TWO ASPECTS OF MODELS AND CULTURAL ROLE OF SCIENTIFIC MODEL

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Abstract

In this paper I will look at the two aspects of models which I call the 'symbolic' and the 'functional'. A comparison is made in this regard between models considered as Kuhnian paradigms, and Durkheim's theory of social cohesion through collective representation. I argue that models serve a similar function with respect to the scientific community. However, this does not imply that practice is independent of belief. What I suggest instead is that practice is reconciled or negotiated with belief. Thus practice in a sense, does not tell us the whole story.

ملخّص

سأنظر في هذه المقالة إلى خاصيتين للنماذج و التي اسميها بالخاصية الرمزية و الخاصية الوظيفية أو العملية. و سأقوم على هذا الأساس بمقارنة النماذج بالبراديجم عند كون و بنظرية دوركايم في ا التماسك الاجتماعي عبر وظيفة التمثّل الكلّي. و أحاجج بأنّ النماذج تقوم بوظيفة مماثلة فيما يخصّ الجماعة العلمية. و لكن هذا لا يجب ان ينجرّ عنه ان التطبيق مستقلّ عن جانب الاعتقاد و الجانب النظري. ما أقترحه بدلا من ذلك هو أنّ التطبيق يجب أن يتمّ مصالحته أو التفاوض حوله مع الاعتقاد. فالتطبيق لا يحكي لنا من ثمّ كل القصّة.

Résumé

Dans cet article, j'examinerai deux aspects des modèles : l'aspect 'symbolique' et celui 'fonctionnel'. Une comparaison sera faite par ce biais entre les modèles considérés comme des paradigmes selon le concept de Kuhn et la théorie de la cohésion sociale par la représentation collective de Durkheim. Je soutiens que les modèles accomplissent une fonction similaire eu égard à la communauté scientifique. Or, ceci n'implique pas que la pratique est indépendante de la croyance. Je suggère plutôt que la pratique est réconciliée et renégociée avec la croyance. En un sens, la pratique ne nous raconte donc pas toute l'histoire.

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى

ISSN: 1737-6432

1.0 Introduction

The symbolic relates to 'sense' or 'meaning' while the functional relates to 'reference' and 'practice'. Models considered as paradigms exhibit both these characteristics, and provide social cohesion both through thought and practice. . However, problems arise when scientists though accepting the functionality of the models, could not accept its 'symbolism' or 'meaning'. Here the scientist (or the philosopher) has the option of either creating a new model/paradigm with a more acceptable symbolism (eg. Tycho Brahe's astronomical model), or provide a philosophical re-interpretation of the model that withholds ontological commitment (i.e. non-realism).

There are several types of models in science, which are used for different purposes and context. Some are used for heuristic purposes, i.e. as aids for scientific research and discovery, and some are used for pedagogical purposes such as the use of pictorial models of molecular bonding in the teaching of chemistry, etc.[179] Previously, models were thought of in *representational* terms, that is as representing the set of observable data for the instrumentalist, or as representing the underlying structure of phenomenal reality for the scientific realist. Recently however, there has been a tendency to construe models in pragmatist terms[180]. In this construal, models are not static entities that 'represent' physical reality or phenomena, but rather function as 'intermediaries' in the chain of scientific practice.

In this paper however, I will not look at models in terms of the current mode of discourse on models –involving representation or pragmatism – but rather in terms of a rather neglected perspective involving paradigms and cultural symbolism. Although it has its roots in the history and philosophy of science, such a treatment of models holds a greater potential or promise in the area of the anthropology or the cultural studies of science.

[179] For an account of the different types of models and their philosophical significance, see Sarkar and Pfeifer (2006), pp.740-749.
[180] See Nersessian (2006), Giere (2004).

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

IX. 2.0 The Symbolic and Functional Aspects of Models

Models can be roughly divided into two main types, namely (i) mathematical models, and (ii) pictorial or visualizable models. My discussion of models will be based on (ii) rather than (i), since (ii) possess 'iconic' or 'symbolic' features which are absent in (i). Pictorial models which are visualizable, contributes to our sense of 'intelligibility of nature' in a way which mathematical models do not. Such pictorial or visualizable models contain two aspects which are relevant for our discussion. These two aspects are what I call the 'symbolic' aspect and the 'functional' aspect. The functional aspect of models is familiar to scientists since it involves the use or application of models in scientific practice. It is what makes scientific concepts or theories operational, and capable of being applied to nature to solve problem. Kuhn's characterization of 'exemplars' in his explication of 'paradigm' is an example of how models serve a functional role. Successful problem – solving through the use of models make its adoption unproblematic for the scientific practitioner. Thus we find scientists accepting and using models found in the reigning paradigm, to conduct their research and scientific work, regardless of the philosophical positions.

