Paradigms, Theories, Frameworks, Incommensurability, and Theory Ladenness[1]

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1. Introduction

In his famous book on scientific revolutions, Thomas Kuhn makes an important distinction between normal science and revolutionary science (Kuhn 1962, 1970). The activities of normal science take place within what he calls a "paradigm" of scientific research. According to him, "A paradigm is what the members of a scientific community share, and, conversely, a scientific community consists of men who share a paradigm." (Kuhn 1970: 176). A scientific revolution takes place when one paradigm replaces another. Galileo, Newton, and Einstein are examples of such scientific revolutions involving paradigm shifts.

Pursuing this distinction, Kuhn makes a controversial claim of incommensurability: scientific theories that belong to two different paradigms are incommensurable, that is, they use different yardsticks to measure their success. Since they do not share a common measurement of success, the superiority of one theory over another cannot be established on empirical-rational grounds. Instead, debates between theories of different paradigms necessarily involve rhetorical strategies, appeal to subjective intuitions, and so on, not unlike what happens in typical election campaigns that are aimed at persuading people to vote for a given candidate. As Kuhn puts it, ". . . the superiority of one theory to another is something that cannot be proved by debate. Instead, as I have insisted, each party must try, by persuasion, to convert the other" (Kuhn 1970:198).

Given that Newton's theory and Einstein's theory belong to two different paradigms, the doctrine of incommensurability claims that the superiority of Einstein's theory over Newton's theory cannot be established on the basis of observation and reasoning. A post modern doctrine that accompanies incommensurability is the idea that the observations that lend support to a theory are theory laden in the sense that they are statable only in the language of the theory, and hence the correctness of the predictions of a theory cannot be evaluated independently of the theory. Such a conclusion is unacceptable to researchers who have some experience of defending theoretical innovations in scientific disciplines. Either these practitioners of science are unable to see the truth that Kuhn has seen, or Kuhn was making an incorrect claim. This article takes the latter position.

The idea that debates between scientific theories and debates between political candidates are conducted along similar lines have had a number of undesirable outcomes among some academics who aspire to be intellectuals, particularly those with "postmodern" leanings in the social sciences. One of them is the failure to acknowledge or even understand the distinction between scientific argumentation and propaganda. The second is the legitimizing of of propagandist rhetorics, which has the result of inhibiting the attempt to strive for more rigorous argumentation. The third is the unavoidable conclusion that all theories are equally good, and therefore one should not try to criticise other people's

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theories. As a practitioner of scientific research, I find the last two results extremely dangerous for honest academic pursuits.

Kuhn's notion of paradigms and the related notions of normal science, scientific revolutions, and incommensurability have had a significant role in illuminating the nature and history of scientific knowledge. As I see it, however, the lack of conceptual clarity in the use of the terms "paradigm shift" and "scientific revolution" to refer to changes in a number of related but distinct parameters have also had the result of confusing subsequent discussions in the field. I will attempt to tease out these different concepts as a way of finding where incommensurability does legitimately occur, and where the alleged incommensurability is an illusion.

That Kuhn uses the term "paradigm" to refer to many distinct concepts has been voiced by many, and is acknowledged by Kuhn himself. In what follows, I will factor apart the different concepts of paradigm in terms of value systems, theories, theoretical frameworks, and observational frameworks. As far as I know, the importance of these distinctions to philosophy of science have not been adequately appreciated in the literature. I will show that true incommensurability arises only when the value systems of two communities are not the same. Disagreements of theories can be rationally discussed without any incommensurability, provided we agree to use the same language for the statement of observations. Such a neutral language is not impossible in principle. Given these findings, it follow that disagreement between a creationist and an evolutionist may involve unresolvable incommensurability, but not the disagreement between Newton and Einstein, or between Galileo and Newton. Within the value system of modern science that Galileo and Einstein share, there is no danger of an unresolvable incommensurability in the debates between competing theories.

2. Ingredients of Paradigms

Let us begin with Kuhn's statement that a paradigm is what the members of a scientific community share. What are the kinds of things shared by the members of a scientific community? When we ask this question, a large number of related but separate possibilities suggest themselves. Among them are the following:

A. Paradigms as **value systems**: rules of the game of knowledge creation and knowledge evaluation (criteria of success).

B. Paradigms as **research interests**: objects of inquiry, points of view in looking at the object, phenomena which are considered important or interesting, etc.

C. Paradigms as **theories**: sets of theoretical laws and the propositions that connect the laws to observations, such that they explain what we observe.

D. Paradigms as **models**: a general conception of reality on the basis of which theoretical laws are formulated (e.g. both Newton's laws and Kepler's laws share the heliocentric model).

E. Paradigms as **bodies of facts**: sets of observations that call for explanation in terms of a theory.

F. Paradigms as **theoretical frameworks**: vocabularies associated with sets of related concepts in terms of which the propositions of the theory are formulated.

G. Paradigms as **observational frameworks**: vocabularies associated with sets of concepts in terms of which the propositions of observation are formulated.

In the postscript to the second edition of his famous book *Structure of Scientific Revolutions*, Kuhn acknowledges that he had been using the term paradigm in many senses, citing Masterman (1970), who lists twenty two different meanings of the term. However, Kuhn (1970:182-2) goes on to say that:

> "Most of these differences are, I now think, due to stylistic inconsistencies (e.g. Newton's Laws are sometimes a paradigm, sometimes parts of a paradigm, and sometimes paradigmatic), and they can be eliminated with relative ease. But, with that editorial work done, two very different usages of the term should remain, and they require separation."

The two non-stylistic distinctions that Kuhn (1970:173) acknowledges are:

> "On the one hand, it stands for the entire constellation beliefs, values, techniques, and so on shared by members of a given community. On the other, it denotes one sort of element in that constellation, the concrete puzzle–solutions which, employed as models or examples, can replace explicit rules as a basis for the solution of the remaining puzzles of normal science."

Kuhn refers to these two meanings as the "sociological sense" of the paradigm and paradigm as "exemplars". One may think of the sociological sense of paradigm as the implicit constellation of beliefs, values, techniques and so on that one can abstract away from the exemplars. The concepts I have listed as A–G may then be thought of as subconstellations of paradigms in the sociological sense of the term.

In another section of the postscript, however, Kuhn introduces the notion of the disciplinary matrix that acts as the prerequisite for the formulation of theoretical laws. Kuhn (1970:182) views a disciplinary matrix as consisting of what he refers to as symbolic generalisations, models, and values. Kuhn's symbolic generalisations appears to correspond to what I have called a theoretical framework (item F). Kuhn's model and value are identical to items D and A respectively. Finally, Kuhn also talks about what he calls the "primitive perceptual experience," which I have called the observational framework that scientists share with lay people (item G). In a sense, therefore, the list of items I have given in A – G is a further clarification and extension of what is implicit in Kuhn's epilogue.

My contention in what follows is that the differences among A – G are not stylistic inconsistencies that a copy editor can easily rectify, but are important conceptual differences whose consequences Kuhn did not pursue seriously. Once these distinctions are made, Kuhn's claims of the inevitability of incommensurability will turn out to be correct for some of these notions of paradigm, and incorrect for others.

I will argue that, contrary to what Kuhn appears to suggest, differences in theoretical frameworks, models or laws do not engender incommensurability. Incommensurability between two theories occurs when they are embedded in two distinct value systems, or when the predictions they make are formulated in distinct observational frameworks. The first type of incommensurability is unresolvable. The second type is resolvable by an observational language neutral to the two theories, contrary to what Kuhn claims. Since Newton's and Einsteins theories are embedded in the same value system, there is no unresolvable incomensurability between the two. The superiority of Einstein's theory can be established on empirical-rational grounds in a way that is acceptable to both Newton and Einstein.

3. Paradigms as Value Systems

3.1. Value system in the physical sciences

Knowledge construction and evaluation presuppose commitment to a value system that allows us to evaluate the reliability of knowledge claims. We may refer to them as "criteria of success", or "rules of the game". In the original text of *Scientific Revolutions*, Kuhn (1970:48) uses the term "standards" but in the postcript he uses the term "values" (Kuhn 1970:184-5):

> "Probably the most deeply held values concern predictions: they should be accurate; quantitative predictions are preferable to qualitative ones; whatever the margin of permissible error, it should be consistently satisfied in a given field; and so on. There are also, however, values to be used in judging whole theories: they must, first and foremost, permit puzzle-formulation and solution; where possible they should be simple, self-consistent and plausible, compatible with other theories currently deployed. (I now think it a weakness in my original text that so little attention is given to such values as internal and external consistency in considering sources of crisis and factors of theory choice). Other sorts of values exist as well – for example, science should (or need not be) socially useful…"

To expand Kuhn's remarks, we may say that the community of theoretical physicists are committed to the following propositions, either tacitly or explicitly:

(**1**) Rules of the game in theoretical physics

a. A theory is a general explanation for a set of observed puzzles in a domain.
b. An explanation is a collection of logically related propositions (hypotheses) from which we can infer a set of predictions that match the observations.
c. The success of a theoretical hypothesis is checked by making observations, and checking how well the hypotheses derive these observations.
d. The best explanation is one which successfully explains the widest range of puzzles (generality) with the smallest number of propositions (simplicity).
e. An argument for a theoretical hypothesis should demonstrate the credibility of the hypothesis. To do this, we must show that for a set of observations that call for an explanation, the hypothesis in question leads to the best available explanation.
f. An explanation should be internally consistent; that is, there should be no logical contradictions between the propositions of an explanation.
g. An explanation should be externally consistent; that is, the collection of explanations within the body of knowledge (within and across disciplines) should not contradict one another.
h. An explanation should be empirically consistent; that is, the predictions of the explanation should not logically contradict the observations (incorrect predictions).
i. Given a set of observations, there can be many alternative explanations.

j. No explanation is infallible. Theoretical knowledge cannot guarantee certainty.
k. The truthhood of theoretical knowledge is tentative. A theory that is deemed to be true on the basis of currently available information may be deemed to be false when additional information becomes available.

