



A Critical Study of Thomas Kuhn's History of Philosophy of Science

Abstract

The paper sets off with the study of the personality of Kuhn and how a physicist by profession became a philosopher, and a historian of philosophy of science. It further discussed some important concepts without which Kuhn's paradigmatic philosophy of science may be misunderstood. Amongst the Kuhnian concepts discussed are: pre-science, normal science, extraordinary science, paradigm shift, scientific revolution, disciplinary matrix, scientific community, incommensurability, and so on. The paper extended to the critical examination of Kuhn's magnum opus: *The Structure of Scientific Revolution (SSR)*, where, with his theory of scientific revolution, he debunked the prevailing positivist assertion that scientific change is necessarily progressive, and therefore, cumulative, objective and linear. By this, new truths are progressively added to the already existing one, in a continuous, unbroken manner. Contrarily, Kuhn replaced this positivist position with his idea of scientific revolution which presents a discontinuous version of scientific development such that the new scientific theory that emerges in the course of scientific revolution is totally different from the old one, leading to a paradigm shift. Despite the heavy scholarly attack on Kuhn's history of philosophy of science, the paper concluded that his unique idea of scientific revolution gives a good insight towards the perception or understanding of the nature of scientific development, and as such, his account of scientific revolution, which he articulated in his *SSR*, deserves commendations not only for presenting a new way of conceiving scientific development and/or progress, but above all, for bringing the final demise of logical positivism. The paper finally agreed with the camp that suggests the integration of both cumulative, linear and non-cumulative, non-linear elements in scientific development.

Keywords: Paradigm Shift, Scientific Revolution, Pre-Science, Normal Science, Incommensurability, Scientific Community, Disciplinary Matrix and Exemplar.

Introduction

Of recent, I was asked to handle a course captioned: "Philosophy of Science," where amongst others, I was mandated to

discuss with philosophy students, Thomas Kuhn's contributions to philosophy of science, with special reference to his *The Structure of Scientific*

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Revolution (SSR). The implication is that this paper is didactic in nature. Consequently, it attempts to critically study Kuhn's history of philosophy of science with special attention to his SSR. However, before the critical examination of Kuhn's SSR, the author chose to elucidate some Kuhnian concepts without which Kuhn's paradigmatic philosophy of science may be misunderstood. For a better understanding of Kuhn's contributions to philosophy of science, the paper began with a concise biography of Thomas Samuel Kuhn.

During the course of this research, it was learnt that amongst Kuhn's major contributions to philosophy of science is his critique of the positivist position that scientific change is necessarily progressive, and therefore, cumulative, objective and linear. Conversely, Kuhn replaced this positivist position with his unique idea of scientific revolution which presents a discontinuous version of scientific development such that the new scientific theory that emerges in the course of scientific revolution is totally different from the old one. While for the positivists, new truths are progressively added to the already existing one, in a continuous, unbroken manner. Nevertheless, after a critical examination of Kuhn's history of philosophy of science, the author suggests the integration of both cumulative, linear and non-cumulative, non-linear elements in scientific development.

Life and Times of Thomas Samuel Kuhn

Thomas Samuel Kuhn, an American philosopher and historian of science, was born on 18th July, 1922 and died on 17th June, 1996. Although Kuhn wrote other works such as *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought* (1956), *The Essential Tension* (1977), *The Road Since Structure* (1977) which was written in response to criticisms attracted by his magnum opus: *The Structure of Scientific Revolutions* (SSR) first published in 1962 and revised with a postscript in 1970. Of all his works, SSR was widely read and discussed (both within and outside of philosophical community) because it presented a view of science very different from those prevalent among philosophers and scientists. "Earlier views were that science is cumulative: scientists discover more and more truths about the world" (Musgrave, 1999, p. 300).

In other words, before the emergence of Kuhn in the arena of contemporary philosophy of science, it was dominantly held by the Logical Positivist that scientific development is a linear as well as continuous activity such that "a new scientific theory is nothing but an extension of the older one." Therefore, "the positivists asserts that a scientific change is necessarily progressive, and the path of scientific change is cumulative, objective and linear ... scientific progress was seen as the addition of new truths to the stock of old ones, or the increasing approximation of theories to the truth, or at least the correction of the past errors" (Thomas & Suleiman, 2019, p. 86).

Kuhn totally rejected this perspective and replaced it with his idea of scientific revolution which “presents a discontinuous version of scientific development such that the new scientific theory that emerges in the course of scientific revolution is totally different from the old one.” It is important to underscore that because Kuhn was not only a philosopher of science; also, as a historian of science, he placed serious emphasis on the historical context of scientific discoveries (Anetoh, 2021, p. 1).

