that theory. Kuhn claims that the problems of translating a scientific text into a foreign language or a later version of the same language are very similar to the problems of translating literature (1990, p. 300). In an illuminating passage which is worth quoting in full, he comments on the translational difficulties which are shared by literary and scientific discourse:

> In both cases the translator repeatedly encounters sentences that can be rendered in several alternative ways, none of which captures them completely. Difficult decisions must then be made about which aspects of the original it is most important to preserve. Different translators may differ, and the same translator may make different choices in different places, even though the term involved is in neither language ambiguous. Such choices are governed by standards of responsibility, but they are not determined by them. In these matters there is no such thing as being merely right or wrong. The preservation of truth values when translating scientific prose is as delicate a task as the preservation of resonance and emotional tone in the translation of literature. Neither can be fully achieved; even responsible approximation requires the greatest tact and taste. In the scientific case, these generalizations apply, not only to passages that make explicit use of theory, but also and more significantly to those their authors took to be merely descriptive. (1990, pp. 300–1)

In this passage, Kuhn does not clarify the specific translational difficulties involved, but in other works, certain specific obstacles emerge. Although Kuhn does not always distinguish them clearly, two can be singled out for special attention.

The first kind of translational difficulty implicated in incommensurability is the problem of *clusters of interdefined terms*. Kuhn uses the example of the eighteenth-century chemical term "phlogiston" to illustrate his point. He says that the term cannot be translated into terms of later chemical theory because of its relation to a number of other terms in the phlogiston theory, like "principle" and "element." "Together with 'phlogiston'," Kuhn explains, "they constitute an interrelated or interdefined set that must be acquired together, as a whole, before any of them can be used, applied to

natural phenomena" (1983, p. 676). He acknowledges that one can introduce a neologism for a term from a previous scientific theory which is no longer part of the current scientific vocabulary. However, he suggests that when there are whole clusters of such interrelated terms, translation is no longer possible, presumably because each neologism needs to be explicated in terms of the extant vocabulary, making whole clusters of them resistant to such explication.

Another translational problem is that of *conceptual disparity* among terms. Kuhn brings this out by adverting to an example drawn from nonscientific discourse. He explains that the French word *doux* does not correspond to any single word in English. It "can be applied, *inter alia*, to honey ('sweet'), to underseasoned soup ('bland'), to a memory ('tender'), or to a slope or a wind ('gentle'). These are not cases of ambiguity, but of conceptual disparity between French and English" (1983, pp. 679–80). He emphasizes that *doux* is a unitary concept for French speakers, and that English speakers have no single equivalent. English paraphrases for this French term provide no substitute because of their clumsiness, and because the term must be learned together with other parts of the French vocabulary (1983, p. 685, n. 12). While he acknowledges that a translation manual is adequate to deal with cases of straightforward ambiguity, he argues that the examples he uses are not to be seen in this light, and should be distinguished from standard examples of ambiguous words, such as "bank" or "cape." The reason seems to be that it is crucial for French speakers, as opposed to English speakers, that there is a single concept at play, rather than a single term which happens to stand for a number of distinct concepts. Thus, a translation which substituted a different English word for *doux* depending on context would be misleading. Though he does not explicitly say so, a scientific example of this phenomenon might be found in Kuhn's discussion of Aristotle's concept of speed, which he says contains "two disparate criteria," the first giving rise to our concept "average speed," the second to our concept "instantaneous velocity" (1977, pp. 246–7). However, Aristotle himself never made the distinction but employed what he would have considered to be a unitary concept.

Therefore, according to Kuhn's mature view, it is not possible to phrase all the claims of two scientific theories in a single language so that they can be put side by side and their exact points of difference pinpointed. Kuhn thereby denies the possibility of what is perhaps the most direct and natural method of comparing two scientific theories. As a result, choices between scientific theories are not based on a point-by-point comparison. Scientists who learn a new theory do not merely translate the new terms into the old terms; rather, they begin from scratch in the way that learners of a first language do. A language-learner, Kuhn states, will not always "be able to translate from his newly acquired language to the one with which he was raised" (1990, p. 300).