The above list of criteria of success is by no means exhaustive, but it will suffice to give a fair idea of what I mean by the value system. I am not in a position to discuss each of these statements in an article, so I will briefly illustrate how pursuit in different paradigms of knowledge can involve commitments to different sets of values.

3.2. Value system in mathematics

Compare the notions of theory in physics and mathematics. When we talk about a theory of gravitation or subatomic phenomena in physics, we are talking about a set of logically related statements that provide an explanation for a body of observations (1a, b). We argue for the hypotheses that make up such theories by demonstrating their ability to explain the observations (1c, d). These two commitments are not important for the pursuit of mathematics. The number theory and graph theory in mathematics are not explanations of any observable phenomana, but a set of axioms and their logical consequences. We argue for theorems in mathematics not by demonstrating their empirical usefulness, but by demonstrating that the theorems follow logically from the axioms.

Compare the requirements in (1a) with (2a), (1c) with (2b), (1e) with (2c), and (1k) with (2e):

(**2**) Rules of the game in mathematics

a. A theory is a combination of (i) a set of axioms, and (ii) a set of theorems that can be inferred from these axioms. (Mathematics may turn out to be useful in constructing explanations of observed phenomena, but this is not a commitment in the discipline)
b. The success of a theorem is checked, not by observing the world, but by checking the derivation of the theorem from the axioms.
c. An argument for a theorem (=proof) demonstrates the credibility of the theorem. To do this, we must demonstrate that the theorem is logically derivable the axioms of the mathematical system in question.
d. A theory should be internally consistent; that is, there should be no logical contradictions between the propositions internal to a theory.
e. A theorem once proved to be true remains true for ever (unless there is an error in the alleged proof). No amount of additional information will reverse the truth status of a theorem.

The only commitment that mathematics shares with physics is that of internal consistency ((1e) and (2d)). In particular, mathematics does not have the empirical commitment to empirical consistency (1h), or explanation of observed phenomena (1a-d). It also does not share the tentativeness of conclusions (1k) vs. (1e). Such differences show that the paradigm of mathematics is fundamentally different from that of physics.

As an illustration of these differences, consider (1e) and (2c). What is known as Goldbach’s conjecture provides a telling example of the difference between a physicist’s argument and a mathematician's argument. The conjecture, proposed by Christian Goldbach in 1742, is given in (3):

(**3**) Every even integer greater than 2 can be expressed as the sum of two primes.

The examples given in (4) illustrate the proposal in (3);

(**4**) Data/examples for the Goldbach's conjecture

4 = 2 + 2
6 = 5 + 1
8 = 5 + 3
10 = 7 + 3
12 = 7 + 5
14 = 7 + 7
16 = 13 + 3
18 = 13 + 5
20 = 17 + 3
22 = 19 + 3
and so on

An extensive search reveals that all the even numbers observed so far obey Goldbach's conjecture. However, no one has been able to prove the conjecture by showing that the conjecture is a logical consequence of the axioms of the number theory (2c). Nor has anyone proved that the conjecture is false. Thus, proposition (3) remains a conjecture in mathematics, neither true nor false.

On the other hand, if we were to accept the paradigm of physics (1e), the argument for Goldbach's conjecture would go as follows:

(**5**) Empirical argument for Goldbach's conjecture

All the even numbers observed so far, including those in (3) and many others, obey Goldbach's conjecture.
We have not yet observed a single even number that violates the conjecture.
In the absence of counterevidence, therefore, we accept (3) as correct.

Though this is a perfectly valid argument in theoretical sciences like physics, it cannot be considered a proof in mathematics. Even if we examine a billion billion even numbers to find that each of them obeys the conjecture, we cannot eliminate the distant possibility that there is some even number that we have not yet observed which violates the conjecture. Thus, a perfectly valid argument in physics is not a valid argument in mathematics ((1e) vs. (2c)).

As another example, consider the issue of tentativeness ((1k) vs. (2e)). Take the theorem of Pythagoras, which was proved to be true more than two thousand years ago. No amount of novel information will reverse the status of this theorem, and make it false (2e). In contrast, take Newton's hypothesis that time and space are independent, i.e., non-interacting. Even though this hypothesis was deemed to be correct for a long time, information available in the twentieth century shows that it is incorrect (1k). Such situations are common in physics, but not in mathematics.

Assuming that physics is a science, does the difference between (1) and (2) indicate that mathematics is not a science? The question is one of terminology. If we wish, we may treat the rules of the game in (1) as definitional of science, in which case mathematics will not be a science by definition. Alternatively, we can treat mathematics and logic as the sciences of reasoning, in which case (1) would be a characterisation of empirical sciences (or at least of the physical sciences), while (2) would be a characterisation of the sciences of reasoning.

3.3. Value system in History

Are anthropology and history sciences? Once again, there is a sense in which the question is one of terminology. It might be more fruitful to ask in what respects anthropology and history are committed to (1) or (2), and in what respects they involve commitments to alternative rules of the game. As an outsider to the discipline of history, I find that the pursuit of history does not involve a commitment to developing a theory (or theories) of history. Like physicists, historians are interested in explanations. Physicists want to know why a bomb dropped from a flying plane continues moving forward and comes down in a curved path. Historians want to know why the second world war took place. To this extent, they have shared characteristics. However, physicists construct their explanations for particular situations by proposing a set of general hypotheses that are applicable to the situations in the domain as a whole. A constellation of such general hypotheses form a theory. In contrast, historians do not appear to have a commitment to developing a theory that would lead to explanations of a large number of historical events. For instance, I take it that a historian would be interested in answering questions such as those in (6), but not those in (7):

(**6**) a. Why did Caesar invade Egypt?
b. What were the causes of the second world war?

(**7**) a. Why do invasions take place in human history?
b. Why do human beings engage in wars?

Answering (7a) would lead to a general theory of invasions. Answering (7b) would lead to a general theory of wars. As far as I can tell, historians do not have a commitment to developing such theories. We may therefore distinguish between the paradigms of physicists and historians as follows:

(**8**) Physics is committed to goal of developing general theories on the basis of which explanations of particular puzzles are proposed. History does not have this commitment.

3.4. Value system in normative pursuits

Research in academic disciplines may be guided by either of the following quesitons:

Explanatory:
What is the best explanation for the observed states of affairs in the world?

Normative:
What is the best course of action to improve the states of affairs in the world?

The goal of an explanatory pursuit, as in physics, biology, and cosmology, is understanding. The goal of a normative pursuit, as in engineering, medicine, and law is to improve the human conditions. The best theory in an explanatory paradigm is one that yields the best predictions of observed states of affairs, while the best theory in a normative paradigm is one that yields the best courses of action to change the existing states of affairs.

Many disciplines in the social sciences such as sociology, economics and linguistics exhibit a conflict between these two value systems. For Noam Chomsky, the best linguistic theory is one that best explains the facts of natural languages. For Michael Halliday, the best linguistic theory is one that maximally helps the pursuits of language teaching, machine language processsing, and so on, in addition to describing the existing facts. Do the laws of human behaviour describe how human beings actually behave (e.g. they are not always honest, they sometimes compete and sometimes cooperate), or do they prescribe how human beings ought to behave? (e.g. they should be honest, they should cooperate). Sociologists and economists appear to be divided on this count. A lack of appreciation of the commitments to the two goals will clearly result in unnecessary controversies.

3.5. Value system in religious studies

Our final example would be the value systems of the sciences and religious studies. As Galileo expressed it, disagreements in the (physical) sciences are settled on the basis of experiments (or observations, to be precise). In contrast, debates in religious studies are settled on the basis of appeal to the authority of scriptures. In order to settle a debate on whether human souls are divine or not, chances are that a community of devotees would appeal to their scriptures. The assertions of the scriptures are taken as representing unchallengable true knowledge in most religions. Appeal to the opinions of authorities would not be considered a legitimate way of settling a dispute in the physical sciences.

Assuming that what I have said above is not an unfair characterisation, an essential difference between the paradigms of science and religious studies may be expressed as follows:

(**9**) Debates are settled in the sciences on the basis of observations and reasoning. Appeals to authority are not legitimate arguments for a position in the sciences. Religious studies permit appeals to authority.

3.6. Value systems and scientific revolutions

The examples discussed in the previous sections should give the reader a fair idea of the possible differences between knowledge paradigms with respect to the rules of the game they subscribe to. If we use the word “paradigm” to refer to constellations of values of the kind illustrated above, it becomes clear there have not been any revolutions in the paradigm of the physical sciences since Galileo. The value system that Galileo subscribed to is that of explanations of observations in terms of correct predictions, simplicity, generality, and so on. These values have continued constraining the growth of science through Newton and Einstein. At best we may say that the paradigm of the physical sciences have evolved somewhat to accommodate an awareness of fallibility and tentativeness (1 i,j,k) characteristic of twentieth century science. If so, the term “scientific revolution” is a misnomer if we wish to describe the transition from Newton to Einstein.

The differences of paradigm discussed in the previous section are mostly independent of the subject matter. Thus, paradigm of research called generative linguistics (led by Noam Chomsky) subscribes to all the commitments listed in (1a-k). In contrast, the paradigm of research called systemic functional linguistics (led by Michael Halliday) rejects most of these requirements. A number of linguists who practice what are called discourse analysis and sociolinguistics also reject the commitments in (1a-k), preferring to associate themselves with the paradigm of literary criticism rather than to the paradigm of the physical sciences. If physics and generative linguistics belong to the same paradigm with respect to the value system, but systemic linguistics and sociolinguistics do not, then the notion of paradigm as value system is useful in describing the current styles knowledge building, but not particularly useful in describing the history of the physical sciences from Galileo and Boyle to Einstein and Bohr.