In fact, had Kuhn not written *SSR*, he would have only merited a minor footnote as a historian of science in the twentieth century. “Although Kuhn was the most influential philosopher of science of the twentieth century, his formal training was in physics and his next career turn was to the history of science. He was trained as a physicist, receiving a B. S. in 1943, an M. A. in 1946, and a Ph.D. in 1949 from Harvard in that discipline” (Ndianefoo, 2016, pp. 318-319).

Moreover, Ndianefoo (2016) continues, Kuhn's first teaching appointment at the University of California, Berkeley, from 1956 to 1964, and his second, at Princeton University, from 1964 to 1979, were in history departments and in the “history and philosophy of science” program, but not in philosophy. “Only when he moved to Massachusetts Institute of Technology in 1979 did he become a member of a philosophy department. (though it was the Linguistics and Philosophy Department).” He was equally elected president of the Philosophy of Science

Association in 1989, after having been a member of that association for only a few years (p. 319).

Also, “while Kuhn was still a graduate student, James Conant, a chemist who was then president of Harvard, ask him to assist in preparing a historically oriented physics course for non-science majors. In the process of preparing for this course, Kuhn, who had read little or no history of science previously, spent an extensive period of time reading Aristotle.” He discovered that “Aristotle had known almost no mechanics, if one understands mechanics as the system discovered by Galileo, Newton, and others” (p. 323). The comments of Thomas and Suleiman (2019) on the academic background of Kuhn illustrated his career shift thus:

Thomas Kuhn's major work (1970), *The Structure of Scientific Revolutions*, is the first full published report on a project originally for several years, particularly since he was a postgraduate student in theoretical physics. It was a fortunate involvement with an experimental college course that treated physical science for the non-science students that exposed him to the history of science. To his utter surprise, that exposure to out-of-date scientific theory and practice radically undermined some of his basic conceptions about the nature of science and the reasons for its special success. This resulted in a drastic shift in Kuhn's career plans from physics to history of science, and then also, gradually from relatively

straightforward historical problems to the more philosophical issues that had initially led him to history. (p.85)

Lastly, Obi-Okogbuo (2015) pointed out that Kuhn (a post-positivist) rejected the positivists' verification criterion and approached science not from philosophy or scientific methodology, but from history and sociology of science (p. 376). This can be noticed in the analogy Kuhn made between political revolutions and scientific revolutions:

Political revolutions are inaugurated by a growing sense, often restricted to a segment of the political community, that existing institutions have ceased adequately to meet the problems posed by an environment that they have in part created. In much the same way, scientific revolutions are inaugurated by a growing sense, again often restricted by a narrow subdivision of the scientific community that an existing paradigm has ceased to function adequately in the exploration of an aspect of nature to which that paradigm itself had previously led the way. In both political and scientific development(,) the sense of malfunction that can lead to crisis is prerequisite to revolution. (Kuhn, as cited in Rosen, 2000, p. 503)

Having understood the person of Kuhn, time is ripe to have a closer look at some critical concepts without which Kuhn's paradigmatic philosophy may be misunderstood.

Key Concepts in Kuhn's Philosophy of Science

Some concepts are critical in the study of Kuhn's paradigmatic philosophy. They are: paradigm, disciplinary matrix, exemplar, paradigm shift, pre-paradigm science or pre-science, paradigm science or normal science, extraordinary science, scientific community, anomaly, revolution and scientific revolution, incommensurability, consensus, scientific development, and so on. These Kuhnian concepts deserves a closer look if one must understand Kuhn's paradigmatic philosophy of science. What is more, most of these concepts are interconnected.

Paradigm

According to Orman (2016), "paradigm" is a central concept in Thomas Kuhn's thought. Little wonder Kuhn was attacked heavily for giving different definitions of the term in his *The Structure of Scientific Revolution* (SSR). Margret Masterman, in her article, "The Nature of Paradigm," identified no fewer than 21 possible meanings for a paradigm in SSR. For Masterman, as captured by Orman (2016), "existing multiple definitions of paradigm in SSR is really problematic" (p. 49). In his *Second Thoughts on Paradigms* (1974) and in the Postscript to the second edition of SSR (1970), Kuhn conceded that he had used "paradigm" too broadly.