Kuhn never says that incommensurable theories can never be compared at all. Since the mismatches between incommensurable theories are local, we should expect that certain comparisons *can* be effected. Often such comparisons will involve concrete measurements of phenomena, presumably ones described in terms shared by the two theories. He states that "proponents of different theories can exhibit to each other, not always easily, the concrete technical results achievable by those who practice within each theory" (1977, p. 339). Although the Ptolemaic theory and the Copernican theory

were incommensurable because of such problematic terms as "planet." "The quantitative superiority of Kepler's Rudolphine tables to all those computed from the Ptolemaic theory was a major factor in the conversion of astronomers to Copernicanism" (1970a, p. 154). But there are also other criteria for comparison; for example, "there are arguments . . . that appeal to the individual's sense of the appropriate or aesthetic – the new theory is said to be 'neater', 'more suitable', or 'simpler' than the old" (1970a, p. 155). Hence, many grounds for comparison remain despite incommensurability, including "accuracy, scope, simplicity, fruitfulness, and the like" (1970b, p. 261).

Feyerabend's notion of incommensurability

Feyerabend is more consistent than Kuhn in giving a linguistic characterization of incommensurability, and there seems to be more continuity in his usage over time. He generally frames the incommensurability claim in terms of language, but the precise reasons he cites for incommensurability are different from Kuhn's. One of Feyerabend's most detailed attempts to illustrate the concept of incommensurability involves the medieval European impetus theory and Newtonian classical mechanics. He claims that "the concept of impetus, as fixed by the usage established in the impetus theory, cannot be defined in a reasonable way within Newton's theory" (1981a, p. 66). On the basis of this and other considerations, he concludes:

> [W]hat happens when a transition is made from a restricted theory T′ to a wider theory T (which is capable of covering all the phenomena which have been covered by T′) is something much more radical than incorporation of the unchanged theory T′ into the wider context of T. It is rather a replacement of the ontology of T′ by the ontology of T, and a corresponding change in the meanings of all descriptive terms of T′ (provided these terms are still employed). (1981a, p. 68)

On several occasions Feyerabend explains the reasons for incommensurability by saying that there are certain "universal rules" or "principles of construction" which govern the terms of one theory and which are violated by the other theory. Since the second theory violates such rules, any attempt to state the claims of that theory in terms of the first will be rendered futile. "We have a point of view (theory, framework, cosmos, mode of representation) whose elements (concepts, 'facts', pictures) are built up in accordance with certain principles of construction. The principles involve something like a 'closure': there are things that cannot be said, or 'discovered', without violating the principles (which does *not* mean contradicting them)" (1975, p. 269). After terming such principles "universal," he states: "[L]et us call a discovery, or a statement, or an attitude *incommensurable* with the cosmos (the theory, the framework) if it suspends some of its universal principles" (ibid.). As an example of this phenomenon, consider two theories T and T′, where T is classical celestial mechanics, including the space-time framework, and T′ is general relativity theory. About these theories, Feyerabend claims:

> The classical, or absolute idea of mass, or of distance, cannot be defined within T′. Any such definition must assume the absence of an upper limit for signal velocities and cannot therefore be give within T′. *Not a single primitive descriptive term of T can be incorporated into*

> T′ . . . the meanings of all descriptive terms of the two theories, primitive as well as defined terms, will be different: T and T′ are *incommensurable theories*. (1981c, p. 115; emphasis original)

Such principles as the absence of an upper limit for signal velocities govern all the terms in celestial mechanics, and these terms cannot be expressed at all once such principles are violated, as they will be by general relativity theory.

The reason that these universal rules affect the meanings of all the terms of the theory which contains them is to be found in Feyerabend's theory of meaning, which he calls a "contextual theory of meaning." He uses this contextual theory to define "strong alternatives" to a given scientific theory: theories which can be considered true competitors to a dominant theory, as opposed to those which are mere variants. He explains that "One of the main properties of strong alternatives is that they disagree everywhere if they disagree at a finite number of points" (ibid.). In other words, one sign that a theory is substantively different from another is that the differences between them affect the meanings of all terms; otherwise, Feyerabend implies, the rival theory is not a genuine alternative, but a mere variant. All such strong alternatives are incommensurable. Elsewhere, he writes that the meaning of a term is not an intrinsic property of it, but is dependent on the way in which the term has been incorporated into a theory (1981a, p. 74). This is the gist of what Feyerabend calls a "contextual theory of meaning." It also accords with his ridicule of what he calls the "hole theory," or the "Swiss cheese theory" of meaning, which holds that the conceptual cavities in a theory or language can be plugged without displacing the meanings of any of the existing terms. "According to the hole theory every cosmology (every language, every mode of perception) has sizeable lacunae which can be filled, *leaving everything else unchanged*" (1975, p. 266). The idea seems to be that the meaning of every term is affected by the general principles governing the theory, and that the principles change with every substantial theoretical change, so that the meaning of every term also changes. But even Feyerabend concedes that large parts of our *total* theory of the world remain constant across some scientific theory changes. "It may be readily admitted," he writes, "that the transition from T to T′ will not lead to new methods for estimating the size of an egg at the grocery store" (1981b, p. 100). And he say that the transition from Newtonian mechanics to the general theory of relativity has left the arts, ordinary language, and perception unchanged (1975, p. 271).