3.7. Value systems and incommensurability

It is fairly obvious that incommensurability will arise if two debating parties do not share the same value system. Imagine, for example, a debate between individual x who is committed to the criterion that truth must be consistent with scriptures, but not necessarily with observations, and individual y who is committed to the criterion that truth must be consistent with observations but not necessarily with scriptures. No rational debate on creationism and evolutionism is possible between x and y. Take another example of a debate between a mystic who seeks to understand reality through direct mystical experience of the hidden reality and a scientist who seeks to understand reality by a combination of guess work and reasoning applied to observable reality. The mystic distrusts the role of reasoning in the pursuit of knowledge, and the scientist distrusts the role of non-replicable experiences. Clearly, no rational debate is possible between the two parties either.

As a generative linguist committed to the criteria of success in (1), I have often experienced incommensurability when arguing with systemic functional linguists who do not share these criteria. While generative linguists view linguistics as a science discipline, systemic functional linguists view linguistics as a humanities discipline. It is natural, therefore, that the yardsticks used by these two communities are distinct, and hence they do not come up with the same judgements of success.

Prior to settling a debate between two theories, therefore, it is necessary to make sure of a shared value system. If the value systems are distinct, the debate should first concentrate on establishing the differences in the value systems, and choosing the best value system appropriate for the phenomenon in question. Quite often, this is indeed what happens when the debating parties are sensitive to differences in the value system. As Kuhn points out, for instance, ". . . assimilation of Galileo's and Newton's mechanics gave rise to a particularly famous series of debates about the standards legitimate to science." (Kuhn 1970:48).

It is natural that a debate on the value system cannot be conducted entirely on rational grounds. Consider, for instance, a debate on the reliability of reasoning between a mystic and a scientist. Since the mystic's starting point involves the rejection of the reliability of rational debates, it is clear that the rationalist cannot use reasoning to convince the mystic that reasoning is reliable. nor can the mystic use reasoning to convince the rationalist that reasoning is unreliable. Hence, Kuhn is correct in pointing out that when it comes to such disagreements, empirical-rational debates are replaced by rhetorical persuasive strategies.

On the basis of the preceding examples and discussion, I take it that we are justified in accepting the following conclusion:

> *It is not necessary that all academic communities share the same value system on the basis of which claims of knowledge are judged. Disagreements between two parties who do not share a single value system generally results in incommensurability.*

4. Paradigms as Research Interests

Differences in subject matter are relevant for the notion of paradigm as a constellation of research interests. Take, for instance, the study of language called linguistics. Language can be studied from many different angles, each angle yielding its own object of inquiry. What I referred to above as Chomskian generative linguistics is interested in the psychological aspect of language, defines its object of inquiry as the mental linguistic system of human beings, and sees itself as a branch of cognitive psychology and neuropsychology. Within this paradigm, the common sense notion of language as in “the English language”, “the French language” and “the Malay language” are sociolinguistic notions, not cognitive notions. Rather, the object of inquiry is the mental linguistic systems of different human individuals and the mental linguistic system of the human race. The question whether two individuals speak the same language or not is irrelevant for Chomskian linguists.

In contrast, what is called sociolinguistics, which is concerned with the social aspect of language, defines its object of inquiry as the social linguistic system, and aligns itself with sociology rather than psychology. Unlike the Chomskian paradigm, the sociolinguistic paradigm is committed to the study of entities like “the English language” and “the French language”. Though related, the research interests of the two paradigms of linguistics, are not the same: they are mutually complementary.

Similar differences of paradigms due to differences in research interests appear in domains like sociology and literary criticism. In the study of both literature and society, some researchers are interested in issues of class differences, while others are interested in issues of gender differences. The best way of viewing such differences is to acknowledge that these two objects of inquiry mutually complement and enrich each other, precisely the way in which the study of the human mind and the study of human society are mutually complementary and enriching. There is no competition or contradiction between these interests (except perhaps in the competition for research funding and teaching positions). Why should one think of physics and chemistry, or chemistry and biology being in conflict?

In practice, however, researchers behave as if differences in research interests necessarily entail contradiction or conflict. In linguistics, for instance, there is unnecessary distrust and even hostility between the researchers who belong to the generative linguistics paradigm and the sociolinguistics paradigm, which is unfortunate. Similarly, there is a mistaken perception of conflict between those who subscribe to the paradigm of Freudian literary analysis and those who subscribe to the study of literature from a historical perspective. One can find examples of such needless paradigm conflicts in almost every domain of social sciences and humanities. Rather than saying “I am interested in X and you are interested in Y”, researchers tend to say, “What I am interested in is more important than what you are interested in.” or “What you are interested in is pointless.”

As can be gathered from these examples, an awareness of the differences in research interests is indeed necessary to gain a general perspective of the research in social sciences and humanities. However, as in the case of paradigms as value systems, terms like “revolution” and “incommensurability” are inapplicable to the description of differences in paradigms as research interests.

Does incommensurability arise between different interest groups? Not if people are sensible enough to see that “I am interested in X, not Y” does not mean the same thing as “X is more important than Y”. There is no need for a debate if A says A is interested in X and B says B is interested in Y. But such debates do happen quite often, particularly in humanities and social sciences.

Once again, Kuhn is right in pointing out that debates on the relative superiority of different interests cannot be settled on rational grounds. But my response to this particular case of incommensurability is that it is futile to engage in debates of self-importance. A debate between generative linguists and sociolinguists on the relative importance of mental linguistic phenomena and social linguistic phenomena is as pointless as a debate between a psychologist and a sociologist on whose field of inquiry is superior. I am aware that there are debates between, say those who subscribe to feminist and Freudian literary theories, or between Jungian and Marxist literary theories, but I fail to see why they engage in debates.

If the reader shares my perception, we can accept the following conclusion:

> *It is not necessary that all academic communities share the same research interests. Debates between two parties who do not have the same research interests on the relative superiority of their interests cannot be settled on rational grounds. However, such debates are pointless and should be avoided if possible.*

5. Paradigms as Theories

Another possible sense in which one might use the term “paradigm” is that of “theory”. The term “theory” can mean different things to different communities of academics, as can be seen from examples like the following:

Newton’s theory of gravitation
Freud’s theory of the unconscious mind
Aristotle’s theory of tragedy
Advanced piano theory

It is fairly clear that the word “theory” is not attached to the same constellation of concepts in the above examples. The exact concept of theory subscribed to by a research community is a matter of the value system of the paradigm. Thus, the use of the word theory in the paradigms of the physical sciences and literary criticism do not indicate commitment to the same concept.

I have already indicated that there can be can many distinct research interests that share the same value system, or vice versa. There can also be many distinct theories sharing the same value system and research interests. Now, we are free to use the term “paradigm”, as Kuhn appears to do, to express differences in any of the above dimensions. If we do, however, we must be careful to specify whether we are referring to differences in the value system, research interest, or theory. For the sake of expositional convenience, let us use the expression **V-paradigm** to refer to differences in the value system, **R-paradigm** to refer to differences in research interests, and **T-paradigm** to refer to theoretical differences.

Take, for instance, Einstein’s and Newton’s theories of gravitation. These two theories share the same value system not shared by theories of literature such as feminist and Marxist theories, or post-modern theories of power and discourse. Therefore the theories of gravitation are examples of the same V-paradigm. They also share the same research interests and hence are examples of the same R-paradigm. However, they are not committed to same theoretical laws, and hence they are examples distinct T-paradigms. The so-called scientific revolution that Einstein initiated therefore is a revolution in the T-paradigm within the same V-paradigm and R-paradigm. In contrast, the scientific revolution that Noam Chomsky initiated in the fifties in linguistics involves a shift in the V-paradigm, R-paradigm, and T-paradigm.

When Galileo enunciated the principle that disagreements in science are settled on the basis of experiment, he was effecting a change in the V-paradigm, which involved the rejection of authority or scriptures as the basis of arbitration and adopting observation as a basis (1c). This paradigm of knowledge is distinct from the one that Decartes enunciated in philosophy, which made an appeal neither to observations or scriptures, but to the first principles or “self-evident” truths. To this extent, the Cartesian paradigm of knowledge is the same as the V-paradigm of knowledge in Euclidean geometry that Decartes took as his role model, not the V-paradigm of physics.

6. Laws and Frameworks

As pointed out above, a theory in the physical sciences is a set of theoretical laws and the propositions that connect the laws to observations, such that they explain what we observe. Now, theoretical laws presuppose a theoretical framework, a language in which theoretical laws are expressed and phenomena are represented. Such a language minimally involves a vocabulary of related concepts. Observational statements presupposes an observational framework, a language in which observations are expressed. In the following sections, we explore the notions of laws, framework and observations.

6.1. An Example of a Theoretical Explanation from the Physical Sciences

Let us take a concrete example of how theoretical explanations involve theoretical laws, theoretical frameworks, observations, and observational frameworks. Take the observational puzzle stated in (10):

(**10**) Two observational puzzles

a. I see someone dropping a coin from a tall building. The coin comes down to the earth in a straight line. Why didn’t the coin come down in a curved path?

b. I also see someone dropping a bomb from a plane flying horizontally. The bomb comes down to the earth in a curved path: it continues moving forward as it comes down. Why didn’t the bomb come down in a straight line?

We can provide an explanation to the puzzle in (10) using Newtonian mechanics. To begin with, we appeal to the laws that Newton formulated. The ones which are relevant for our purposes are the simplified versions in (11a), (11b) and (11d).