Similarly, as recorded by Ndianefoo (2016), Masterman (1974) presented taxonomy of twenty-two distinguishable senses of the term (paradigm) in SSR. Kuhn may have disagreed with this. However, he was sufficiently persuaded

by Masterman's critique and those of many other critics that clarification was necessary (Ndianefoo, 2016, p. 321). Thus, in the *Postscript*, Kuhn accepted to have used the word in two different ways: *Disciplinary Matrix* and *Exemplar*. Kuhn delineates paradigm as:

The entire constellation of beliefs, values, techniques, and so on shared by the members of a given community (or) on the other hand it denotes one sort of element in that constellation, the concrete puzzle-solutions which (if) employed as modes or examples can replace explicit rules as a basis for the solution of the remaining puzzles of normal science. (Kuhn, 1970, p. 175 cited in Okogbuo, 2015, p. 377)

Therefore, "paradigm" signifies that scientific enterprise should not only be conceived as theories, but should equally involve such extraneous factors as beliefs, attitudes, procedures and techniques of a scientific community. In a clearer language, "a paradigm is a specific theoretical orientation that is based upon a particular epistemology and research methodology, reflective of a particular scientific community at a particular time in history. A paradigm constrains and directs the nature of type of research inquiries generated from the theoretical orientation, as well as provides the fundamental basis for evaluating the results of the generated research" (Thomas & Suleiman, 2019, p. 94), or in the words of Orman (2016); a paradigm "also frames and directs the nature of the type of research inquiries generated from that theoretical orientation, as well as

provides the fundamental basis for evaluating the results of the generated research" (p. 51).

Furthermore, a paradigm takes care of: what should be asked, what phenomena should be observed, and how the observations should be interpreted. Owing to the criticisms attracted by *SSR* (first edition), Kuhn after a deeper reflection, expressed in the *Postscript* to the second edition of *SSR*, a desire to replace the term "paradigm" with two new terms: "disciplinary matrix" and "exemplar."

Paradigm as Disciplinary Matrix

According to Ndianefoo (2016), Kuhn intends to include in a disciplinary matrix the following six elements: (i) equations or other symbolic representations, (ii) instruments, (iii) standards of accuracy and experimental repeatability, (iv) metaphysical assumptions, (v) the domain of inquiry, and (vi) exemplars (p. 322). In other words, a disciplinary matrix is the cluster of "an entire theoretical, methodological, and evaluative framework within which scientists conduct their research. This framework constitutes the basic assumptions of the discipline about how research in that discipline should be conducted as well as what constitutes a good scientific explanation." Paradigm in this first sense designates what the members of a certain scientific community have in common, i.e., "the whole of techniques, patents, and values shared by members of the community" (Orman, 2016, p. 49; Thomas

& Suleiman, 2019, p. 88). In the words of Kuhn (1970) as recorded by Orman (2016):

... I suggest 'disciplinary matrix': 'disciplinary' because it refers to the common possession of the practitioners of a particular discipline; 'matrix' because it is composed of ordered elements of various sorts, each requiring further specification. All or most of the objects of group commitment that my original texts make paradigms, parts of paradigms, or paradigmatic are constituents of the disciplinary matrix, and as such, they form a whole and function together. (p.50)

Paradigm as Exemplar

In this second sense, as already observed, paradigm refers to a single element (exemplars) of a whole. Exemplars are concrete examples of "problem solutions." These examples provide guidance for future research. Also, these examples, says Ndianefoo (2016), are implicitly constrained by rules and are instances of a method, but neither the rules nor the method is explicit in them (p. 322). In other words, *normal science*, for Kuhn, is not guided by a coherent system of rules, on the contrary, "the rules can be derived from the paradigms, but the paradigms can guide the investigation also in the absence of rules." Orman (2016) writes: "The paradigm is in this sense, just an example, a single phenomenon, a singularity, which can be repeated and thus acquires the capability of tacitly modelling the behavior and the practice of scientists" (p. 50). Kuhn in his Postscript to *SSR* (second edition), refers

to an achievement of this sort as an exemplar. For him;

Exemplars are "the concrete problem-solution that students encounter from the start of their scientific education, whether in laboratories, on examinations, or at the end chapters in science texts." Also, to be included as exemplars are "some of the technical problem-solutions found in the periodical literature that scientists encounter during their post-educational research careers and that also show them by example how their job is to be done" (p. 50). For the fact that *normal science* not only builds on exemplars, but is also built by exemplars, these exemplars are inculcated and transmitted by training young scientists with them. This enables them to solve scientific problems in ways analogous to those in the exemplars. *Scientific revolution* occurs when the existing exemplars are substituted with new ones – which also effects changes in the disciplinary matrix.

Scientific Community

It has been pointed out that these Kuhnian concepts under discussion are interrelated. For the fact that the nature of paradigm is intimately connected with the nature of scientific community, and to further clarify the notion of the former, the latter must be discussed. According to Kuhn, members of a scientific community are connected by common elements in their education and apprenticeship, and they regard themselves and are regarded by others as men responsible for the pursuit of a set of shared goals along the line of their discipline. For more clarity,

Kuhn queries: "What do its members share that accounts for the relative unanimity of their professional judgments?" The answer to this Kuhnian query, of course, is paradigm or a set of paradigms. "Paradigm govern the shared community life and not the subject matter. Entrance into the scientific community requires acquisition of its lexicon" (Thomas & Suleiman, 2019, p. 95).