However, there is a second aspect of models which is not quite as straight forward as the first, and which could be problematic. This is what I call the 'symbolic' aspect of models.[181] While the functional aspect treats models in terms of 'reference', the symbolic aspect of models relates more to 'sense' or 'meaning', to use Fregean terminology[182]. Thus even though we might have two 'empirically equivalent' models referring to the same phenomena or domain of experience, yet they might constitute different ontologies, and convey different meanings or senses. Examples would be: (i) field theory vs. action-at-distance (ii) Ptolemaic theory vs. Copernican theory (iii) wave vs. particle theory.

Philosophers of science have often concentrated on explicating the semantic and syntactic aspects of scientific theories, without paying much

[181] 'Symbolic' thought is sometimes contrasted with 'rational' thought since it is pre-analytic or even described by some as 'pre-rational' in nature. For a discussion on the distinction between symbolic and rational thought, see Dan Sperber (1980).
[182] See Geach and Black (1966).

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

attention to its *semiotic* aspect.[183] It is my contention that investment on the semiotic aspect of theories can yield dividends, and help understand the concern with the nature of scientific theories. Scientific theories do not only have a *referential* aspect, however reference might be construed—it also has a "symbolic" or "semiotic" aspect which is more difficult to capture but which has been alluded to by some writers under various guises. Frege (Geach and Black 1966) has brought out the distinction in terms of "sense" and "referent", Holton (1973) has used the notion of "themata" to refer to this symbolic aspect of theories, while Kuhn's (1970) use of the concept of "paradigm" is an acknowledgement that theories not only have a referential aspect but also a symbolic one.

This becomes clearer when we contrast the nature and role of scientific theories of the present age with those in the past, i.e. with the theories of the Greeks and the Medievals. Their theories serve a more epistemological or even ontological purpose, i.e. to give us an understanding of what the world is like. This understanding however, is not a solely cognitive one, but one which is "integrated" with the religious, the cultural, and of life generally. Hence the preoccupation with Aristotelian theories of nature in both ancient and medieval science and the difficulty involved in dislodging it.

The "symbolic" role played by theories in the past helped to sustain the sense of *enchantment* towards nature, with the exception perhaps of atomistic theories. It is no surprise therefore that in an age dominated by philosophy and later theology, atomism did not fare well or loom large. The *disenchantment* of nature that Weber spoke about arose precisely out of the "emptying" of the symbolic content of nature through the "mechanistic" theories of science beginning from the 17th century, which were given empirical sanction through experimentation. In fact it signals a new mode of approach towards nature in which *thought was intimately connected to action*. The relationship between thought and action was reversed in that thought was made "subservient" to

[183] Semiotics is sometimes defined as consisting of: (i) semantics (ii) syntax, and (iii) pragmatics. But the study of semantics and syntax by semioticians differ from the approach adopted by philosophers of science when they talk about the semantic conception of theories, or when the Logical Positivists talk about the syntax of theories. In semiotics, the treatment of models/icons as signs/symbols involve both 'sense' and 'reference'.

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

action, with the goal of achieving mastery over nature. Whereas humanistic and religious philosophies of the past have emphasised liberation and enlightenment through the mind and spirit, the new Baconian ethos of the 17th century placed a definite emphasis on *action* and practical results. Thus nature was to be *acted upon*, not merely contemplated. This changed relationship in the interaction between man and nature is exemplified and manifested in the very nature of the scientific theories which were then constructed.

X. 3.0 The Symbolic and the Functional in Kuhn's Concept of Paradigm/ Model

A striking feature of Kuhn's analysis of paradigms is its dualistic nature; as a 'symbolic' representation of nature, and as a functional conceptual tool. Paradigms or models in modern science, serve both roles, often with the latter constraining the former. In other words, in order to qualify as a 'symbolic' representation of nature, a theory or paradigm has to pass the experimental test and prove its technological or pragmatic efficacy. In this new science, what cannot issue in practical or technological efficacy, cannot be admitted even conceptually, as a legitimate symbolic representation of nature.