(**11**) Newton’s Laws

a. A body (such as a coin, bomb, or the moon) continues in a state of rest or uniform motion in a straight line unless there is a force acting on it.

b. A force which acts on a body has the effect of increasing its velocity. The rate of change of velocity is proportional to and in the same direction as the force acting on it.

c. Every body exerts a force of attraction on every other body.

(11c) is a simplified version of Newton's law of gravitation.[2] (11a) and (11b) are simplified versions of Newton's first and third laws of motion.[3] In order to connect (11) to (10), we need the additional statements in (12). Following Kuhn, I will refer to them as definitions.

(**12**) Definitions

a. The VELOCITY of a body is its rate of change of LOCATION.

b. Change of LOCATION is DISTANCE.

c. VELOCITY is distance divided by TIME.

Given (11) and (12), the explanation for (10) can be stated as (13), along the lines of the familiar derivations in mathematics and logic:

(13) Derivation of (10a):

a. <u>observation 1</u> in (10a) = The person drops a coin from a stationary tower.

b. Given (11c), it follows that the earth exerts a force on the coin.

c. Given (11b), it follows that the coin will increase its velocity in the direction of the earth. Since the coin was originally at rest ((13a)), by (12a-c) we infer that the location of the coin will be nearer the earth with the passage of time (= the coin will start moving towards the earth).

d. Since there is no other force acting on the coin, by (11a) it will move in a straight line.

e. = <u>observation 2</u> in (10a): the coin moves in a straight line towards the earth.

The derivation in (13) explains (10a) by demonstrating a connection between the two observations in (10). Likewise, derivation (14) explains (10b) by connecting the two observations in (10b):

(14) a. <u>observation 1</u> in (10b) = The person drops a bomb from a plane flying horizontally. .

b. Given (11c), it follows that the earth exerts a force on the bomb.

c. Given (11b), it follows that the bomb will increase its velocity in the direction of the earth. Since the bomb was originally at rest in the perpendicular axis ((14a)), by (12a-c) we infer that that the location of the

---

[2] .A fuller version of (11c) is: There is a force of attraction between any two bodies in the universe. For any two bodies, the force of attraction is directly proportional to (the product of) their masses and inversely proportional to (the square of) the distance between them.

[3] The standard formulation of (11b) is "The rate of change of momentum of a moving body is proportional to and in the same direction as the force acting on it." I have taken liberties with this law to make it more accessible to readers who are uncomfortable with physics.

bomb will be nearer the earth with the passage of time (= the bomb will start moving towards the earth).

d. Since the bomb was originally moving horizontally ((14b)), and there is no force on the bomb along the horizontal direction, it follows from (11a) that it will keep moving in the horizontal direction.

e. The combined effect of the vertical and horizontal motions above will be motion towards the earth on a curved path.

f. = <u>observation 2</u> in (10b): the coin moves towards the earth in a curved path.

6.2. Theories, Theoretical Laws, and Theoretical Frameworks

Let us take a closer look at the example of puzzles and explanation in the previous section. The observational puzzles that Newtonian mechanics is concerned with and the explanations they provide for these puzzles crucially involve a vocabulary that includes terms like force, momentum, acceleration, mass, distance, and so on. We will use the term **theoretical framework** to refer to such a vocabulary, the concepts associated with it, and the relations amongst these concepts.

(15) Theoretical framework of Newton's theory

a. Concepts: FORCE, MOMENTUM, ACCELERATION, VELOCITY, DISTANCE, TIME, MASS.

b. Definitions:
force = product of mass and acceleration
momentum = product of mass and velocity
velocity = change of location divided by time (rate of change of location)
acceleration = change of velocity divided by time (rate of change of velocity)

The laws of Newton's theory in (11), as well as the definitions in (12), are formulated in terms of this framework.

It is important to note that even though the theoretical laws and definitions presuppose a theoretical framework, it is possible to formulate many altenative theories using the same framework simply by changing the laws. Take, for instance, Newton's law of gravitation that we stated as (10d), a fuller version of which is given in (16):

(16) Newton's law of gravitation

There is a force of attraction between any two bodies in the universe. For any two bodies, the force of attraction is directly proportional to (the product of) their masses and inversely proportional to (the square of) the distance between them.

Let us perform the thought of experiment of revising (16) as (17):

(17) A hypothetical law of gravitation

> There is a force of attraction between any two bodies in the universe. For any two bodies, the force of attraction is **inversely** proportional to (the product of) their masses and inversely proportional to (the **cube** of) the distance between them.

For the sake of this discussion, let us ignore the problem that (17) will yield incorrect predictions. What is important for the present discussion is the point that (17) yields a different theory, but the theoretical framework remains the same, namely, the one in (15). Such variations in any of the laws of motion or gravitation will yield distinct alternative theories that compete with Newton's theory. It just so happens that no one has proposed an alternative theory within Newton's theoretical framework.

The preceding discussion makes a distinction between theories and theoretical frameworks in science. Crucial to the concept of a scientific theory is a set of laws that lead to correct predictions of phenomena. A theory presupposes a theoretical framework in the sense that theoretical laws are formulated in terms of the concepts of the framework. What is important for our purposes that the Newtoninan framework in (15) is not a scientific theory in this sense, because it does not include Newtons laws. It is only when (15) is combined with Newton's laws that it becomes a scientific theory.

For readers in humanities and social sciences, my distinction between theories and frameworks may appear to be confusing, because it is common practice in the social sciences to use the word "theory" to refer to what I have called frameworks. Thus, the so called "feminist theory", "deconstructionist theory", "post colonial theory", and "critical theory" do not include theoretical laws that lead to any predictions, and hence do not have the status of theories in the sense I have outlined above. It may therefore be preferrable to refer to use the terms "feminist framework", "post colonial framework" etc. to refer to the collection of concepts and ideas they contain.

6.3. Laws versus Framework: another example

To see the difference between theoretical frameworks and theoretical laws, take an example from linguistics. In Mandarin, the word *ziji* 'self' is the translation equivalent of the English words *himself, herself,* and *themselves*. Thus, the English sentence in (18a) is the same as the Mandarin sentence in (18b):

(18) a. John hit himself.

b. John da ziji
John hit self

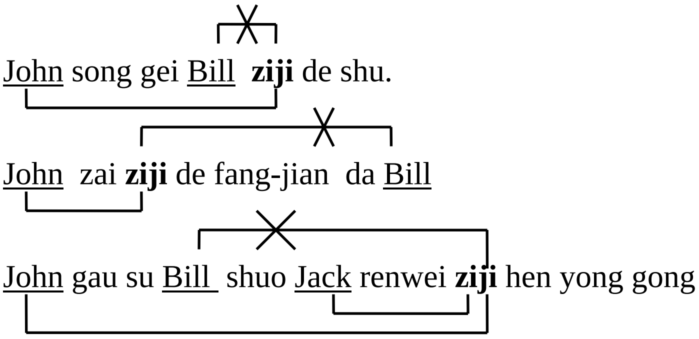
In slightly more complex cases, we see interesting restrictions on what *ziji* can refer to:

(19) a. John song gei Bill ziji de shu.
John sent Bill self's book
John sent Bill self's (John's, not Bill's) book.

b. John zai ziji de fang-jian da Bill
John at self's room hit Bill
John hit Bill in self's (=John's, not Bill's) apartment.

c. John gau su Bill shuo Jack renwei ziji hen yong gong
John toldBill that Jack think self very hard working.
John told Bill that Jack thinks that self (=John's or Jack's, not Bill's) is hard working.

Most Mandarin speakers interpret (19a) as saying “John sent Bill John’s book.”, they do not interpret it as saying “John sent Bill Bill’s book.”. (19b) means “John hit Bill in John’s room.”, not “John hit Bill in Bill’s room.”. Similarly, they interpret (19c) as saying “John told Bill that Jack thinks that Jack is hard working, or “John told Bill that Jack thinks that John is hard working”. They do not interpret it as “John told Bill that Jack thinks that Bill is hard working”. These interpretations can be schematically given as follows:



These asymmetries in the interpretation of (19a-c) constitute a puzzle that call for an explanation.

In order to construct explanations for observations of this kind, linguists construct general laws. These laws are formulated in terms of frameworks whose legitimacy is taken to be well established. In special cases, the one who proposes the laws will do so in a novel framework, in which case the legitimacy of the framework itself has to be argued for.

Most linguists who are interested in problems of the kind illustrated in (19) accept the following framework of grammatical categories and grammatical functions.

(20) A theoretical framework in syntax

a. grammatical categories

NOUN, VERB, ADJECTIVE, PREPOSITION, NOUN PHRASE, VERB PHRASE, PREPOSITIONAL PHRASE, ...

b. clausal grammatical functions

SUBJECT, OBJECT, PREDICATE, ADJUNCT ...

c. sentential grammatical functions

TOPIC, FOCUS, ...

For the purposes of this discussion, it is not necessary for the reader to know what the terms in (20a-c) mean. However, we do need to know what the terms “subject” and “topic” mean. The use of these terms is illustrated by the English examples in (21):

(21) a. Mary kissed that boy again and again.
subject

b. That boy was kissed by Mary again and again.
subject

c. That boy, Mary kissed again and again.
topic subject

Given these notions, the puzzle in (19) can be solved by assuming either (22a) or (22c), but (22b) makes incorrect predictions.

(22) Laws

a. The antecedent of *ziji* must be a subject.
b. The antecedent of *ziji* must be topic.
c. The antecedent of *ziji* must be a subject or a topic.

The subject in (19a) is John. It follows by (22a) that *ziji* can refer to John, but not Bill, which correctly predicts the interpretation of (19a). In (19b), John is the subject and Bill is the object of “hit” and hence by (22a) it follows that *ziji* can refer to John, not Bill. In (19c), John is the subject of “tell” Bill is the object of “tell”, and Jack is the subject of “think”. It follows by (22a) that *ziji* can refer either to John or to Jack, but not to Bill, which correctly predicts the interpretation of (19c).