In other words, a scientific community not only organizes science around a paradigm, it is composed of adherents to a paradigm, i.e., men and women who share a paradigm; persons who share one scientific specialty (Obi-Okogbuo, 2015, p. 377).

Pre-paradigm Science or Pre-science

This is said to be the period when a scientific community lacks a central paradigm, but from which as archetypal, a paradigm gradually begins to develop. During this period, scientists start from zero level and attempt to build a science from the scratch. "Because of the absence of paradigm to organize the data, all facts appear to be equally relevant. So, science begins from simple data collection with no real organizing principle or method. There is then a proliferation of facts and hence little progress in solving problems under these conditions because of the competition among the various schools" (Thomas & Suleiman, 2019, p. 87). Kuhn concludes that this situation presents "something less than science" (Agbo, 2017; Kalman, 2016; Kuhn, 1970 as cited in Thomas & Suleiman, 2019, p. 87).

Normal or Paradigm Science

Normal Science, according to Kuhn, is another key concept that closely relates and, in fact, almost synonymous with paradigm. It refers to the prevalent scientific activities of a scientific community. It is a science regime that answers their questions, solves their problems and dominates their attitudes. Normal Science is "research based upon one or more past scientific achievements; achievements that some particular scientific community acknowledges for a time as supplying the foundation for all its further practice" (Kuhn, 1970, p. 10). Normal Science is a science conducted within an accomplished paradigm. "When observations or the results of research fails to conform to the paradigm, they are seen as the error of the researcher, rather than refuting the paradigm" (Thomas & Suleiman, 2019, p. 88 & 89).

In other words, Normal Science is a particular point in time when a particular scientific community shares a paradigm. At this time, "the energies of the members of the community are expended to solving the puzzles defined by their paradigm. It follows that 'normal science' is puzzle-solution within the ambient of a paradigm," or in the words of Musgrave, 'normal science,' which as its name suggests, is the norm; it "is puzzle-solving under the aegis of an unquestionable paradigm" (p. 300; Obi-Okogbuo, 2015, pp. 377-78). On another note, Anetoh (2021) further states that Normal Science "has to do with the daily as well as dogmatic activities of scientists characterized by complete acceptance as

well as fidelity to the prevailing paradigm (p. 1).

Anomaly

As time goes by, the number of unsolved puzzles accumulate to the extent that the confidence of the scientific community is eroded. This “surprise” or crisis of confidence is what Kuhn calls “anomaly” or “crisis state” or “scientific crisis.” This is a situation that comes up when Normal Science or “paradigm” fails to account or solve most of the puzzles of a scientific community (Obi-Okogbuo, 2015, p. 378). Furthermore, anomaly violates the paradigm-induced expectation that govern Normal Science. “Anomalies are violations of paradigm expectations during the practice of normal science, and they can lead to unexpected discoveries. It must be noted that the detection of anomalies can only occur due to the background provided by a paradigm (Agbo, 2017; Kuhn, 1970 as cited in Thomas & Suleiman, 2019, p. 94). Note that anomalies generate crisis for a paradigm.

Extraordinary (or Revolutionary) Science

When anomaly persists, scientists take different attitudes towards the current paradigm. They begin extraordinary research. This, according to Kuhn, is the period of “extraordinary or revolutionary science.” During this period, alternative paradigms are canvassed. A new paradigm is inaugurated if one of the

competing paradigms succeeds in solving the recalcitrant anomaly.

Paradigm Shift and Scientific Revolution

Scientific change, according to Bird (2012) takes the pattern of: normal science, crisis, extraordinary science, a new phase of normal science, etc. The shift from an earlier to a new paradigm is known as scientific revolution. Kuhn (1970) defines it as: “... those non-cumulative developmental episodes in which an older paradigm is replaced in whole or in part by an incompatible new one” (p. 92). He cited examples with the transition from Ptolemaic/Aristotelian astronomy to Copernican revolution, and Newtonian mechanics to Einstein’s. In other words, when anomalies arise and the existing paradigm fails to solve them, “then some individual(s) may step out of the paradigm, and propose some new principle or law. If the scientific community accepts the proposed change, the science experiences a revolution or paradigm shift, and the new science proceeds with/as a new paradigm” (Kalman, 2016 as cited in Thomas & Suleiman, 2019, p.94).

Incommensurability

Paradigms, according to Kuhn cannot be compared. They are incompatible and hence, incommensurable because each paradigm defines its own legitimate puzzles and what amounts to puzzle-solutions. What constitutes a puzzle in one paradigm may not be one in another paradigm. Simply put, after a scientific revolution, the old and the new scientists

work in a different observational world. For instance, the terms used in Newtonian and Einsteinian mechanics may look alike, but they denote different concepts. Kuhn argues that the paradigms in these two systems are incommensurable. "It is not possible to understand one paradigm through the conceptual framework and terminology of another rival paradigm, because the reality of members of a scientific community is determined by the paradigm through which they view the world" (Thomas & Suleiman, 2019, p. 94). Therefore, recognized in Kuhn's philosophy of science are: semantic, observational and methodological incommensurability.