Kuhn's analysis is relevant because of his insistence on the primacy and hegemony of singular paradigms in post 17th century science. This implies that only the ruling paradigms can dominate the cultural mainstream, because of the dominant status of science in modern society. Although Kuhn confines his analysis to the "scientific community", its extension to 'society at large' can be made given the 'priesthood of the scientific intelligentsia' in modern culture. Kuhn's characterization of paradigms in terms of "world-view", "norms governing behaviour", and "conceptual tools" for action, is significant in that it highlights the integration between *theory and praxis* in modern science.

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

3.1 The Iconic Role of Models and Social Cohesion

Kuhn's (1970) work on "Paradigms" in the *Structure of Scientific Revolutions* (*SSR*), explicates the paradigm or model not only as an intellectual construct, but also as a source of social cohesion amongst the scientific community. Kuhn lists down several elements of paradigm or what he sometimes called "disciplinary matrix" (Kuhn 1970:182). He identifies four major components of the disciplinary matrix, namely: (i) symbolic generalisations, such as the formula "f=ma", (ii) the metaphysical part of paradigms, (iii) shared values, for example logical consistency and accuracy of predictions, and finally, (iv) exemplars or concrete problem-solutions (Kuhn 1970:182-187). These different aspects of a paradigm, however, share one important sociological feature: their ability to act as a source of social cohesion for the scientific community by providing a common framework for them to work in. By providing a shared picture of the world, the model or paradigm thus functions as the community's icon or "collective representation".

Very few have commented on Kuhn's paradigm as the source of social cohesion within a scientific community. Even though Kuhn restricts himself to the scientific community, in a modern society that has science as its backbone, this tends to have a wider implication. If we consider the scientific community as the source from which knowledge about the world emanates in modern society and that society as a whole depends on the scientific community for knowledge about the world, then the thesis can be applied *writ large* to society as a whole.[184]

[184] One possible model for understanding the role and function of science in society and culture is to look at it in terms of Habermas' theory which has been dubbed as the 'technocratic consciousness' model by Margaret Archer (1996). In this model, science through the economic pressures exerted in society 'from below', bursts forth, becomes independent, and forms society's overarching paradigm and mode of interaction. Thus science in this model, occupies a central, dominant, and perhaps monolithic position in society. The diffusion of science occurs at various levels and domains, such as the economic-technological, the educational, and the socio-cultural. This sociological model of the place and role of science in modern society, can find historical support in the historical works of Margaret Jacob and Larry Stewart (2004). What these historians have shown is that, the diffusion of science in society occurred in both the realms of economy and knowledge. Their favourite example is Newtonianism and applied mechanics. Because of the applied nature of Newton's physics through mechanics, it found ready

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

Kuhn's analysis also has the merit of bringing out both the symbolic as well as the functional aspects of paradigm. Kuhn's earlier thesis about the major role played by "aesthetic" considerations in theory adoption or conversion, goes to show how elements of symbolism serve as a powerful emotional source of theory generation and pursuit.[185] This has been variously described by other writers such as Gerald Holton (1973) as "archetypes" or themata. The irrationality partly consists in the subjectivity of the individual scientist in allowing his "aesthetic sense", governed perhaps by his psychological archetype, to determine which theory to pursue. But as Holton has shown for instance, Kepler is one such individual, who has successfully advanced the science of astronomy.

But Kuhn was also keen on showing how "symbolism" then becomes internalised through repeated practice in various situations. This is shown through Kuhn's notion of paradigms as *exemplars*, where the symbolic becomes concretised through puzzle-solving, i.e. its entry into the realm of action. Thus, Kuhn has succeeded in showing us just how 'theories' or 'paradigms' become entrenched in a (scientific) culture through their relationship with practice.

3.2 Kuhnian Paradigms as Durkheimian Collective Representation

What is the basis of consensus within the scientific community? How do we explain the high degree of consensus and social cohesion prevailing within the institution of science? As Kuhn has pointed out in his *SSR*, science reaches a level of maturity when there cease to be disagreements regarding fundamental issues. In fact that is what distinguishes science from the non-sciences such as history or philosophy. Kuhn locates the source of social cohesion existing within the scientific community in the existence of paradigms, and through the

application in engineering and technology, for example in Desaguliers. Here we have an example of how a scientific model/paradigm becomes diffused through society by virtue of its application in the economy.