Given that (22a) is sufficient to yield the right predictions for (19a,b), it is easy to see that (22c) will also be able to perform this task. In contrast, (22b) fails, since *ziji* can take a non-topic antecedent like *Bill* in (19b). Since (22b) incorrectly predicts that, say, the *ziji* in (19a-c) cannot refer to any of the non-topic subjects, we reject it.

The purpose of discussing (22a-c) is not to develop an adequate theory which will explain the behaviour of *ziji* in Mandarin, but simply to illustrate the difference between theories and theoretical frameworks. As stated earlier, the distinguishing feature of a theory is a set of laws formulated in terms of the concepts of a theoretical framework. The combination of (20) and (22) can be considered a theory, but not (20) by itself. Depending on which of the laws in (22) we adopt, we have different theories of Mandarin syntax. However, all these theories rely on the same theoretical framework, namely, (20).

6.4. Observational Frameworks

To go back to the theoretical framework in (15), we notice that some of its constructs are strictly theory internal, in the sense that they are interpretable only within Newton’s theory. Thus, terms such as force and momentum, for instance, are interpreted only within Newton’s theory (e.g. (11a-c)). In contrast, the terms time, distance and mass, even though central to Newton’s theory, have an interpretation independently of Newton’s theory. The concept of time, for instance, is part of the genetic inheritance of all human beings. Independently of any familiarity with Newtonian mechanics or any physics for that matter, any lay person with knowledge of the English language will agree that the propositions asserted by the sentences in (23a,b) are true, while those in (24a,b) are false:

(23) a. Given an ant and a snail, it takes more time for the snail to travel a given distance.
b. An apple is heavier than a grape.

(24) a. Given an ant and a snail, it takes more time for the ant to travel a given distance.
b. A grape is heavier than an apple.

Time, distance, and mass are human concepts which have been with us even before Galileo and Newton started constructing theories of motion. These are the constructs in terms of which we state our propositions of observation, such as those in (10). We may treat them as forming an **observational framework**:

(25) The observational framework for Newton's theory

DISTANCE, TIME, MASS.

In order to formulate the puzzles that we need a theory to explain, or to state the predictions on the basis of which a theory can be tested, all that we need is the observational framework. Now, the observational framework of distance, time, and mass is something that Einstein shares with Newton and Galileo. Therefore, in spite of their theoretical differences, it is possible for (the spirits of) the three people to get together and determine on a rational basis which of their theories make the widest range of correct predictions of observations. Contrary to what Kuhn imagines, Einstein would not require rhetorical persuasive strategies to convince Galileo and Newton.

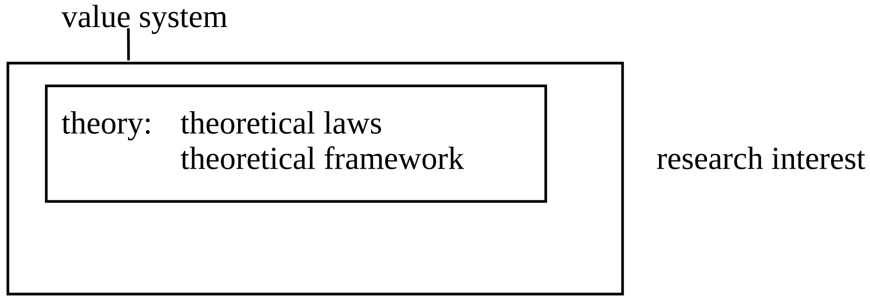
In an earlier section, we decided to use the terms V-paradigm to refer to the value system, R-paradigm to refer to the research interests, and T-paradigm to refer to the theory. We have now unpacked theoretical differences along three strands, namely, the theoretical laws, theoretical framework, and observational framework. Though the theory is built on the observational framework, the observational framework is **theory neutral** in the sense that many competing theories can be constructed on the same observational framework.

Pursuing the terminological strategy that we introduced earlier, we will use the term TL-paradigm to refer to differences in theoretical laws, TF-paradigm to refer to differences in theoretical framework, and OF-paradigm to refer to differences in observational frameworks. We saw in an earlier section that Galileo, Newton, and Einstein share the same V-paradigm and R-paradigm. We now see that they share the same OF-paradigm as well. The differ only in the TL-paradigm and TF-paradigm. Since they share the same V-paradigm and OF-paradigm, Galileo, Newton and Einstein can engage in a fruitful debate on the relative merits of their theory without any danger of incommensurability. We may state this result explicitly as follows:

> *If two competing theories share the same value system and observational framework, there is no incommensurability between them.*

The intuitive substance of the above statement can be visualised by the diagram given below:

(27)



|

observational framework

|

the world outside

The success of the contents internal to the box, namely, theoretical laws and theoretical framework relevant for any given research interest can be judged on empirical-rational grounds if there is agreement on the value system and the observational framework.

6.5. Frameworks as Languages

Let me make a few general remarks. The propositions of the puzzle in (10), the propositions of the explanation in (11) and (12), and the derivations in (13) and (14), all need to be formulated as sentences in some language or the other. It is crucial that we appreciate the distinction between sentences and propositions. It happens to be the case that the propositions in (10)-(14) are stated in terms of sentences in the English language. If I were writing this article for a group of readers in a remote village in Kerala in India, I would formulate the same propositions in terms of Malayalam sentences, not English sentences.

The use of any language presupposes that the speaker and the listener share a set of conventions on how the **sentences** of a language are interpreted as **propositions** about the world. A subset of these conventions involve the conventions on the use of a vocabulary, including the conventions regarding the concepts associated with each word in the vocabulary. Thus, if I use the word *finger* in an English sentence, I assume that the readers share the convention that the word refers to the digits on my hands. In contrast, if I use the Malayalam word *wiral* which is the translation equivalent of the English *finger*, I assume that the readers share the convention that *wiral* refers to the digits on my hands or feet. Thus, we have propositions and concepts on the one hand, and sentences and words on the other:

(28) sentences, words
‘’
propostions, concepts
‘’
states of affairs in the world

The relation between sentences and words on the one hand and the propositions and concepts about the world is a matter of linguistic conventions within a speech community. The picture in (27) therefore needs to incorporate (28).

When members of two different speech communities talk to each other about the world, chances are that there will be miscommunication because of differences. Let us imagine that a community of English speakers, call them community A, use the word *finger* to mean the digits on one’s hands, while community B of English speakers use the same word to mean the digits on one’s hands or feet. When faced with a human being, the two groups of speakers assert two different observational sentences, namely,

(29) a. Speaker A: “That man has ten fingers.”
b. Speaker B: “That man has twenty fingers.”

We would say that there is an incommensurability here, because the term *finger* does not have the same value in the observational frameworks of the two groups of people. In order to avoid the miscommunication, we need to restate the propositions of the two speakers into a neutral language:

(30) a. Speaker B: “That man has ten digits on his hands”
b. Speaker B:“That man has twenty digits on his hands and feet.”

What appears to be a contradiction in (29) disappears in (30).

Interestingly enough, Kuhn was aware that incommensurability was due to differences in the language of the sentences that express the observational propositions. He points out that “...men who hold incommensurable viewpoints be thought of as members of different language communities and that their communication problems be analysed as problems of translation” (Kuhn 1970:175). Elsewhere, he makes the following remark on incommensurability and the choice between successive theories.

> “In sections X and XII I have argued that the parties to such debates inevitably see differently certain of the experimental or observational situations to which both have recourse. Since the vocabularies in which they discuss such situations consist, however, predominantly of the same terms, they must be attaching some of those terms to nature differently, and their communication is inevitably only partial. As a result, the superiority of one theory to another cannot be proved in the debate. Instead, I have insisted, each party must try, by persuasion, to convert the other” (Kuhn 1970:198).
>
> “Two men who perceive the same situation differently but nevertheless employ the same vocabulary in its discussion must be using words differently” (Kuhn 1970:200).

Though Kuhn recognises that the root of the problem lies in the use of words with different meanings, he also asserts that:

> “Such problems, though they first become evident in communication, are not merely linguistic, and they cannot be resolved simply by stipulating the definitions of troublesome terms. ... the participants in a breakdown of communication cannot say, ‘I use the word ‘element’ (or ‘mixture’ or ‘planet’ or ‘unconstrained motion’) in ways determined by the following criteria’. They cannot, that is, resort to a neutral language which both use the same way and which is adequate to the statement of both their theories or even of both those theories’ empirical consequences.”

Kuhn is right in pointing out that incommensurability arises as a result of differences in vocabulary. It is strange, however, that he asserts that a break down of communication due to different use of words cannot be resolved through negotiation towards a neutral language. I have already given an example of how a breakdown of communication such as in (29) is resolved through the neutral language in (30). As an example within the sciences, take Kuhn’s example of the incommensurability involved in the use of the word *planet*. Ptolemy treated the moon as a planet, while Newton treated the moon as a satellite. This is a difference internal to the theoretical explanations of Ptolemy and Newton. Imagine the scenario of Ptolemy and Newton looking up the night sky:

(31) a. Ptolemy: There is a planet at the edge of the horizon right next to that elm.
b. Newton: There is no planet at the edge of the horizon next to that elm.

These two observational reports would be an instance of incommensurability for Kuhn. The incommensurability arises because the two sentences appear to contain logically contradictory propositions. However, once Newton and Ptolemy realise that they have been using the word *planet* with different meanings, it does not take any intellectual gymnastics to resolve the breakdown of communication:

(32) a. Ptolemy: There is a bright crescent shaped object (which I call the "moon") in the sky at the edge of the horizon next to that elm. I use the word "planet" to refer to that object.

b. Newton: Yes, I agree there is a bright crescent shaped object (which I too call the "moon") in the sky at the edge of the horizon next to that elm. But why do you use the word "planet" to include the moon?