Consensus

In order to establish a new paradigm, there must be community consensus, i.e., when most community members are convinced by the techniques of the argument and not simply by empirical evidence or logical analysis. In other words, "what explains the possibility of normal science is the existence of a certain consensus among the community of scientists. It is the consensus that breaks down during a crisis and which is reconstituted in the wake of a revolution" (Fleck in Agbo, 2017, p. 60 as cited in Thomas & Suleiman, 2019, p. 95). Again, "to accept the new paradigm, a community of practitioners must be convinced that there is no chance for the old paradigm to solve the anomalies" (Agbo, 2017; Kuhn, 1970 as cited in Thomas & Suleiman, 2019, p. 95).

Examination of Kuhn's Structure of Scientific Revolution

Thomas Kuhn was a prolific writer. However, amongst his works, *The Structure of Scientific Revolutions (SSR)*, which has been recognized as his masterpiece, is widely read both within and without philosophical community. This research therefore concentrates more on this important but controversial work. The reason is partly because most (if not all) of his later works seems to be a reaction to the scholarly attack on *SSR*. The central thesis of *SSR*, says Ndianefoo (2016), "is that the development of natural sciences and their subfields proceed through alternations of two kinds of scientific development: normal and revolutionary science" (p. 319).

In his *SSR* Kuhn suggests that "science evolves when there is a consensus among scientists about basic ontological commitments, explanatory principles, general methodology, research priorities, and guidelines which should be followed, when scientists share paradigm" (Thomas & Suleiman, 2019, p. 86). According to Kuhn, when scientists share a paradigm, they are said to be practising what is known as "normal science." However, "... real progress did not result from the puzzle-solving of normal science. Rather, true breakthroughs arise in a totally different way: where the discovery of anomalies leads scientists to question the paradigm, and this, in turn, leads to a scientific revolution that he termed paradigm shift" (Thomas & Suleiman, 2019, p. 86). Precisely,

Kuhn claims that a science does not progress as a linear accumulation of new knowledge, but undergoes periodic revolutions called paradigm shifts. This happens whenever the fundamental assumptions of the paradigm become subject to widespread doubt, and there may be general consensus that a replacement must be found. (Kalman, 2016; Orman, 2016; and Kuhn, 1970 as cited in Thomas & Suleiman, 2019, p. 86).

Thus, scientific revolution occurs when scientists or a scientific community encounters anomalies that cannot be addressed by the generally accepted paradigm within which scientific progress has hitherto been made. Consequently, one among the competing approaches to resolving the anomaly or anomalies will eventually produce a solution that gains great loyalty in the scientific community owing to its universality and prospects for future research. The proponents of this solution regard it as a concrete, definitive scientific achievement that defines by example how future research in that discipline should be done. The result is that a new paradigm with new converts is formed. Intellectual battle ensues between followers of the new paradigm and the hold-outs of the old paradigm. Accordingly, progress of scientific change displays this pattern: normal science, crisis (from anomalies), extraordinary science, and a new phase of normal science (Orman, 2016; Kuhn, 1970 as cited in Thomas & Suleiman, 2019, pp. 86-87).

Again, the concept of scientific revolution, which Kuhn discussed in his *SSR*, is very significant in the history of philosophy of science. It brought about a perspective of scientific development which departs totally from logical positivists' cumulative version of scientific development, and a linear conception of scientific progress, which implicates a continuous addition of new ideas to the already existing one. This is because logical positivists watered-down the history of science in their conception of scientific development. That is to say, their approach to science is ahistorical. Whereas Kuhn's idea of scientific development is enshrined in his concept of scientific revolution which is historically oriented. Kuhn (in *SSR*) emphatically states that science develops through revolution which comes up after a long period of *normal science*.

Kuhn's delineation of scientific revolution deserves a closer look. He describes it above as "non-cumulative developmental episodes in which an older paradigm is replaced in whole or in part by an incompatible new one." Here, some important terms must be explicated, namely: non-cumulative, developmental, and incompatible.

The term "non-cumulative," implies that the new scientific tradition that emerge after scientific revolution is not an extension of the old one. By the term, "developmental," Kuhn emphasizes that science develops through revolution. Hence, the transition from paradigm in crisis to a new one through revolution is

the actual developmental pattern of science. The term “incompatible,” entails that the new scientific tradition that emerges after scientific revolution is different from the old one (Anetoh, 2021, p. 4).

