A Critical Assessment of Thomas Kuhn's Understanding of Scientific Progress

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Abstract

Thomas Kuhn, in *The Structure of Scientific Revolution*, distinguishes between two types of sciences – one, normal; the other, revolutionary. However, the transition from normal to revolutionary science (what he calls paradigm-shift) is initiated by anomaly. This anomaly arises when the paradigm guiding a particular community of scientists malfunctions, thus resisting all efforts to reposition it. Hence, science for Kuhn, grows through the paradigm-shift initiated by tension. However, Kuhn argues that the process of choosing another paradigm that will guild scientific practices requires a thorough debate among a community of scientists. In this debate, a new paradigm is selected out of numerous competing others by the method of elimination. This selection is based on their ability to solve problems and to guide research work without developing further faults. Nevertheless, in this understanding of scientific growth, in our view, inheres some contradictions. In the first places, Kuhn attributes growth to paradigm-shift through tension and anomaly but argues that a new paradigm must be selected based on its ability not to develop fault. It is not, however clear how paradigm-shift can occur if there is no fault, tension or anomaly in research. Secondly, he bases the selection of a new paradigm on the inarticulate aesthetic sentiments, faith and destiny, which contradicts the initial argument that it must be selected based on its observed inherent problem-solving ability out of the numerous others. We shall discuss these notable flaws in Kuhn's view of scientific growth, using the method of critical argumentation and conceptual clarification.

Introduction

Epistemology, or the theory of knowledge, is that branch of philosophy concerned with the nature of knowledge, its possibility, scope, and general basis (Honderich, 1995). Traditional skepticism poses a great challenge to epistemology. The challenge is its stout denial of the possibility of knowledge (Bewaji, 2007). For the skeptics, we must be certain of anything which we claim to know before we can be justified in making the claim to such knowledge. However, by the nature of human epistemic capacity, we cannot know anything for certain. Therefore, the skeptic will argue, we cannot know anything at all.

This position is also known as philosophical skepticism in the sense that it is more thorough and tougher than its other strands. Philosophical skepticism as a denial of an indubitable knowledge, has led many philosophers such as Plato, Aristotle, Aquinas, Thomas Hobbes, Francis Bacon, Rene Descartes, David Hume, Immanuel Kant, and so on, to venture into the task of searching for the basis, foundation or justification of knowledge. The search for the basis or justification of an indubitable knowledge, in turn, necessitated the criteria for knowledge. These criteria are sought for from different angles. According to the traditional epistemologists like Plato, anything that will serve as knowledge must be a belief; the belief must be true, and the true belief must be justified.

Justification of knowledge, however, took a different turn in the twentieth century. In this period, epistemology as a branch of philosophy took a scientific dimension and philosophy of science became somehow meta-epistemological in nature. Accordingly, methods of scientific discoveries became synonymous with justification of knowledge claims, while science itself was seen as the epitome of epistemology, the paradigm of reason, knowledge and truth. The Logical Positivists' criteria of verification and meaningfulness, for instance, are responses to the challenge of justification posed to epistemism, after the traditional account of knowledge was shattered by Edmund Gettier, because he enunciated the need for a fourth condition (Bewaji, 2007).

Some of the advocates of positivistic stance are Rudolf Carnap, A. J. Ayer, and Otto Neurath. There is also Karl Popper's falsification rule which is a critique of the logical positivists' criterion. However, Thomas Kuhn criticized the various postulations of his predecessors and substituted them with the concept of paradigm. All these are attempts to provide an intelligible explanation for how we can know and justify what we know through science. Accordingly, with *The Structure of Scientific Revolutions* as our primary source, this paper discusses and attempts a critical assessment of Thomas Samuel Kuhn's explanation of the growth of knowledge.