[185] See Kuhn's discussion of the role of aesthetics in theory-choice in Kuhn (1977:337), and the question of 'subjectivity' versus 'objectivity'.

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

mechanism of normal science. These are factors that give the scientific community a distinct identity and mark them out from the rest of society.

According to Kuhn, those who adopt different paradigms "live in different worlds". Even though a lot has been written about Kuhn's theory of "paradigms", most of them are in relation to the issue of scientific rationality. My interest in Kuhn's notion of paradigm/model has a different focus. I am basically interested in Kuhn's idea of paradigm/model as a source of social cohesion *in the anthropological or sociological sense*. In this respect, I find it quite natural to compare Kuhn's theory of paradigms with Durkheim's theory of *collective representation*.[186] According to the Merriam Webster dictionary, a 'collective representation' is defined as 'a symbol that articulates and embodies the collective beliefs, sentiments, and values of a social group'[187]. It is in this sense that a model such as the Ptolemaic model, or the Copernican model can be considered as a 'collective representation' insofar as it articulates and embodies a world-view, be it geocentric (i.e. man-centred) or heliocentric.[188]

There are interesting similarities and parallelisms between Kuhn's paradigms[189] and Durkheim's 'collective representation' which have implications for our understanding of the cultural role of science. Kuhn's theory of paradigms is interesting to me precisely because it ties in *belief with practice*. And the belief in question is not private, individual or solitary belief, but belief of a *collective* nature, shared by members of a group or a community. Kuhn's account of the acculturation process of a scientist through paradigm adoption and the workings of normal science indicates quite clearly *how belief is reinforced through practice*. Kuhn's "disciplinary matrix" account of paradigms shows quite clearly that finally paradigms boil down to two important dimensions, i.e (i) belief, and (ii) practice. The components of the disciplinary matrix that involve

[186] Durkheim's concept of 'collective representation' is to be distinguished from his earlier concept of 'conscience collective'. The latter relates more to social norms and values that govern social behavior and that it transcends individual thought or conscience, being located in the collectivity. The former however, also refers to a tangible representation of the collective in the form of for example, an icon.

[187] www.merriam-webster.com/dictionary.

[188] Also see Hutchison (1987) for an account of how astronomical models can function as cultural and political symbols/ icons in history.

[189] Here I am using the words 'paradigm' and 'model' interchangeably. Although 'paradigm' is more all-encompassing, but insofar as scientific models possess the two key components of 'belief' and 'practice', the same analysis holds for both.

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

'metaphysical world-views' and 'symbolic generalisation' relate to *beliefs*. Paradigms as "exemplars" or models for problem-solving, involve practice or action. So the conceptual "seeing" of nature in terms of paradigms construed as "exemplars", is further reinforced through the phenomenology of utilitarian and manipulative acts, as found in methodological practice. Link this to experimentation, technological prototype and finally the industrial economy, what we then have is a progressive entrenchment of the world-view of a paradigm/model in modern industrial society as a whole. This characteristic of the paradigm of modern science compares somewhat readily to Durkheim's idea of collective representations. For Durkheim, "collective representations" are the shared beliefs, and the practices associated with those beliefs, which play a role towards providing social cohesion in that group or community. These representations, being collective, do not reside in any one individual, but is of a somewhat "transcendent" nature – social to be sure, but transcending the individual member nevertheless. Again, like Kuhn's paradigm, they have a practice aspect, in that rites and rituals are conducted either on the basis of such representations, or to further reaffirm belief in such representations, providing group solidarity and social cohesion in the process. What is different perhaps is the nature of the emotional content or commitment invested in these different paradigms/models, and the distance between such investments and their final trickling down to practice. In the collective representations of pre-modern societies, the distance is short and hence the emotional content transferred to the social act (rites and rituals) is high, consequently 'the enchanted world–view' provides a greater sense of group or cultural identity. The very nature of the 'long-winded' process of production in modern industrial economies assures us that by the time a scientific idea reaches the lay consumer, very little of that 'symbolic' content of a paradigm is transmitted. The result is an 'anemic' from of paradigm-induced social cohesion –reduced to the level of bare minimalities– that lacks 'enchantment'. But in a sense, that is built into the very nature of science itself, when science restricts its study of nature to the bare essentials. Where paradigms offer to be a substituted form of enchantment, leading to proclamations about the aesthetic value of a scientific theory, there sometimes occur vigorous controversies in the history of science. These controversies sometimes not only relate to matters of logical procedure but relate more to an individual's aesthetic sense *of what constitutes enchantment_for different*

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

psychological archetypes. This relates to Kuhn's controversial view on 'incommensurability' and his idea of 'metaphysical commitments'. For instance, it is known that Einstein's opposition to Quantum Mechanics is largely due to his uneasiness about its broader metaphysical and philosophical implications; that Einstein feels 'unsafe' living in a universe that at bottom is left to chance.