I fail to see why reformulations such as in (32) do not count as neutral statements, or why such reformulations are impossible.

In the first century BC, long before there were theories of electricity and magnetism, the Greek philosopher Thales studied a certain piece of iron ore, found near the town of Magnesia. He discovered that this ore had the property of attracting pieces of iron. Thales called the ore "ho magnetes lithos" (the Magnesian rock). Centuries later, Thale's observation was explained by the theory of magnetism. Thales also found that lumps of amber when rubbed would attract any light object. The Greek word for amber is "elektron". Centuries later, Thales' observation was explained in terms of a theory of electricity.

Thales' observational claims of the properties of the Magnesian rock and amber have survived unaffected by the virus of incommensurability till the present day, irrespective of all the scientific revolutions that Kuhn discusses. Let me state the observation on amber such that even hard core Kuhnians will have to agree that the observation is correct.

(33) When amber is rubbed, and sufficiently light pieces of matter are kept near it, the pieces of matter kept near the amber move towards the amber.

This observation is clearly neutral to the differences among the theoretical frameworks of modern science because it was stated long before modern science was born and continues to be accepted as true both by scientists and non-scientists.

Long before Einstein, Newton, Kepler, and Galileo, people could see that a stone dropped from a stationary position comes down to the earth straight line, while a stone thrown up at an angle moves up and comes down in a curved path. A child unacquainted with physics can observe this experiment and verify the correctness of these observations.

Since the observational claims about Magnesian rock, amber, and stones thrown up in the air are tested the same way by scientists and those who have never been exposed to science, it cannot be the case that these claims involve incommensurability in the debates between competing scientific paradigms. We are therefore led to the following conclusion:

> *At least some observational claims can be formulated in a language that is neutral to the theory or theoretical framework in question, in such a way that they are understood and tested by all human beings alike, irrespective of their educational background. Such observational claims are free of incommensurability arising from differences in scientific paradigms.*

From this, we can go a step further and make a stronger demand:

> *The choice between two competing theories must be based on observations which are formulated in an observational framework that is neutral to the theoretical frameworks of the two theories.*

If scientists go by this criterion, there is no incommensurability, provided they share the same value system. I have not seen any demonstration that it is impossible to meet this criterion, and hence I take it that the doctrine of the inevitability of incommensurability across paradigms and the idea of theory laden observations in the post modernist literature are simply mistaken.

If we accept the above position, then what happened in the transition between Newton and Einstein can be described as follows. The superiority of Einstein's theory was established on empirical-rational grounds because the two parties shared the same value system and observational framework. Acceptance of Einstein's theory entails the acceptance of Einstein's theoretical framework, which involves a new set of concepts of the interaction between time and space. Hence, the success of Einstein's theory causes a change in the world view. Contrary to what Kuhn thought, it was not the change in the world view that led to the success of the theory.

6.6. Frameworks as Systems of Representation: Seeing in Terms of a Framework

As Kuhn points out, scientists *see* the world in terms of the entities of the theoretical frameworks they construct. Thus, they often behave as though they saw electrons and electric fields, and the representations they construct are objects of the real world. Why is this so?

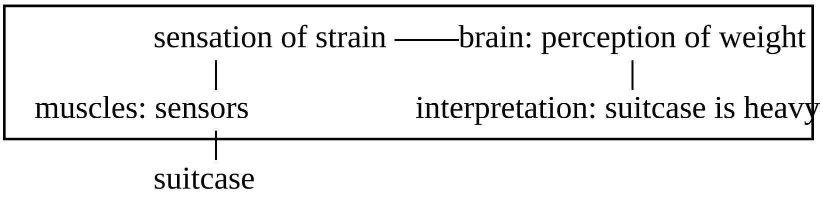
To answer this question, we need to understand the nature of frameworks as systems of representation. Let me recapitulate what I said in preceding sections first:

> A framework is a set of constructs associated with a vocabulary.
>
> An observational framework allows us to formulate sentences that express our observations of the states of affairs in the world.
>
> A theoretical framework allows us to formulate theoretical explanations of the observed states of affairs in the world.

What is common to theoretical frameworks and observational frameworks is that they are both systems of representation, that is:

> A framework allows us to represent information from the outside world in a meaningful fashion.

The notion of **representation** is central to our understanding of the notion of paradigms, so I will provide a few brief illustrations. First, let us begin with how the human brain represents sensory information. Take the notion of weight in our ordinary experience. When we lift a suitcase packed with books, our muscles undergo a strain. The measured strain on the muscles is transmitted to the brain, which is interpreted as weight. The muscles act as biological instruments which carry built in *sensors* that measure strain. The connection between the *measurement* of strain and the *perception* of weight can be viewed as follows:



The human brain interprets the sensation of strain in the muscle as weight, and projects it into the external world as a property of the suitcase. We may say that the human brain represents strain as weight:

Representation: weight of the suitcase.
Measurement: strain on the muscle when lifting the suitcase.

In a similar manner, the brain represents the measurements of the human retina as colour, distance, size, shape, texture, solidity, etc. and projects them as properties of the external world. In other words, the information measured by the sensors of the biological instrument of retina is represented by the human brain as colour, distance, size, shape, and so on. The sensors built into the muscles and skin of the arm also transmit information that is represented by the brain as distance, size, shape, texture, and solidity. When the representations based on information from the eye and the hand converge, we feel that our representation is real. If not, at least one of the representations is dismissed as illusory. Thus, if the eye and brain tell us that there is a solid object out there but our hand is able to pass through that object, we conclude that what the eye and brain represent as a solid object is an illusion, say, a hologram.

The example given above is that of representations using the observational framework that all human beings have in common. Kuhn refers to this framework as **primitive perceptual experience:**

> "Seeing droplets of water or a needle against a numerical scale is a primitive perceptual experience for the man unacquainted with cloud chambers and ammeters ... Regarding the vapour in his breath on a cold winter afternoon, his sensation may be the same as that of a layman, but viewing a cloud chamber he sees (here literally) not droplets but the tracks of electrons, alpha particles, and so on. ... Or consider the scientist inspecting an ammeter to determine the number against which the needle has settled. His sensation is probably the same as the layman's, particularly if the latter has read other sorts of meters before" (Kuhn 1970:197-8).

The observational framework of scientists, some of which may not be shared by lay people, has an additional component. In addition to using biological instruments such as the muscles, skin, eye, and ear to construct representations of the external world, scientists also rely on the information provided by manmade instruments. Some of these instruments, such as clocks and rulers, are shared by all educated people of the modern world, though not by the other members of the human species who have not been trained by modern education. Others, such as cloud chambers and ammeters, are restricted to the community of scientsts.

Take, for instance, the construct of weight mentioned. As pointed out above, "weight" is part of the primitive perceptual experience of the human race. It is a representation of the outside world, constructed on the basis of the interpretation of muscle strain. Now, we can also interpret the numbers provided by the sensors of a weighing machine as weight. We lift two suitcases and the muscles measure greater strain for suitcase A than for suitcase B. This information is represented as "Suitcase A is heavier than suitcase B". We now place these suitcases on a weighing machine and the sensors of the weighing machine record a higher number for A than for B. This information is also represented as "Suitcase A is heavier than suitcase B".

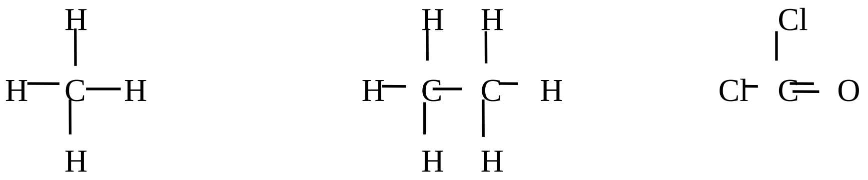
Repesentation:	weight	weight
Measurement:	strain on muscles	numbers on a weighing machine

Since the two interpretations converge, we take the representation of the numbers of the weighing machine as weight is justified and proceed to rely on weighing machines when the information from muscles is inadequate, as in determining the relative weights of two grapes.

The representations discussed above are part of the observational framework. What is the relation between instrumental measurements and the entities of the theoretical frameworks?

A theoretical representation of a phenomenon is an abstract object that a scientist constructs. Such a representation is expected to stand for the the deeper aspects of the phenomeon. Water, for instance, is represented by chemists as H_2O, and carbon dioxide as CO_2. To take more interesting cases, the structural representations that chemists postulate for methane, ethane, and phosgene are as given in (34a-c) respectively:

(34) Representation of substances in chemistry



a. methane b. ethane c. phosgene

CH_4 $H_3C{-}CH_3$ $Cl_2C{=}O$

Competent theoretical chemists (though not high school students) are perfectly aware that they do not see the structures in (34) through any of their instruments of measurement. These structures are postulated by chemists in order to explain a set of observed measurements. However, once the measurements are successful in providing these explanations, chemists take these representations to be essentially correct, and proceed to investigate higher order problems by taking them as granted. It is this use of a theoretical framework to see the world that Kuhn is talking about when he says that scientists “see” electric charges and caloric flow.

Let me give the reader an example from my own research experience. When talking to one another, linguists often use the terminology of morpheme and affix, giving the mistaken impression that these are observational entities. Why do linguists talk as if they can “see” morphemes and affixes?

Let me explain the terminology first. If we compare the words *happy, unhappy*, and *happiness*, we have an intuition that they are related words. On the basis of this intuition, we might like to suggest that the word unhappy consists of two pieces *un* and *happy*. Similarly, we may say that the word *happily* consists of the pieces *happy* and *ly*. Linguists refer to such pieces of words as MORPHEMES.