Background to Kuhnian Epistemology

Kuhn's epistemology can be situated within the fold of scientific approach to the justification of knowledge claim. In other words, he is in the circle of those who identify epistemology with science and who believe that the search for an indubitable knowledge can be found in science. However, his epistemology is a new worldview on scientific progress or development which frowns at the 'popular image' of scientific progress during his time. This popular image of scientific progress viewed science as a cumulative enterprise where new discoveries or innovations are additive to the whole previous stockpile of others. Besides, this prevalent view or understanding of science differentiates between the context of discovery and the context of justification. Kuhn, however, rejects both impressions, arguing instead that science is not a cumulative but a tension-laden enterprise, punctuated by occasional disruption or revolution. He first introduces this idea in his work titled *The Essential Tension* where he contends that:

> I have argued in the draft that the historian constantly encounters many far smaller but structurally similar revolutionary episodes and that they are central to scientific advance. Contrary to a prevalent impression, most new discoveries and theories in the sciences are not merely additions to the existing stockpile of scientific knowledge. To assimilate them the scientist must usually rearrange the intellectual and manipulative equipment he has previously relied upon, discarding some elements of his prior belief and practice while finding new significances in and new relationships between many others. Because the old must be revalued and reordered when assimilating the new, discovery and invention in the sciences are usually intrinsically revolutionary (1977, 226-227).

Following Kuhn's reservations regarding the erstwhile understanding of scientific growth and his perceived need to immediately replace it with another explanation, he introduces a new worldview about scientific progress through the popularization of the concepts of paradigm, paradigm-shift, incommensurability, normal science and extraordinary or revolutionary science in philosophy of science. However, when we talk about a new worldview, it presupposes the existence of an old worldview which ought to be briefly discussed here.

Before Kuhn's new worldview of scientific progress, the predominant traditions in the scientific approach to knowledge in the twentieth century were the logical positivists' verification principle and Karl Popper's falsifiability rule (Nickels, 2003). The logical positivists' principle of verification lays claim to two major theses. The first is that for a statement to be meaningful, it must be analytic, that is true by virtue of definition; second, any statement relating to matters of fact must be empirically verifiable in order for it to be meaningful (Stumpf and Fierser 2003). So, analyticity and empirical verifiability are the two theses of the logical positivists' verification principle. Logical positivism also views scientific progress as a cumulative experience.

Aside from logical positivism, there is Karl Popper's falsifiability rule. The main thesis of this rule is that every theory should be tested and the main purpose of testing a theory is to falsify it. Any theory that is not refutable or falsifiable is not scientific. If the falsification of such theory is successful, it is unnecessary to re-mend the theory or reconstruct it in order for it to suit a scientific explanation. Consequently, any attempt to reconstruct a falsified theory thereby making it irrefutable reduces the scientific status of such theory (Worrall, 2003). The refutation of a particular theory necessitates its replacement. In other words, any falsifying instance warrants a rejection of a falsified theory and warrants its immediate replacement with another theory.

Thomas Kuhn's epistemology is a reaction to, and a departure from the above understanding of scientific growth. Kuhn believes that to make progress in science, one does not necessarily adhere to rules like the one Popper suggests or to certain criteria of meaningfulness like the one the logical positivists provide. What we need is a paradigm. While rules do not encompass paradigm, paradigm encompasses rules.

Moreover, tradition, for Kuhn, is very important in science. The achievements or discoveries of past scientists such as Aristotle or Galileo ought not to be perceived as mistakes or ruled out as unscientific. This is because these achievements have been recognized as monumental discoveries in the past for the community of scientists who carried them out. In light of any improvement on those discoveries by the succeeding communities of scientists however, they ought not to be ruled out as unscientific. In other words, succeeding groups of scientists are not closer to the truth than their predecessors. In fact, Kuhn calls some of these past discoveries paradigm. That is, something that gives a prelude to, and serves as a basis for subsequent scientific practices. Accordingly, he conceptualizes an entirely different way of scientific understanding and of measuring scientific progress and development. He distinguishes two types of sciences: the normal science and the extravagant or revolutionary science (Nickels, 2003) These will be explained one after the order in the subsequent sections. For Kuhn, there are various stages in scientific growth: pre-paradigm stage, normal science stage, stage of anomalies and crisis, stage of paradigm-shift, revolution and incommensurability; and the stage of resolution.