Despite the interesting parallels between Kuhnian paradigms and Durkheim's collective representation, there exist equally interesting and important differences between them which help to further clarify the cultural role of scientific models/ paradigms. One important difference is that while a Dukheimian Collective Representation requires an *emotional commitment* to the symbol or icon in order to function effectively as a means of social cohesion, the scientific model does not impose such a similar commitment for its functioning within a scientific community. This has to do with the operational nature and efficacy of the scientific model, and Durkheim's distinction between 'organic' and 'mechanical' solidarity. In a traditional/ primitive society governed and characterised by the so-called 'mechanical solidarity', there is a dogmatic allegiance to the 'symbol' or 'totem' which acts as a focal point for social action and cohesion. Examples are the 'cross' in Christianity and statues of deities in Hindu society. In a 'modern' society characterised by 'organic' solidarity, the role of the 'symbol' as a source of social cohesion has been replaced by the functionality of the institutional interactions/interconnections. The scientific model then complements this inter-institutional functioning/efficacy by itself being an efficacious, operational instrument that facilitates both man's dealing with nature as well as with his fellow-men.

4.0 Models in the Context of Thought and Practice: A Critique of Rouse's Revisionist Interpretation of Kuhnian Paradigms

Models can be thought of in terms of both cognition and practice. They are embodiments of certain ideas about reality, or constructions aimed at explaining or constituting phenomenal reality. The construal of models as a form of 'representation', makes it rather 'static' and implicitly employs a 'correspondence theory of truth'. Construed in this way, it gives primacy to

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

cognition rather than practice. It puts models in a 'contemplative' rather than an 'active' mode. However, models are rarely 'merely presented' without being put to use, especially in post 17th century science in which scientific concepts have become operational rather than merely explanatory as in ancient and medieval science. What is the relationship between thought and practice in relation to models, and is it meaningful to ask whether thought or practice is primary? In this regard, I would like to recall the earlier account which I gave on models construed as Kuhnian paradigms. In that account, although I acknowledge the practice aspect in Kuhn's account of paradigms, I also put an emphasis on the 'belief' aspect in making the comparison with Durkheim's theory of 'collective representation'. Here, models not only serve as tools or instruments, but also as 'icons' imbued with meaning. For this to be possible, models have to acquire meaning and understanding prior to, and independent of, practice. However, this view was challenged by Joseph Rouse (2003) in his article, "Kuhn's Philosophy of Scientific Practice". Rouse wrote:

> Paradigms should not be understood as beliefs (even tacit beliefs) agreed upon by community members, but instead as exemplary ways of conceptualizing and intervening in particular situations (p. 107).

> Scientists *use* paradigms rather than believing them. Scientists need only understand *how* to use these various elements in ways that others would accept. These elements of shared practice thus need not presuppose any comparable unity in scientists' beliefs about what they are doing when they use them (p.108).

> Paradigms are thus first and foremost to be understood as *exemplars*, "accepted examples of actual scientific practice—examples which include law, theory, application, and instrumentation together—[that] provide models from which spring particular coherent traditions of scientific research" (p.108).

> …Kuhn even identified the concept of a paradigm with a move away from conceiving scientific communities as held together by common beliefs… .

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

> The result of this recognition is to think of scientific communities as composed of fellow practitioners rather than of fellow believers (p.109).