Kuhn, as earlier stated, compared scientific revolution with political revolution in his *SSR*. One can deduce from that comparison that in both political and scientific revolution, there are always cases of malfunctioning of the existing system or theory which has failed to adequately solve the problems posed by the political or scientific environment as the case may be. This malfunctional system triggers crisis which may result to revolution. While political revolutions change political institutions, and necessitate the partial relinquishment of one set of institutions in favour of another, scientific revolution, in a similar manner, changes the scientific conceptual worldview. As crisis weakens the role of political institutions, so it debilitates the role of scientific paradigms.

Also, as crisis deepens in the case of political revolution, many individuals sought to reconstruct the society via a new institutional framework. This polarizes the society – while one camp defends the old institution, the other camp seeks for a new one. This is equally applicable to scientific revolution. Revolutions play significant role in the evolution of political as well as scientific paradigms. Kuhn claims that both in political and scientific revolution, the assent of the relevant community as well

as the techniques of persuasive argumentation play critical role in the choice of a new system or theory (Anetoh, 2021, pp. 4-5). Therefore, the transition from the scientific theory in crisis to a new and different one is regarded by Kuhn as scientific revolution. He gave instances with Copernican revolution, Newtonian revolution, Einsteinian revolution, among others. He clarifies further on these scientific revolutions:

Each of them necessitates the community's rejection of one time-honoured scientific theory in favour of another incompatible with it. Each produced a consequent shift in the problems available for scientific scrutiny and in the standards by which the profession determined what should count as an admissible problem or as a problem-solution. And each transformed the scientific imagination in ways that we shall ultimately need to describe as a transformation of the world within which scientific work was done. Such changes, together with the controversies that almost always accompany them, are defining characteristics of scientific revolution. (as cited in Anetoh, 2021, p. 5)

Kuhn substantiated his claim with Copernican example. According to him, Nicholas Copernicus transferred to the Sun many astronomical functions attributed to the earth in Ptolemaic astronomy: Copernican revolution, therefore, “was a revolution in ideas, a transformation in man's conception of the universe and of his own relation to it.” It transformed the way scientists conceive

the universe, and ushered in a new approach to astronomy, which is very different from Ptolemaic astronomy. Copernican revolution is “an epochal turning point in the intellectual development of western man.” Revolution “always involves the rejection and replacement of a framework or some of its integral parts” (Kuhn as cited in Anetoh, 2021, p. 5). This kind of change characterizes scientific development. And the transition from one paradigm to another, one via scientific revolution, Kuhn insists, is not a cumulative process. Rather, scientific revolution reshapes the commitments of scientists.

The new paradigm that emerges after scientific revolution, according to Kuhn, must conflict with the old one. Not only that scientific revolution brings about conceptual transformation, it is difficult, says Kuhn, to see how new theories could arise without destructive changes in belief about nature. In other words, Kuhn argues in his *SSR* that the scientific paradigm that emerges after scientific revolution is both incompatible and incommensurable with the old one.

The above discourse points to the fact that scientific revolution, according to Kuhn, changes completely the scientific world-view of scientists within a scientific community. This implies that scientists see the world differently after scientific revolution. “Kuhn likens the perceptual transformation as well as the conversion experience of scientists after scientific revolution to ‘gestalt switch,’” that is, a sudden change in world-view.

He, once again, insists that scientific development cannot be cumulative, which implies that “One cannot describe the new theory in the vocabulary of the old one or vice versa.” For example, the term “planet” was both used in Ptolemaic astronomy and Copernican astronomy, but the term means different things in the two theories: “The planets revolve around the earth in Ptolemaic astronomy, but in Copernican astronomy, they revolve around the sun” (Anetoh, 2021, p. 9).

In a similar case, after a serious reflection, Kuhn discovered that it is wrong to approach Aristotelian mechanics via Newtonian perspective. He noted that historians reading old scientific texts encounter passages that seem to make no sense; and he equally observed that apparent textual anomalies are products of misreading. The reason being that the “historian has been understanding words and phrases in the text as he or she would if they had occurred in contemporary discourse.” Some interrelated terms are used differently (Kuhn, 2000, p. 59 as cited in Anetoh, 2021, p. 9). This points to what Kuhn calls incommensurability of scientific theories, which is also depicted in the transition from Aristotelian to Newtonian mechanics; and this sort of difference between Aristotelian and Newtonian mechanics characterizes revolutionary change; a change that also entails change in language. Thus, for Kuhn, revolution displaces some of the basic concepts in the existing scientific theory.

Some Critical Remarks

Firstly, it must be said that *The Structure of Scientific Revolutions* (SSR) received both widespread praise and condemnation. Despite Thomas Kuhn's significant impact and contributions to the growth of knowledge in the area of philosophy of science and other disciplines via his ideas, especially his view on scientific revolution, which he discussed extensively in his SSR, some of his positions are highly controversial, and thus have been subjected to severe attack by scholars. Some of the criticisms were based on the weaknesses of Kuhn's arguments, while others were as a result of misconception and/or misinterpretation of his ideas. This section of the paper attempts a critical evaluation of Kuhn's philosophy of science.