The Pre-Paradigm Stage in Research

The pre-paradigm stage in research is also called a prescience stage, where scientist have no common rules or principles guiding their research works. In that case, they try anything that works. It can also be described as a period of confusion, where the previous paradigm guiding research work collapses, hence rejected by researchers due to its malfunction and its persistent resistance to modification. At this stage also, community of scientists are left with no clear paradigm. As a result, they brainstorm and determine a new paradigm that will guild their research work. At this stage, there are as many candidates for paradigm as many scientists propose different candidates for paradigm. This is the stage of competition and disagreement among a community of scientists about legitimate methods, problems and standards of solution. According to Kuhn,

> The pre-paradigm period, in particular, is regularly marked by frequent and deep debates over legitimate methods, problems, and standards of solution, though these serve rather to define schools than to produce agreement. We have already noted a few of these debates in optics and electricity, and they played an even larger role in the development of seventeenth-century chemistry and of early nineteenth-century geology. Furthermore, debates like these do not vanish once and for all with the appearance of a paradigm. Though almost non-existent during periods of normal science, they recur regularly just before and during scientific revolutions, the periods when paradigms are first under attack and then subject to change. The transition from Newtonian to quantum mechanics evoked many debates about both the nature and the standards of physics, some of which still continue (1996, 47-48).

There are a number of problems which are outlined by the community of scientists at this particular stage. Any candidate that will emerge as a paradigm must be able to solve those problems. Besides, a new paradigm is selected based on its ability to resist anomaly or tension, thereby reducing crisis or disruption in research. These considerations are prerequisite to the selection of a new candidate for paradigm. Accordingly, puzzle-solving potential is an important criterion in the selection of a new paradigm (Kuhn, 1996, 155). Any candidate for paradigm that is suspected to have a feeble puzzle-solving ability is automatically rejected, while the one which has the ability to solve problems triumphs through the method of elimination as a paradigm guiding that particular community of scientists. After this stage, the next is the stage of normal science.

The Stage of Normal Science

Normal science is a tradition-bound enterprise, practiced by those who Kuhn calls a community of scientists. This community has the same focus in the area of scientific discovery. And they have a common paradigm guiding their research work. Normal science is cumulative in nature. It is cumulative in the sense that it erects its new scientific discoveries on the achievements made by the previous community of scientists in the same field of discovery. In this wise also, it is additive. According to Kuhn,

> Normal science means research firmly based upon one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice. Today such achievements are recounted, though seldom in their original form, by science textbooks, elementary and advanced (1996, 6).

Kuhn cites some instances of works that serve as past scientific achievements. Those works include Aristotle's *Physica*, Ptolemy's *Almagest*, Newton's *Principia* and *Opticks*, Franklin's *Electricity*, Lavoisier's *Chemistry* and Lyell's *Geology*. These works, for Kuhn, are enough to define the legitimate problems and methods of a research field for succeeding generations of practitioners.

These are the works that can generate new thoughts and ideas for the succeeding community of scientists and whatever discoveries they make will be additive to the previous achievements made in the past. In this wise, normal science is cumulative. Apart from defining research problems and methods of a research field for the succeeding generation of practitioners, the previous achievements serve as foundations upon which the new scientific discoveries are based.

According to Kuhn, normal science does not aim at novel discoveries. Instead, it aims at solving puzzles and articulating paradigms. In other words, normal science does not set out to discover new things but to solve puzzles or problems. If the aim of normal science is not to discover new things, why are these problems explored at all? Kuhn's answer to this question is that to scientists, at least, the results gained in normal research are significant, because they add to the scope and precision with which the paradigm can be applied (That is, the paradigm guiding that particular community of scientists) (1996, 36). This reaffirms the nature of normal science as a cumulative enterprise.

Kuhn however emphasizes the importance of paradigm for a community of scientists. It is the paradigms that supplies the puzzles and the tools for solving them. Thomas Nickles captures Kuhn's conception of paradigm as a crucial parameter to normal science more vividly.