It is clear from the quotations above and from other explicit statements made by Rouse concerning his intention to 're-interpret' Kuhn in terms of the primacy of scientific practice, that Rouse relegates the role of beliefs with respect to paradigms/models. However, despite the current fashion in conferring primacy to scientific practice, I think Rouse's interpretation will not do justice to Kuhn's (1970) account of paradigms as given in his *Structure of Scientific Revolutions (SSR)*, regardless of what Kuhn himself might say later on[190]. On my reading of the Kuhn of *SSR*, practice enhances belief rather than replaces it. The role of practice is supplementary or complementary to belief and there exists a sort of symbiotic relationship between the two, rather than practice being conducted independently of belief. Thus one cannot make sense of Kuhn's idea that 'scientists live in a different world after a scientific revolution', or that paradigm change is like a 'conversion experience', if the element of belief is eliminated or sidelined. To me the role of belief is crucial in Kuhn's account of paradigms as given in *SSR.* Although it is true that practice might lead to a revision or refinement in one's understanding of a paradigm, they nevertheless occur in relation to belief.

Given that the belief element is an important aspect of the acceptance and use of models[191], one can then see more clearly why the 'symbolic' or 'iconic' aspect of models play an important role in scientific practice. Gerald Holton (1973) has captured this idea more pointedly through his concept of *themata* as expounded in his *Thematic Imagination.* Thus Holton claims that scientists are basically driven by a commitment to certain underlying themata in theory choice and practice. (Binary) examples of themata are; quanta vs continuum, atomism vs organicism, wave vs particle, field vs action-at-a-

[190] The quotation from Kuhn used to support the statement in the last quote was from a later work by Kuhn, which was published in Kuhn's (1977) book, *The Essential Tension.*

[191] This view is also supported by the fact that atomism or the mechanical philosophy, which laid the foundations for modern science/physics in the 17th century was devoid of empirical practice when it was first accepted. It was only later, when its belief was already well entrenched, that it bore empirical fruit in chemistry and physics.

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

distance etc. Here themata can be understood as 'icons' in relation to our earlier discussions. Such commitments do not have a totally 'rational' basis, but is a matter of archetypal preference. For example, Einstein's rejection of an indeterministic universe led him to reject the Copenhagen interpretation of quantum mechanics, and the desire to formulate a more deterministic physical theory.

5.0 Gellner on the Non-Entrenchment of Scientific Belief: A Reply to Gellner

Gellner (1974) in his assessment of the social and cultural role of scientific theories/models, has this to say:

> Some traditions of thought in modern philosophy (in very broad sense) had supposed that certain substantive pieces of science were destined to acquire an 'entrenched' clause status comparable to the key religious dogmas of the past. Newtonian physics, for instance, was revered by many thinkers as the very paradigm of well-established, permanent truth. It is interesting to note when Newtonian physics was tumbled from this pedestal, virtually no tremors were noticed in the rest of the social fabric. Little or no entrenchment had in fact taken place, contrary to what philosophers had supposed. (Gellner 1974:166-67).

Gellner's remark above seems to suggest that the 'model as symbol' thesis is false. Science, it seems, has simply not taken over from traditional religion / world-views, the symbolic function of conferring 'cosmological meaning' to society. Gellner's observation however, I contend, does not necessarily imply the falsity of the view. The surprised 'non-entrenchment' of Newtonian Science can be understood as follows.

A scientific paradigm commands 'emotional commitment' on the part of its adherents to the extent that it symbolises a certain "archetype" that the scientist identifies with. In the case of Newtonian Science such an "archetype" might be found in the notion of "absolute spaces" or "absolute time", and the programme of mechanical philosophy which it supports. Such "archetypal foundations" of Newtonian science have been explicitly challenged by Leibniz in the 17th century, and Ernst Mach in the 19th century, for instance. For there people, and

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

those who think like them, the dislodgement of Newtonian physics would be a welcome event.

Similarly, in other episodes in the history of science, for example, thermodynamics vs statistical mechanics, and especially the rise of quantum theory, there are significant “emotional attachments” to the foundational archetypes of the competing programmes/paradigms. The controversy surrounding quantum theory in the 1920s, especially late 1920s, testify to this. In fact, Einstein refuses to accept the ‘quantum view of the world’ to the very end, not so much on scientific grounds, but more because its ‘implied world-view’ is unpalatable to him. Given these historical facts, it cannot be claimed that no sector of society remained unaffected. At least as far as the physics community was concerned, there were indeed, significant tremors. However, if what Gellner meant was that there was no large-scale effect on society’s beliefs/world-view as a whole, then perhaps he is right. But this can be explained in term of the esoteric nature of scientific paradigm, and the ‘thinning out’ of its ‘emotional context’ as it is diffused out into the wider society. For eventually, the “masses” placed their reliance on the scientific authorities/experts, and accordingly whatever emotional upheaval that could or would occur will eventually be manifested within the scientific community itself and not amongst the laity. Later on, however when the wider society, especially its intellectuals or religious elites, come to know of the new theory, they will then be busily constructing meanings for their own special audience. In that sense major paradigm changes in science do create significant responses from society as a whole.