If we accept the notion of morphemes, the word *editors* can be broken up into three morphemes, namely, *edit*, *or*, and *s*. Similarly, the word *softened* can be broken up into *soft*, *en* and *ed*. We may represent the internal structure of these words as (35a) and (35b) respectively:

(35) Representations of the structure of words

a. *editors*

b. *softened*

(35a) says that the noun *editors* consists of the noun *editor* and the morpheme *s*. The noun *editor* in turn consists of the verb morpheme *edit* and the morpheme *or*. (35b) says that the verb *softened* consists of the verb *soften* and the morpheme *ed*. The verb soften consists of the adjective morpheme *soft* and the morpheme *en*.

A typical textbook in linguistics takes such representations as granted, giving the mistaken impression that words such as morpheme, noun, and adjective refer to observable entities rather than entities of a theoretical framework. Having taken the entities of the framework for granted, linguists go on to make "observations" such as the following:

(36) a. The morpheme *ly* can be attached to *happy*, but not to *joy*:
(*happily* is an acceptable word, but **joyly* is not)

b. The morpheme *ness* can be attached to *happy*, but not to *joy*.
(*happiness* is an acceptable word, but **joyness* is not).

Theoretical claims in the domain called morphology in linguistics are often defended on the basis of "observations" such as those in (36). Strictly speaking, the statements in (36) are not observations but theoretical interpretations, that is, they are statements based on a prior theoretical representation of the words. They, are, in other words, "theory laden" observations.

Most often, theory laden observations such as those in (36) are left unchallenged, since the whole community accepts the representations as correct. Occasionally, however, a researcher challenges the theoretical framework of such representations, and refuses to accept such statements as legitimate observations. Such a situation did arise in linguistics during the recent years, when alternative theories called "amorphous morphology" and "projection morphology" claimed that the study of morphology did not require the notion of morphemes.

The theory laden observational statements in (36) do entail incommensurability if we are trying to decide between morpheme-based theories and theories which oppose morphemes. However, this incommensurability is not unresolvable. What happens in such an instance is that instead of taking the notion morpheme as given, a proponent of the notion morpheme makes a rational argument for morphemic representations on the basis of observations that both parties accept as correct. In a recent paper of mine, for instance, I make an argument for representations such as in (35) on the basis of observations such as in (37):

(37) A speaker of English is taught the coinage *blemous* , as illustrated in the sentence *This vegetable is very blemous* which means "easy to cook by frying". (S)he is then asked to interpret the sentence *Those carrots are unblemous* Even though the speaker has never come across the word *unblemous* before, (s)he interprets the sentence as asserting that the carrots are not easy to cook by frying. The results are replicated in experiments with other pairs of coinages like *grimpish/ungrimpish*, *sisp/unsisp*, and *frelous/unfrelous.* In contrast, when the same experiment is done with coinage pairs like *blemous/fiblemous*, they are unable to interpret the meaning of the second coinage.

The observation in (37) is acceptable to both supporters and opponents of morphemes. The argument that I advance is that puzzles such as those in (37) are best explainable in terms of theoretical laws that presuppose morpheme based representations such as in (35), and therefore one must accept such representations (Mohanan 1996). Once the relation between observations and the theoretical construct of morphemes is established on empirical-rational grounds, it is demonstrated that the words in (36) are represented framework internally as *happy + ly, joy + ly, happy + ness,* and *joy + ness*.

To take a more telling example, let us imagine that we have brought the souls of Aristotle and Linus Pauling to a laboratory in 1997. Suppose they are shown the pictures in figure 1 and figure 2:

figure 1 figure 2

The picture in figure 1 is that of a single layer of tomato bushy stunt virus molecules, and figure 2 is that of the crystals of necrosis virus protein, but this information is withheld form them. Both Aristotle and Pauling will agree that the pictures they are looking at have closely packed circular shapes of approximately the same size. In addition, however, Pauling will also see in these pictures molecules of tomato virus and necrosis virus. Clearly, Aristotle will not see molecules, tomato virus, or necrosis virus. Pauling's observation of molecules and viruses in the pictures is clearly laden by the modern atomic and molecular theories which are unfamiliar to Aristotle. However, the observation of closely packed circular shapes of approximately the same size is not laden by any of the theories of modern science.

Aristotle will no doubt be sceptical of the molecules in the pictures. In order to convince Aristotle, Pauling will have to answer the following questions:

> What is the evidence to believe that matter is composed of molecules?
> What is the evidence to believe that the circular shapes in the photographs taken by the electron microscope correspond to entities in reality, and are not artifacts created by the instrument?
> What is the evidence to believe that these shapes are those of molecules, rather than, say, crystals, atoms, atomic nuclie, or electrons?

Pauling's task will not be easy. He will probably have to begin with Dalton's arguments for atoms, and proceed, in a step by step fashion, to arguments for molecules, subatomic structure, electrons, and the whole network of theoretical assumptions that connect the concept of molecules to the electron microscope and the pictures they produce. If Aristotle is patient enough, however, this is indeed a possible enterprise. Thus, at least some theory laden representational observations can be justified on the basis of theory neutral observations.

In sum, we grant that when scientists talk to each other, they often use their theoretical frameworks as shortcuts to make pseudo-observational statements. It is true that physical scientists tend to formulate their "observations" of the world in terms of shared theoretical constructs like electrons, molecules, phlogiston, calory, ether, magnetic field, and so on. Such propositions are **theory laden** in the sense that they are formulated in the language of their theoretical framework. When challenged by a sceptic, however, they will either proceed to reformulate the observation in a cumbersome neutral language (32), or make a rational argument for their theory internal representational statements in terms of observations that both parties agree on (37). The commitment to such argumentation is an indispensable part of the value system of science.

Like Kuhn, most good scientists are aware that "We do not *see* electrons, but rather their tracks or else bubbles of vapour in a cloud chamber. We do not *see* electric currents at all, but rather the needle of an ammeter or galvanometer" (Kuhn 1970:196). It requires extraordinary naiveté to imagine that scientists like Einstein and Feynman did not know that fields and electric currents are not observable entities. Furthermore, most good scientists are perfectly capable of restating their framework-laden observations in the framework neutral language of the cloud chamber and galvanometer, and arguing for their theoretical frameworks in terms of what even lay people can verify for themselves. Hence, theory ladenness of observations, though quite common in scientific communities, is not something that cannot be avoided.

To go back to what Kuhn himself said, scientists share with lay people the primitive perceptual experience common to the members of the human race. If so, I do not see what makes it impossible for the scientist to translate the framework laden statement into a set of statements in the language of the primitive perceptual experience, or a set of statements that can be justified on empirical-rational grounds using the statements in the language of primitive perceptual experience. I have given examples of such translations and justifications on the basis of primitive perceptual experience, showing the feasibility of these strategies. We must therefore accept the following conclusion:

> *Kuhn's claim that scientists cannot resort to a neutral language to express the empirical consequences of their theories is false.*

6.7. Operationalisation: Commitments to Instrumentation

According to Kuhn "commitments to preferred types of instrumentation and to the ways in which accepted instruments may legitimately be employed" are also part of research paradigms (Kuhn 1970:40). The selection of a reliable measurement for a construct in a representational system is called **operationalisation** in the social sciences. Extending this terminology to the physical sciences, we may say that we operationalise the concept of time as numbers on a clock, and the concept of distance as numbers on a ruler. Thus, the issue that Kuhn raises here is that of the justification of operationalisation across scientific communities.

I will not go into this issue here but simply remark that disagreements on operationalisation must be subjected to empirical-rational debates to arrive at mutually agreeable conclusions before making observational claims, that is, in order claim that a truck is heavier than a car, one has to make an empirical-rational argument to demonstrate that the numbers of the weighing machine in question gives us reliable measures of the concept of weight. Similarly, if community X uses sun dials to measure time and community Y uses digital quartz clocks, disagreements about observations on time demand that the two communities engage in a debate on the relative merits of sun dial and quartz clocks first.

In the case of the operationalisation of the entities of observational framework such debates will be straightforward. In the case of the relation between instrumental measurements and theoretical constructs like electrons and magnetic field, the argumentation will be somewhat complex, consisting of appeals to a large body of interacting data. Though laborious, there is no evidence to believe that we cannot conduct empirical-rational debates on the "types of instrumentation and to the ways in which accepted instruments may legitimately be employed", or that rational choices cannot be made on the basis of such debates. All that we need to acknowledge is the following:

> *Debates between theories can be settled only if both parties agree on the operatinalisation, that is, the relation between measurements and the entities of the framework. If there is a controversy on operationalisation, this disagreement must be settled prior to the debate on alternative theories.*

6.8. Observational vs. Theoretical Frameworks

The preceding discussion underlines the importance of distinguishing between observational and theoretical frameworks in evaluating Kuhn's ideas of scientific revolutions and incommensurability. There are three fundamental differences between the two types of frameworks. First, entities of observational frameworks are motivated by their usefulness in talking about observable phenomena. In contrast, the entities of theoretical frameworks are motivated by their usefulness in formulating the laws that correctly predict observable phenomena. The terminology in (38), for instance, is part of the observational framework of astronmers but they are not part of the theoretical framework of astronomy or the physical sciences in general because these entities do not figure in the theoretical laws of the physical sciences.

(38) a. The Sun, The Moon, The Earth, Venus, Saturn, Mars, pole star, ...
b. Big Dipper, Orion, Orion's belt, Cassiopia, Andromeda, Pegasus, ..

In contrast, concepts like curved dimensions, electromagnetic radiation, and gravitational field are part of the theoretical framework of the physical sciences.