> Normal science is highly regimented work under a paradigm. It aims to extend and articulate the paradigm, not to test it, for the paradigm defines the research tradition, the scientific life, of a particular discipline and its practitioners. Normal research consists in attempting to solve research puzzles by modeling them and their solutions on exemplary problem solutions previously achieved. Good science is delimited not by rules such as Popper's criterion of falsifiability, or positivist meaning postulates, or even by more content-laden rules specific to the discipline, but by how practitioners perceive and apply these "exemplars" (as Kuhn termed them). In fact, there is no scientific method in the sense of a set of rules that guide inquiry (2003, 1).

The explanation above makes it evident that paradigm is a necessary instrument which a specific community of scientists must possess. It defines the research problems, methods and concerns of the community of scientists. It is not however a rule or a theory of scientific discovery; it is an essential instrument or tool, necessary for a good scientific research work. And it is like a trademark of a particular group of scientist. as different from other groups of scientists.

Kuhn on the Concept of Paradigm

Kuhn uses the word paradigm in two major senses. First, he conceives it as an exemplar, in the sense that it serves as a previous model for subsequent scientific practices; second, he conceives it as a disciplinary matrix, in the sense that it determines the problems and guilds research work and provides the framework within which a particular community of scientists operate (Ladyman, 2007), In other words, paradigm, on the one hand, can be seen as a previous achievement by a particular community of scientists, attractive enough to provide a task or an engagement for the succeeding groups of scientists. On the other hand, it can be seen as the trademark or defining principle of a particular group of scientists. In this wise, paradigm provides the leading light in research work.

He outlines two major characteristics which any past scientific achievements must possess in other for it to set a model of scientific problems and methods of a research field for succeeding generations of practitioners. The first is that the achievement of the previous community of scientists must be unprecedented to attract an enduring group of adherents away from competing modes of scientific activities (Kuhn, 1996, 10). That is, succeeding generations must be so attracted to their achievements to the extent that they will see it as a priority to continue from where they stopped and as unnecessary or irrelevant to propound new methods of scientific discoveries.

The second characteristic is that the previous scientific discovery must be sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to solve (1996, 10). In other words, succeeding generations must be able to generate a wide range of problems from their discoveries, which will later serve as their own engagements or preoccupations. Any previous scientific discovery that possesses these two characteristics is what Kuhn refers to as a paradigm. This is the sense in which he uses paradigm as an exemplar or model. Paradigm is also a necessary instrument or tool, that defines the problems, methods and focus of a particular group or community of scientists. That is, it is a disciplinary matrix or trademark like we previously said. According to Kuhn, "Men whose research are based on shared paradigms are committed to the same rules and standards for scientific practice. That commitment and the apparent consensus it produces are prerequisite for normal science, i. e., for the genesis and continuation of a particular research tradition" (1996, 11).

From the above it follows that paradigm defines the problems and proposes solutions for a particular community of scientists of research tradition. In another place, Kuhn defines paradigm as an object for further articulation and specification under new or more stringent conditions. This definition is consistent with his former definition of paradigm as a disciplinary matrix and not as a rule or criterion of scientific activities. In fact, Kuhn states it expressly that:

> Normal science is a highly determined activity, but it need not be entirely determined by rules. That is why at the start of this essay, I introduced shared paradigms rather than shared rules, assumptions, and points of view as the source of coherence from normal

> research traditions. Rules, I suggest, derive from paradigms, but paradigms can guide research even in the absence of rules…The determination of shared paradigms is not, however, the determination of shared rules…Lack of a standard interpretation or of an agreed reduction to rules will not prevent a paradigm from guiding research. Normal science can be determined in part by the direct inspection of paradigms, a process that is often aided by but does not depend upon the formulation of rules and assumptions. Indeed, the existence of a paradigm need not even imply that any full set of rules exists (1996, 23).

The above makes it evident that Kuhn does not attribute the same function to rules and paradigms. That is one of the reasons why his conception of paradigm cannot be rightly described as rule, just like Popper's falsifiability, or reduced to a criterion just like the logical positivists' analyticity and verificationism. Paradigm determines the problems and supplies tools for the solution of the problems. While it encompasses rules, rules do not encompass paradigm. That is the reason why Kuhn emphasizes the importance of paradigm and not of rules like Popper and the Logical Positivists suggest for a community of scientists.