Comparison of Kuhn and Feyerabend

Feyerabend's differences with Kuhn can be reduced to two basic ones. The first is that Feyerabend's variety of incommensurability is more global, and cannot be localized in the vicinity of a single problematic term or even a cluster of terms. That is, Feyerabend holds that fundamental changes of theory lead to changes in the meanings of all the terms in a particular theory. The other significant difference concerns the reasons for incommensurability. Whereas Kuhn thinks that incommensurability stems from specific translational difficulties involving problematic terms, Feyerabend's variety of incommensurability seems to result from a kind of extreme holism about the nature of meaning itself.

One significant point of agreement between Kuhn and Feyerabend is that neither thinks that incommensurability is incomparability *tout court*. Both countenance, and indeed recommend, alternative modes of comparison. Feyerabend says that "the use of incommensurable theories for the purpose of criticism must be based on methods which do not depend on the comparison of statements with identical constituents. Such methods are readily available" (1981c, p. 115). But although he mentions a number of methods, he does not explicate them in full. For example, he says that theories can be compared using the "pragmatic theory of observation," according to which you attend to causes of the production of a certain observational sentence, rather than the meaning of that sentence (1981a, p. 93). He does not elaborate further, but this claim is difficult to uphold given his insistence that even the meanings of "descriptive terms" are different in incommensurable theories. He also argues that "when making a comparative evaluation of classical physics and of general relativity we do not compare meanings; we investigate the conditions under which a structural similarity can be obtained" (1981b, pp. 102–3). And he insists that "there may be empirical evidence against one [theory], and for another theory without any need for similarity of meanings" (1981c, p. 116). On a more sarcastic, though revealing, note, Feyerabend states: "Of course, *some* kind of comparison is *always* possible (for example, one physical theory may sound more melodious when read aloud to the accompaniment of a guitar than another physical theory)" (1975, p. 32; emphasis original). At any rate, he insists that "it *is* possible to use incommensurable theories for the purpose of mutual criticism," adding that this removes "one of the main 'paradoxes' of the approach" that he suggests (1981c, p. 117; emphasis original). Finally, he uses the same analogy that Kuhn uses to explain a scientist's ability to learn a new theory, that of a child learning a new language. Rather than translating between languages, "[w]e can learn a language or a culture from scratch, as a child learns them, without detour through our native tongue" (1987, p. 266).

Responses to incommensurability

Responses to incommensurability have been profuse in the philosophy of science, and only a small fraction can be sampled here. Two main trends may be distinguished. The first denies some aspect of the claim, and suggests a method of forging a linguistic comparison among theories, while the second, though not necessarily accepting the claim of linguistic incommensurability, proceeds to develop other ways of comparing scientific theories.

In the first camp are those who have argued that at least one component of meaning is unaffected by untranslatability: namely, reference. Israel Scheffler (1982) enunciates this influential idea in response to incommensurability, but he does not supply a theory of reference to demonstrate how the reference of terms from different theories can be compared. Later writers seem to be aware of the need for a full-blown theory of reference to make this response successful. Hilary Putnam (1975) argues that the causal theory of reference can be used to give an account of the meaning of natural kind terms, and suggests that the same can be done for scientific terms in general (see NATURAL KINDS). But the causal theory was first proposed as a theory of reference for proper names, and there are serious problems with the attempt to apply it

to science. An entirely different language-based response to the incommensurability claim is found in Donald Davidson (1985). Davidson contends against Kuhn that all putative conceptual schemes, presumably including the scientific theories embedded within them, are intertranslatable. The argument is a powerful one, but it proceeds at a purely general level. Davidson does not show in practice how specific scientific theories can be expressed in the same terms.