Second, the relation between observables and the entities of the observational framework is a matter of arbitray linguistic conventions and convenience. There are no special reasons, for example, why we should group what we see in the sky into eighty-eight constellations (38b), rather than, say sixty-seven or ninety-two. The Chinese system has 28 constellations, but no astronomer in the right senses would bother to argue that the 28 constellation system is false. In contrast, the relation between observables and the entities of a theoretical framework is a matter of evidence and argumentation. In order to postulate theoretical entities such as curved dimension, superstrings, or electrons, a scientist has to demonstrate that these entities are necessary to provide the best available explanations for a set of observable phenomena. There is no such commitment to evidence and argumentation for the entities of observational framework.

Third, the entities of a theoretical framework are subject to Occam's razor, that is, the requirement of minimising the total set of theoretical constructs to what is absolutely necessary for satisfactory explanations. Observational frameworks are not subject to this requirement. Take a hypothetical argument to the effect that the three-way distinction between yellow, orange, and red is unnecessary in English because the concept of orange can be stated as a combination of yellow and red. This is a ludicrous argument because the concepts of red, orange, and yellow are not part of the theoretical framework of an explanation. However, parallel arguments for the reduction of concepts in theoretical frameworks are an essential part of the building of scientific knowledge.

Occasionally, the same constructs serve as entities of both theoretical and observational frameworks, as is the case with the constructs of time and distance in the theories of Einstein and Newton. It is important therefore that we are alert to the different roles of such terms in the two levels of frameworks. For instance, it is important that as theoretical constructs, time and space interact in Einstein's theory, but not in Newton's theory. Therefore the words *time* and *distance* refer to distinct theoretical concepts in the two theories. This difference needs to be defended on the basis of observation and rational argumentation. Experimental evidence shows that changes in velocity do affect the measurements of time, and that Einstein's theoretical constructs are superior to Newton's, a conclusion that Newton would have been forced to accept had he engaged in a debate with Einstein.

In contrast to the theoretical constructs of space and time, the idea of interaction is irrelevant to the observational constructs of time and distance. As part of the observational framework that is common to Galileo, Kepler, Newton, and Einstein, time is the quantity measured by clocks, and distance is the quantity measured by rulers. This distinction between the two levels of frameworks was probably not appreciated by Kuhn. It is because Newton and Einstein agree on the observational framework that Enstein can convince Newton on empirical-rational grounds.

7. Disciplinary Matrix: Symbolic Generalisations, Models, and Values

Kuhn's epilogue indicates that even though he failed to appreciate the distinction between observational and theoretical frameworks, he was well aware of the distinction between theoretical laws and theoretical frameworks. Kuhn refers to theoretical frameworks as "symbolic generalisations". He was also clear about another equally important distinction, namely, theoretical laws and models. A survey of the ingredients of paradigms must therefore include these ideas.

In order to understand what Kuhn means by symbolic generalizations and models, it is important to outline Kuhn's notion of **disciplinary matrix** first. A disciplinary matrix, according to him, is " ... composed of ordered sets of elements of various sorts, each requiring further specification. All or most of the objects of group commitment that my original text makes paradigms, parts of paradigms, or paradigmatic are constituents of a the disciplinary matrix, and as such they form a whole and function together" (Kuhn 1970:182).

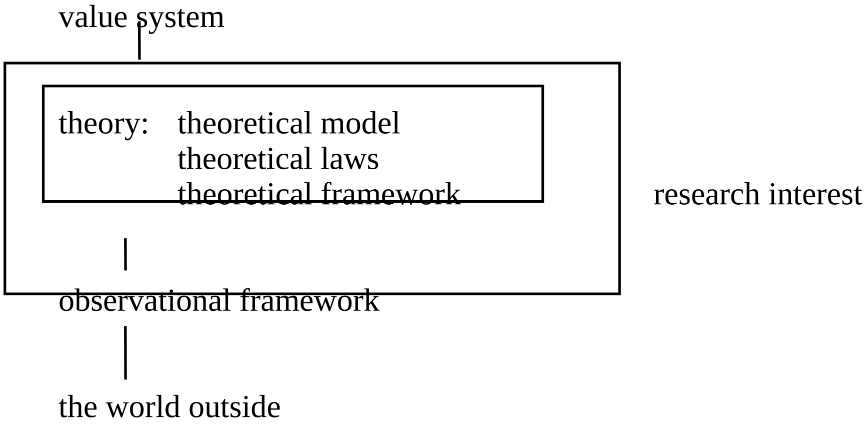
A disciplinary matrix is distinct from laws, and is composed of three sorts of things, namely, symbolic generalisations, models, and values. As examples of **symbolic generalisations**, Kuhn discusses equations like $f = ma$ that state a relationship between the concepts of f(orce), m(ass), and a(cceleration). As another example, he discusses the Joule-Lenz Law $H = RI^2$. “When that law was discovered, community members already knew what H, R, and I stood for, and these generalisations simply told them something about the behaviour of heat, current and resistance that they had not known before” (Kuhn 1970:183). Kuhn continues: “. . . the nature of commitment to a law is very different from that of commitment to a definition. Laws are often corrigible piecemeal, but definitions, being tautologies, are not. For example, part of what the acceptance of Ohm’s law demanded was a redefinition of both ‘current’ and ‘resistance’; if those terms had continued to mean what they had meant before, Ohm’s Law could not have been right; that is why it was so strenuously opposed as, say, the Joule-Lenz Law was not.

We have already explored in detail Kuhn’s notion of paradigms as **value systems**, so we will not pursue this topic here. By **model**, Kuhn has in mind “shared commitments to such beliefs as: heat is the kinetic energy of the constituent parts of bodies; all perceptible phenomena are due to the interaction of qualitatively neutral atoms in the world, or alternatively, to matter and force, or to fields; . . . the electric circuit may be regarded as a steady-state hydrodynamic system; the molecules of a gas behave like tiny elastic billiard balls in random motion” (Kuhn 1970:184).

From the above description, it seems to me that Kuhn’s use of the term “model” coincides with the general use of the term to refer to such entities as the heliocentric model of the solar system, the geocentric model of the solar system, Dalton’s model of the atom, and Bohr’s model of the atom. A model then is an abstract metaphorical conception of the phenomenon under investigation, such that it acts as a scaffolding for the formulation of theoretical laws. A number of different theories may share the same model. The heliocentric model, for example, underlies the theories of Copernicus, Kepler, and Newton, and Einstein.

We may incorporate the notion of models into our general conception of science by revising (27) as (39):

(39)



Since Kuhn considers the notion of model as an ingredient of the notion of paradigm, we may use the expression TM-paradigm to refer to this aspect of the paradigm, extending the terminological convention we introduced earlier.

8. Normal and Revolutionary Sciences: the Status of Incommensurability

Having factored out the different ingredients of Kuhn's concept of scientific paradigms, we are now in a better position to consider the notion of revolutionary science that involves effecting a change in an existing paradigm. If we go by (39), the prime candidates are value system, research interest, theoretical model, theoretical framework, theoretical laws, and observational framework. Of these, it seems to me that the formulation of a new theoretical law would not qualify as a scientific revolution for Kuhn if it does not entail a change in the value system, model, or framework. If it did, every theoretical innovation would become an example of a scientific revolution, and there would no longer be any normal science except for the activity of conducting experiments to test existing theories. If so, we conclude that if two competing theories differ solely in their theoretical laws, there is no incommensurability between them, even for Kuhn.

Having removed theoretical laws from the list of candidates, we see that there are at least five types of scientific revolutions in the Kuhnian sense, namely, changes in the value system, research interest, theoretical model, theoretical framework, and observational framework. Since Kuhn himself acknowledges most of these distinctions in the postscript, I take it that the remark on the typology of scientific revolutions is a logical consequence of Kuhn's own position. Which of these paradigm shifts would engender incommensurability?

As I have argued, differences in research interest do not result in competition among theories, although they often cause competition among research communities for funding and prestige. Therefore, it would be reasonable to eliminate research interests as a candidate for incommensurability.

Theoretical models and theoretical frameworks are to be defended on the basis of their ability to yield correct predictions. If two theories use the vocabulaty of time and distance to refer to distinct theoretical constructs, it is necessary to construct empirical-rational arguments to choose between these different constructs on the basis of shared observations. Such justifications do take place in scientific communities. We conclude therefore that scientific revolutions in models and theoretical frameworks do not result in incommensurability.

Thus, the only real candidates for incommensurability are differences in the value system and observational framework. If two theories do not share an observational framework, incommensurability is bound to occur. When theoretical frameworks are shared in a community, scientists often state what they need to explain in terms of the representational entities of their framework. However, such incommensurability can be resolved by replacing theory laden observations with observational statements in a theory neutral language. I believe I have provided sufficient examples that demonstrate how this can be done. Hence there is no convincing basis for the Kuhnian claim that such a neutral language is in principle impossible.

Differences in the value system also create incommensurability. Unlike observational frameworks, differences in values and the tension between different values are not fully explicitly articulatable, and hence are not resolvable. Hence, the only unresolvable instance of incommensurability is one that arises due to differences in value systems.

There is no evidence to believe that Galileo, Kepler, Newton, and Einstein have differences in value systems that lead them to choose different theories on the basis of the same experiments. Their value systems are the same, namely, the one listed in in (1a-k). Their observational frameworks are also the same, consisting of entities such as time as measured by a clock, distance as measured by a ruler, mass as measured by a physical balance. As theoretical entities, mass and distance are different concepts for Newton and Einstein, but since their observational counterparts are the same, theoretical disagreements can be settled on the basis of the shared value system and observational framework. We must conclude therefore that Kuhn’s claims of incommensurability during the transitions from Galileo to Einstein are untenable.

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Paradigms, Theories, Frameworks, Incommensurability, and Theory Ladenness

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