Anomaly, Crisis and Paradigm Shift

Kuhn argues that a community of scientists enjoy a certain period of stability in their research work, guided by their chosen paradigm. Remember that the paradigm dictates the problems to solve and the solutions to the problem. However, it gets to a certain point where the paradigm no longer proves to be effective in solving the problems it proposes. The recurrent failure of the paradigm to produce impressive results in the course of research is what Kuhn calls anomaly. According to Kuhn,

> Sometimes a normal problem, one that ought to be solvable by known rules and procedures, resists the reiterated onslaught of the ablest members of the group within whose competence it falls. On other occasions, a piece of equipment designed and constructed for the purpose of normal research fails to perform in the anticipated manner, revealing an anomaly that cannot, despite repeated effort, be aligned with professional expectation. In these and other ways besides, normal science repeatedly goes astray. And when it does - when, that is, the professional can no longer evade anomalies that subvert the existing tradition of scientific practice - then begin the extraordinary investigation that lead the professional at least to a new set of commitments. A new basis for the practice of science (1996, 5-6).

In this wise, Kuhn uses the terms "paradigm" and "equipment" interchangeably. To be sure, he asserts that scientific discovery commences with the awareness of anomaly, that is, with the recognition that nature has somehow violated the paradigm-induced expectations that govern normal science. At this stage of anomaly, the community of scientists being guided by this dysfunctional paradigm try to re-articulate or readjust it to solve the problems it suggests, but the paradigm keeps resisting all the attempts made to rearticulate it. Hence, it continues to malfunction.

The persistent malfunction of the paradigm, despite the efforts of scientists to re-articulate it, is what Kuhn refers to as crisis. When these crises occur, the need for another paradigm that will guide normal research work arises. This crisis necessitates another paradigm. Consequently, Kuhn sees crisis as a necessary condition for a community of scientists and a special occasion for retooling. For him,

> Invention of alternates is just what scientists seldom undertake except during the pre-paradigm stage of their science's development and at very special occasions during its subsequent evolution. So long as the tools a paradigm supplies continues to prove capable of solving the problems it defines, science moves fastest and penetrates most deeply through confident employment of those tools. The reason is clear. As in manufacture so in science - retooling is an extravagance to be reserved for the occasion that demands it. The significance of crises is the indication they provide that an occasion for retooling has arrived (1996, 76).

Researchers, therefore, brainstorm on paradigms and offer candidates for paradigm, like at the pre-paradigm stage. This is another stage of disagreement and competition among researchers. Here again, they set a number of problem which any candidate for paradigm must be able to solve before it can be adopted as a paradigm guiding that research tradition. Any candidate for paradigm that prevails becomes the new paradigm guiding research work. This is what Kuhn calls paradigm-shift.

Extraordinary or Revolutionary Science

Paradigm-shift is also known as revolution. For Kuhn, revolution marks a growth in the progress of scientific discoveries. As we said previously, it is an occasion for retooling. It is contrary to the cumulative nature of the normal science. When a shift in paradigm occurs, it divides a community of scientist into two. Some adhere to the old paradigm while some abandon the old paradigm for the new one. This change in paradigm necessitates the change in worldview of a particular scientific tradition. According to Kuhn, "The extraordinary episode in which that shift of professional commitments occurs are the ones known in this essay as scientific revolutions. They are the tradition-shattering complements to the tradition-bound activity of normal science (1996, 6).

Revolutionary science is tradition-shattering because it alters the flow of research work and this brings about a change of perspective to the community of scientists and sets their minds on new and different commitments. Kuhn likens revolutionary science to the real revolution in the actual human society in which a new political ideology replaces an old one and in which the society is polarized over the revolution: one part supporting the old ideology and the other supporting the new. However, as time goes one, the new ideology emerges triumphant and replaces the old one entirely through what Kuhn calls the techniques of mass persuasion, which often includes force (996, 93. The application of force in political revolution is, however due to the unconstitutional nature of such revolution (Bird, 2000),

Unlike political revolutions, however, there are debates which ensue among the community of scientists before the beginning of revolutionary science. When anomalies and crises arise, scientists endeavour to re-articulate the paradigm guiding their research work. The persistent failure of the paradigm to yield a positive result after re-articulation necessitates another paradigm. This exercise is like the pre-paradigm stage, where different paradigms are proposed. At this stage, scientists use their paradigms to argue in defense of themselves. In other words, a particular paradigm is used to defend itself. That is the reason Kuhn contends that when paradigms enter, as they must, into a debate about paradigm choice, their role is necessarily circular (1996, 94). A paradigm ultimately triumphs and divides the community of scientists into two: one part holding on to the old paradigm, and the other holding onto the new paradigm. Kuhn argues that the paradigm cannot be logically or probabilistically made compelling for those who refuse to step into the circle.