Another reason why the supersession of Newtonian physics by Einstein’s theories did not have such a major impact compared to the Copernican Revolution for example- is its lack of religious connotations, and the important fact that Newtonian mechanics is still used as a basis for engineering practice. So while it is intellectually dislodged, it remains visible in practice.

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

6.0 Handling the Discrepancy Between Belief and Practice

Given the close relationship between belief and practice, in relation to models, what happens when there is a 'mismatch' between the two? What happens for example. When a scientist accepts a model in terms of 'practice' but not 'belief', 'techne' but not 'episteme', or 'reference' but not in terms of its 'sense'? This can be most clearly seen in the case of the controversy over the Copernican model in the history of astronomy. Although the Copernican model can explain the astronomical data as well as the Ptolemaic model, if not better, yet it was rejected by Catholics who were committed to a scriptural understanding of physical reality. In this particular case, two options were open: (i) the articulation of an alternative model in the form of the Tychonic model to match the empirical scope of the Copernican model, and (ii) the formulation of an instrumentalist philosophy of science to interpret the epistemological status of the Copernican model. In fact this form of response became the prototype of future responses to such crises involving belief and action in relation to models. At the scientific level, the response is to create an alternative model or theory with an agreeable 'sense' to account for the 'reference'. At the philosophical level, the strategy is to articulate a non-realist philosophy of science to enable the adoption of the model in terms of practice, but withholding belief or an ontological commitment to the model because of its disagreeable 'sense'.

7.0 Conclusion

Models therefore, serve a dual role; a scientific role and a cultural role. In its scientific role, it acts as a 'paradigm' that guides scientific research as well as function as a focal point for group identity and allegiance. In its cultural role it serves as a 'symbol' initially for the scientific community that first creates it, and eventually diffusing to the rest of society. However, as 'symbol' it becomes problematic for those who do not accept its symbolism- for example, the case of the reception of the Copernican model by the Roman Catholic Church in the 17th

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

century. In the event of such a clash, two options are open, namely: (i) the attempt to create an alternative model with a congenial symbolism, and (ii) a philosophical re-interpretation of models in non-realist terms. In this way the tension between 'belief' and 'practice' is resolved, enabling practice to continue by practitioners of different persuasions. However, contrary to Rouse's interpretation, which privileges 'practice' over 'belief' in his account of paradigms/ models, I suggest that practice has to come to terms with belief to ensure its functionality. And contrary to Gellner, I maintain that scientific models/ paradigms do play a cultural role, being strongest within the scientific community and diffusing as it spreads throughout the rest of society.

The account of models which I proposed, presented models as having two main aspects, i.e. the 'symbolic' and the 'functional'. I then tried to show how both aspects play a role in making models as a source of social cohesion and group identity—drawing parallels between Kuhn's account of paradigms/models and Durkheim's theory of collective representation and social cohesion. I then referred to the writings of Joseph Rouse (2003) and Ernest Gellner (1974) which posed certain problems to my sociological account of models, and tried to answer them. Having dealt with those problems, I then turned my attention to another problem, this time implicit in the account which I myself gave. This relates to the question of what happens when there is a discrepancy, or even conflict, between 'belief' and 'practice' with regard to a model or theory. By 'belief', I here mean an ontological commitment to the model or theory and not in the sense of Arthur Fine's (1991) Natural Ontological Attitude (NOA) in which acceptance is based on practice, and not some deeper belief. I suggest that the discrepancy or tension is resolved by two means, i.e. (i) the attempted formulation of an alternative model or theory which is congenial to one's belief, and (ii) a philosophical re-interpretation of the model or theory in non-realist terms. However, this does not imply that – as suggested by Joseph Rouse (2003) – practice is independent of belief. Instead what I suggested is that practice was reconciled or negotiated with belief. Thus practice in a sense, does not tell the whole story.

AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى
ISSN: 1737-6432

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AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى

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AL-MUKHATABAT Numéro 03 Année 01/2012 المخاطبات العدد 03 السنة الأولى

ISSN: 1737-6432