The second kind of response to incommensurability proceeds to look for nonlinguistic ways of making a comparison between scientific theories. Among these responses, one can distinguish two main approaches. One approach advocates expressing theories in model-theoretic terms, thus espousing a mathematical mode of comparison. This position has been advocated by writers such as Joseph Sneed and Wolfgang Stegmüller, who have shown how to discern certain structural similarities among theories in mathematical physics. But the methods of this "structuralist approach" do not seem applicable to any but the most highly mathematized scientific theories. Moreover, some advocates of this approach have claimed that it lends support to a model-theoretic analogue of Kuhn's incommensurability claim. Another trend which has emerged more recently involves the so-called cognitive approach to science, which takes scientific theories to be entities in the minds or brains of scientists, and regards them as amenable to the techniques of recent cognitive science; proponents include Paul Churchland, Ronald Giere, and Paul Thagard. Thagard's (1992) is perhaps the most sustained cognitivist attempt to reply to incommensurability. He uses techniques derived from the connectionist research program in artificial intelligence, but relies crucially on a linguistic mode of representing scientific theories without articulating the theory of meaning presupposed. Interestingly, another cognitivist who urges using connectionist methods to represent scientific theories, Churchland (1992), argues that connectionist models vindicate Feyerabend's version of incommensurability.

The issue of incommensurability remains a live one. It does not arise just for a logical empiricist account of scientific theories, but for any account that allows for the linguistic representation of theories. Discussions of linguistic meaning cannot be banished from the philosophical analysis of science, simply because language figures prominently in the daily work of science itself, and its place is not about to be taken over by any other representational medium. Therefore, the challenge facing anyone who holds that the scientific enterprise sometimes requires us to make a point-by-point linguistic comparison of rival theories is to respond to the specific semantic problems raised by Kuhn and Feyerabend. However, if one does not think that such a piecemeal comparison of theories is necessary, then the challenge is to articulate another way of putting scientific theories in the balance and weighing them against one another.

References and further reading

Churchland, P. M. 1992: A deeper unity: some Feyerabendian themes in neurocomputational form. In *Minnesota Studies in the Philosophy of Science*, vol. 15: *Cognitive Models of Science*, ed. Ronald Giere (Minneapolis: University of Minnesota Press), 341–63.

Davidson, D. 1985: On the very idea of a conceptual scheme. In *Inquiries into Truth and Interpretation* (Oxford: Oxford University Press), 183–98 (1st pub. 1974).

Feyerabend, P. K. 1970: Consolations for the specialist. In *Criticism and the Growth of Knowledge*, ed. I. Lakatos and A. Musgrave (Cambridge: Cambridge University Press), 197–230.

—— 1975: *Against Method* (London: Verso).

—— 1981a: Explanation, reduction, and empiricism. In *Philosophical Papers*, vol. 1: *Realism, Rationalism and Scientific Method* (Cambridge: Cambridge University Press), 44–96 (1st pub. 1962).

—— 1981b: On the "meaning" of scientific terms. In *Philosophical Papers*, vol. 1: *Realism, Rationalism and Scientific Method* (Cambridge: Cambridge University Press), 97–103 (1st pub. 1965).

—— 1981c: Reply to criticism: comments on Smart, Sellars, and Putnam. In *Philosophical Papers*, vol. 1: *Realism, Rationalism and Scientific Method* (Cambridge: Cambridge University Press), 104–31 (1st pub. 1965).

—— 1987: Putnam on incommensurability. In *Farewell to Reason* (London: Verso), 265–72.

Kuhn, T. S. 1970a: *The Structure of Scientific Revolutions*, 2nd edn (Chicago: University of Chicago Press; 1st pub. 1962).

—— 1970b: Reflections on my critics. In *Criticism and the Growth of Knowledge*, ed. I. Lakatos and A. Musgrave (Cambridge: Cambridge University Press), 231–78.

—— 1976: Theory-change as structure-change: comments on the Sneed formalism. *Erkenntnis*, 10, 179–99.

—— 1977: *The Essential Tension* (Chicago: University of Chicago Press).

—— 1983: Commensurability, comparability, communicability. In *PSA 1982: Proceedings of the 1982 Biennial Meeting of the Philosophy of Science Association*, vol. 2, ed. P. D. Asquith and T. Nickles (East Lansing, MI: Philosophy of Science Association), 669–88.

—— 1990: Dubbing and redubbing: the vulnerability of rigid designation. In *Minnesota Studies in the Philosophy of Science*, vol. 14: *Scientific Theories*, ed. C. Wade Savage (Minneapolis: University of Minnesota Press), 298–318.

Putnam, H. 1975: Is semantics possible? In *Philosophical Papers*, vol. 2: *Mind, Language and Reality* (Cambridge: Cambridge University Press), 139–52 (1st pub. 1970).

Scheffler, I. 1982: *Science and Subjectivity*, 2nd edn (Indianapolis: Hackett; 1st pub. Indianapolis: Bobbs-Merrill, 1967).

Thagard, P. 1992: *Conceptual Revolutions* (Princeton: Princeton University Press).