Scientific growth, therefore, for Kuhn, represents an occasional breakage or disruption, which sets the minds of scientists to another set of commitments and changes their worldviews and perspectives concerning the same issue or old problems. The science that emerges after the revolution is what Kuhn calls matured science. This is a blatant disagreement with the traditional view of scientific development, which sees scientific progress and growth as cumulative.

Incommensurablility and the Resolution of Revolution

Kuhn argues that after a paradigm-shift, the new or succeeding paradigm is incommensurable or inconsistent with the old one, though the scientists working in the two different worlds may try to convert one another to their ways of seeing science; this attempt must fail. To be sure, Kuhn argues that they must fail to make complete contact with each other's viewpoints. And this is because of a particular reason: they now practice their trades in different worlds and they hold different perspectives about the same issue. This, according to Kuhn, is the incommensurability of the pre- and post-revolutionary normal science traditions. This incommensurability starts from the disagreement over the list of problems that the new candidate for paradigm must solve and matures to the difference in their definition of science (1996, 148). Kuhn, however, admits that difference in the worldviews of the adherents of the old and new paradigms is not predicated only on incommensurability but also on misunderstanding. According to him,

> More is involved, however, than the incommensurability of standards. Since new Paradigms are born from old ones, they ordinarily incorporate much of the vocabulary and apparatus, both conceptual and manipulative, that the traditional paradigm had previously employed. But they seldom employ these borrowed elements in quite the traditional way. Within the new paradigm, old terms, concepts, and experiments fall into new relationships one with the other. The inevitable result is what we must call, though the term is not quite right, a misunderstanding between the two competing schools (1996, 149).

Paradigm-shift involves the incorporation of the vocabulary of old paradigm by new paradigm, but those incorporated vocabularies are not adopted or applied in the same way they are applied and used in the old paradigm. Old apparatuses that are borrowed by the new paradigm are modified and used in ways that are different from how they are used in the old paradigm. This makes it difficult for the practitioners of the post-revolutionary science to interact with the practitioners of the pre-revolutionary science.

Furthermore, on the notion of incommensurability, Kuhn argues that the proponents of competing paradigms practice their trades in different worlds. They see different things when they look at the same thing and what is unclear to one is obvious to another. This, of course, is what Kuhn describes using various words such as misunderstanding, incompatibility and incommensurability. Paradigms are incommensurable mainly because they are "theories, methods, and standards" all in one - that is to say, they include criteria of evaluation of theory as well as theory itself (Siegel, 1987).

However, there is a point at which the revolution is resolved. At this point, some members of the old paradigm are converted to the new paradigm, while others continue to articulate the old paradigm as to whether it can resolve the problems it propose.

Nonetheless, this resolution and conversion are not based on a rational conviction about the plausibility of the new paradigm over the old one, but on what Kuhn calls inarticulate aesthetic considerations about the new paradigm and faith in it. According to him, a person who embraces a new paradigm must make that decision on faith that the new paradigm will succeed with the many large problems that confront it, knowing only that the older paradigm has failed with few. He explains further that:

> There must also be a basis, though it need be neither rational nor ultimately correct, for faith in the particular candidate chosen. Something must make at least a few scientists feel that the new proposal is on the right track, and sometimes it is only personal and inarticulate aesthetic considerations that can do that. Men have been converted by them at times when most of the articulable technical arguments pointed the other way (1996, 158).