In his earlier works, especially *The Copernican Revolution* (1956) and *The Structure of Scientific Revolutions* (SSR), Kuhn seems to be against the rationality, objectivity and progress of science. In fact, critics argue that his account of science made it neither rational nor objective. This is because he failed to give a rational account vis-a-vis the justification of theory-choice. His assertion that "there is no algorithm for theory choice," i.e., there is no step-by-step rule for theory (or paradigm) choice simply means that there is no step-by-step rule as regards the theory or paradigm to be accepted by the scientific community. The choice among the competing theories seems to be based on mob psychology, i.e., by a

mere consensus. Kuhn's analogy or comparison between political and scientific revolution buttresses this point. This analogy betrays Kuhn's sociological account of science; where scientists in "normal science" adhere to conventional paradigm/theory without question. Agbo (2017) adds:

Another weakness of Kuhn's philosophy of science is that he has been accused of introducing the duo of irrationalism and subjectivity in science: the analogy between scientific revolutions and political revolutions has tempted commentators to think of a scientific revolution as a thorough and radical break with the past whose outcome is determined by highly contingent factors that are equivalent of the revolutionary mob, propaganda, coercion and so on obtainable in political revolutions. Correspondingly, they think that while in normal science, what matters as a rational preference among competing theories is determined by reference to the paradigm, and in the revolution the absence of a paradigm means there will be no agreed standard of rationality. This is to say that scientific revolutions are irrational. (as cited in Thomas & Suleiman, 2019, pp. 89-90)

According to Kuhn, in the choice of one paradigm or theory over another, other psychological and sociological factors (like the biography and/or personality of the scientists, and not only the objective factors) should be considered; "... the acceptance or rejection of a new theory depends not only on 'scientific' factors

but also on social factors" (Ndianefoo, 2016, p. 331). In other words, Kuhn failed to rationally justify the preference of one paradigm over another. The preference, for Kuhn, is only based on the general acceptance of the scientific community. This psycho-sociological explanation differs from that of Paul Karl Feyerabend, "the self-styled anarchist non-rationalist, who denies that there is any such agreement of the scientific community" (Obi-Okogbuo, 2015, p. 379-380).

However, Alan Musgrave (1999) has a contrary opinion: "Many philosophers thought that Kuhn was impugning the rationality, objectivity and progress of science. In his later writings (especially the 'Postscript' to the second edition of his book) Kuhn tried to reassure them that this was not so" (p. 301). Again, Ndianefoo (2016) posits: "Probably(,) Kuhn's most important contribution was to bring both history of science and psychology into contact with philosophy of science." But for some, "Kuhn's use of history was frequently seen as dealing with the context of discovery and thus as irrelevant to philosophy of science" (p. 338).

Karl Popper (as recorded by Ndianefoo) criticized Kuhn's notion of normal science. For him, normal science is not science at all, because scientists under the conditions within normal science were only presupposing the cognitive elements of the disciplinary matrix and not testing them. However, in response, Kuhn affirmed the necessity of presuppositions for scientific progress; "Continual re-

examination of what is taken as basic knowledge would impede the process of extending knowledge ... it was only through the vigorous pursuit of normal science that further revolutions could be achieved" (Ndianefoo, 2016, p. 328). Again, Ndianefoo (2016) observed that Kuhn's account made scientific activity of normal science uninteresting and routine;

Although his use of the term 'puzzle solving' to describe normal-scientific activity may have made it sound more routine. Kuhn certainly did not think that normal science was uninteresting and routine. The phrase 'puzzle solving' may have been unfortunate, because it tends to suggest crossword puzzles or jigsaw puzzles, challenges that have been created by humans with explicit rules and a solution that is known in advance before the puzzle solvers enter the activity. In contrast, the 'puzzles' of normal science are posed by scientists, but the answers are not known by anyone in advance, and the rules for solution are given at best implicitly by previous exemplars. (p. 329)

Critics did not spare Kuhn's unique conception of scientific progress. His idea of non-linear, dichotomous or discontinuous progress via scientific revolution, though looks plausible, was severely criticized: his overemphasis on discontinuity undermines the impact or contribution of earlier theories/ideas over new ones.

Besides, his history of science is lopsided – it seems to be history of physical sciences alone, and not history of science

in general. Little wonder, he often cites examples with developments in the history of physical sciences, especially in the area of physics and astronomy. Kuhn's philosophy of science may, therefore, sound plausible when applied to physical sciences (chemistry, physics, astronomy), but not in other sciences like biology and social sciences. The reason being that while objects of study in the hard sciences are relatively fixed and much more stable and predictable, that of other sciences (like social sciences) are not. For instance, social sciences (such as: Sociology, Political Science, Economics, Anthropology, Psychology, and so on) deal on human behaviour which is very complex. In consonance with this argument, one can say that Kuhn's philosophy of science lacks universal application.