The above shows the way by which scientist get converted into the new paradigm. Since there cannot be a complete communication between the old and the new traditions of scientist, owing to the incommensurability and incompatibility of their scientific traditions, irrational subjective and personal considerations predicated on faith and inarticulate aesthetic considerations become the basis for converting from the old scientific tradition to the new one. Those who convert from the old scientific tradition to the new one may have few supporters according to Kuhn, but if they are competent, they will explore the paradigm and improve it. And as that goes on, if the paradigm is the one destined to win its fight, the number of persuasive arguments in support of it increases and many people get converted to it and its exploration will continue and experiments, textbooks and articles on the new paradigm increase. For Kuhn, this is the way through which scientific revolutions are resolved.

Progress Through Revolution

Kuhn's epistemology is against the traditional scientific belief that scientific development, growth or progress is cumulative, that there is a unified method for all sciences, that new generations of scientists are closer to the truth than old generations, that science moves towards some goals in nature, etc. (Ladyman, 2002). This is evident in his attack on the logical positivists' criterion of verifiability and on Karl Popper's falsification rule. Karl Popper does not, however, adhere to the cumulative view of scientific growth like the logical positivists. There are two main points of departure between Kuhn and Popper. The first is Kuhn's emphasis on the importance of scientific tradition or community; the second is his discontentment with Popper's falsification (Kuhn, 1965).

The logical positivists, according to Kuhn, emphasize the verification of theories. However, being aware that theories cannot be exposed to all possible relevant tests, they ask about the probability of a theory in the light of evidence that actually exist instead of asking for its verification. Theories that are improbable in the light of the actual available evidence are rejected. Karl Popper's falsification rule, on the other hand, emphasizes the rejection of an established theory if its outcome is negative after being tested. This for Kuhn, is similar to his own explanation about anomalous experiences that prepare a way for a new theory, by invoking crisis, but he argues that anomalous experiences are not falsifying. This is because no theory can solve all puzzles. For Kuhn, if any and every failure to fit were ground for theory rejection like Popper contends, all theories ought to be rejected at all times. On the other hand, if only persistent failure to fit justifies theory rejection, then Popperians will require some criterion of improbability or degree of falsification. In this wise, they will encounter the same problem that the probabilistic verification theory encounters. Kuhn argues that falsification does not occur as a result of anomaly or falsifying instance. In fact, for him, falsification rule can equally be called verification (Kuhn, 1996).

Against the above background, Kuhn argues that scientific progress is not what it has been previously believed to be. For him, there need not be progress of another sort and change in paradigm does not take scientists closer to the truth. He, therefore, describes scientific progress as an evolutionary development from primitive beginnings through successive stages characterized by an increasingly detailed understanding of nature, but which aims at no specific goal set by nature in advance. In this wise, Kuhn understands science as an enterprise that begins from the evolutionary stage of normal science and transmogrifies into the revolutionary stage of extraordinary science, to which he attributes progress and growth. Against the traditional epistemologists' view that knowledge must be stable and constant, we may say that knowledge, for Kuhn, must be unstable and tension laden. In other words, change is a necessity for knowledge and tension is essential to scientific growth.

A Critique of Kuhn's Understanding of Scientific Progress

Having discussed Kuhn's epistemology and his view of scientific growth above, it is necessary to consider some objections raised against his epistemology and some notable flaws in his explanation of scientific growth. Kuhn has been criticized on different grounds by different philosophers of science such as Scheffler, Shapere and Kordig (Siegel, 1987, 54). For instance, he was criticized by Israel Scheffler for giving a relativistic account of scientific development and for proposing irrationality in the choice of paradigm.

These criticisms arise due to Kuhn's description of the method of paradigm evaluation, which is paradigm-bound. In other words, that the justification of a paradigm and the criteria for its evaluation are based on, or internal to the paradigm to be evaluated. In this wise, there are no external criteria for evaluating paradigms. This suggests irrationality as against objectivity in the choice of paradigm. Besides, the allegation of relativism levelled against Kuhn stems from his introduction of the concept of incommensurability and his explanation about the incompatibility of the old paradigm with the new one. This suggests that science is what each man describes it to be and that each man will be justified in describing it in his own way. Israel Scheffler lays his criticism against Kuhn in the following ways:

> To accept a paradigm (according to Kuhn) is to accept not only theory and methods, but also governing standards or criteria which serve to justify the paradigm as against its rivals, in the eyes of its proponents. Paradigm differences are thus inevitably reflected upward, in criteria differences at the second level. It follows that each paradigm is, in effect, inevitably self-justifying, and that paradigm debate must fail of objectivity (Siegel 1987, 55).

Scheffler's contention in the above excerpt is that Kuhn's proposed irrationality in the choice of paradigm rules objectivity out in paradigm choice and this unavoidably leads to relativism in science.

Apart from the above objections, there are some others that worth discussing. First, in his explanation of how some members of scientific community get converted from the old to the new paradigm, Kuhn argues that the consideration is not based on rational conviction but on inarticulate aesthetic considerations and faith. Besides this, he argues that a particular paradigm can be destined to emerge. In this wise, he lumps his explanations up by predicating scientific revolution, which is synonymous with paradigm-shift, on both subjective artistic and metaphysico-religious concepts of aesthetic (attraction), faith (dogma) and destiny, thereby divesting science totally of objectivity. However, by venturing into this explanation, Kuhn launches himself into a serious contradiction.

It could be argued in concord with Kuhn's position that science is not totally free of convention, sentiments and prejudices. However, it amounts only to a sheer oversimplification or over-deconstruction to claim that science, in fact, progresses on religious prejudices, inarticulate aesthetic sentiments and unguided metaphysical assumptions, deprived of an atomic iota of objectivity.

Kuhn's usage of a metaphysical concept such as destination in justifying the triumph of a paradigm over another, is absolutely unwarranted. For instance, he says if the paradigm is the one *destined* to win its fight, the number of persuasive arguments in support of it increases and many people get converted to it and its exploration will continue and experiments, textbooks and articles on the new paradigm increase (Kuhn, 1996, 159). In this wise, he predicates his entire contemplation of the structure of scientific progress through revolution and tension on destination. This again makes his explanation on scientific progress not only contradictory but confusing. If a particular paradigm has already been destined to win, what, it could be asked, is the need for a pre-paradigm debate in the first place?

Moreover, Kuhn argues that paradigms are selected based on their ability to solve puzzle and guide research without easily developing faults and anomalies. However, he seems to have forgotten his explanation that tension and crisis are both precipitating factors to revolution or paradigm-shift to which he attributes growth and development in science. This is, again, contradictory. It is contradictory because it is not clear at all how a paradigm-shift can occur if a paradigm that will solve a wide range of puzzles, thereby having a lesser capability to develop anomaly or crisis that will galvanize tension and revolution, is always selected during pre-paradigm debates.

Despite the above objections, Kuhn's *Structure of Scientific Revolutions* is a significant achievement in the philosophy of science. It is, itself, seen as a revolution. According to Marcum James, apart from its significant influence on the philosophy of science, Kuhn's work has tremendously influenced several other disciplines such as natural science, sociology, political science, economics, psychology, religion, Fine Arts, etc, through the introduction of the concepts of incommensurability, paradigm and paradigm-shift (Marcum, 2005). It is therefore, an exceptional legacy.

Conclusion

In this essay, we have discussed Thomas Kuhn's epistemology and his revolutionary perspective of scientific growth and development against the traditional cumulative understanding of scientific progression. We have explained his departure from the logical positivists' criterion of verification, Karl Popper's falsification rule, and his replacement of these previous rules with paradigm, which, for him, is all-encompassing. We have discussed Kuhn's division of science into normal and extraordinary and his attribution of scientific development to the extraordinary science, which is tradition-shattering. We have also discussed Kuhn's concept of incommensurability and the relativistic and irrationalist charges against it, mainly by Scheffler. Besides, we have raised some objections against Kuhn's epistemology, especially on his explanation of paradigm choice and replacement, which he predicates on faith, destiny and inarticulate aesthetic sentiments thereby totally stripping scientific research of objectivity. However, we have noted that against all these objections, Kuhn's *Structure of Scientific Revolutions* is an exceptional legacy because of its significant influence on the philosophy of science and on other disciplines.

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