It is pertinent to underscore that Kuhn's idea of scientific development or progress is a direct offshoot of his concept of scientific revolution which necessitates non-cumulative as well as discontinuous fashion of scientific development. But in reality, all sciences do not operate in this manner. Example: while physical sciences like physics may adhere to the *non-cumulative, discontinuous* fashion, biology and social sciences may not strictly adhere to this fashion of *paradigm shift*. Social sciences often accept plurality of paradigms which exists side by side; and can even complement each other because of the complexity in the nature of their object of study.

On the question of incommensurability and incompatibility of paradigms or

theories, social sciences, for instance, often synthesize concepts – that is, the old concepts are not totally discarded because they still remain valid for the new paradigm in explaining the new issues that the old paradigm could not explain; there is the possibility of combining different ideas into a complex whole. Also, because old concepts are not thrown away, social sciences (and biology) seem to adopt *paradigm progress* and not *paradigm shift*. Hence, progress in knowledge can be cumulative within social sciences. The implication is that in the progress of knowledge, there are both cumulative, linear and non-cumulative, non-linear elements. Thomas and Suleiman have this to say:

Thomas Kuhn's paradigm shift thesis as advanced in his *The Structure of Scientific Revolutions* (1970) has minimal theoretical accuracy for understanding what actually takes place in the process of the development of social scientific knowledge, although it provides an alternative way of theorising about the history of scientific development in the physical sciences. In the social sciences, there is a plurality of paradigms which social science students use singly or in combination; there is a synthesis of concepts; the acceptance of paradigm depends not on consensus, but on its theoretical relevance for understanding real social phenomena; and instead of a paradigm shift, there is what we call paradigm progress where concepts of previous/other paradigms are redefined and expanded to reflect current realities.... In a nutshell, the nature

of the social science which is predicate on the nature of the objects of study, defy any and every theoretical absolutism, thereby giving room for intellectual innovations that accommodate both the plurality and syntheses of paradigms for better systematic analysis of social phenomena. (pp. 91-2)

Ndianefoo (2016), equally pinpointed an important oversimplification in Kuhn's SSR; where he adopted "the same vocabulary to describe the process of change in a scientific community and in an individual – both are characterized as 'Gestalt switches,' or instantaneous changes of perspective" (340).

Kuhn's idea (in his philosophy of science) says Orman (2016) was itself revolutionary in its time, as it caused a major change in the way academics perceive science. "Thus, it could be argued that it caused or was itself part of the paradigm shift in the history and sociology of science. However, Kuhn would not recognize such a paradigm shift in the social sciences, people can still use earlier ideas to discuss the history of science" (p. 50).

Furthermore, Kuhn seems to be an unsystematic and unstable thinker. This is owing to the modification and continuous reformation and even complete change of his original ideas. He states in his *Road Since Structure*; "If I were now rewriting 'The Structure of Scientific Revolution,' I would emphasize language change more and the normal/revolutionary distinction less" (Kuhn, 2000, p. 57 as cited in Anetoh, 2021, p.13). Again, Kuhn reported on a

book in progress (which remained unfinished till his death):

No longer do we hear of revolutions as paradigm change, certainly not in the sense of large paradigms. In fact, Kuhn preferred to speak of developmental episodes instead of revolutions. However, he does retain something of his original ideas of small paradigms, the concrete problem solutions that he had termed exemplars in the *Postscript* to SSR. Most revolutions, he tells us, are not major discontinuities in which a successor theory overturns and replaces its predecessor. (Orman, 2016, p. 51)

The reason for the above instability is alluded to the fact that Kuhn became a philosopher by accident. He was never thoroughly trained as a philosopher. Rather, he was a physicist by profession. However, "Thomas Kuhn, the author of SSR, is probably the best-known and most influential historian and philosopher of science of the last century" (Orman, 2016, p. 51). He has been commended for bringing about the final demise of logical positivism. In fact, his SSR "was one of the major final blows to the logical positivist program ..." (Ndianefoo, 2016, p. 346).

Conclusion

Despite the above avalanche of criticisms levelled on Kuhn's philosophy of science, his unique idea of scientific revolution, says Anetoh (2021), gives a good insight towards the perception or understanding of the nature of scientific development, and as such, his account of scientific

revolution which he articulated in his SSR, deserves commendations, especially for presenting a new way of conceiving scientific development and/or progress (p. 1). Lastly, from the foregoing, it is most plausible to accept both cumulative, linear and non-cumulative, non-linear elements in scientific development, if knowledge must progress.

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