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Is Modern Science Rational?

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ABSTRACT

This study was conducted to demonstrate whether modern science as represented by microphysics satisfies the criteria of rationality set for sciences; and if it does not, then whether the programmes that berate metaphysics as a system of truth are still tenable. The research became necessary in the face of a dangerous onslaught against philosophy, since the beginning of the twentieth century till date, by the so-called pro-science academics. The method adopted for the study was content analysis. On the basis of the paradigm of rationality of science, which is given in the paper as the provision of explanatory and predictive theories, it has been demonstrated that modern science fails in satisfying the criteria of rationality because of its overemphasis on predictive theories over and above explanatory theories.

***Keywords:** Rationality, Science, Truth, Justification, Falsifiability, Incommensurability, Verisimilitude.*

Introduction

The desire to understand the environment is natural to humans. It was this situation that provoked Aristotle to remark, after careful consideration that all men by nature desire to know (Bkl.1). The desire to know is even made manifest in the curiosity of children. But the attainment of the desired goal (knowledge) has not proven to be an easy task. The difficulty prevalent in the search for understanding of the environment is identifiable in the increasing relativity of worldviews. Such difficulties could be blamed to a large extent on the obscurity of the objects (Stumpf, 1994). But there is also the aspect arising from the condition of the knowing subject. The case with relativism, or rival systems of knowledge of the same object, is properly illustrated by different philosophical worldviews. Some of these systems are either different from or directly opposed to each other. In most cases, the possibility of ever reconciling these systems is understood to be a great illusion. Such that the situation, in philosophy, could be described as the world of islands that may never meet.

Prior to the revolution in physics in the hands of Archimedes, Galileo, and especially Newton, the case in the philosophy of nature was not different. Ancient physics presented rival systems of the same reality without any criterion for preference. The situation appeared to be calm in the classical period under the domination of the

Newtonian Paradigm. But classical physics was not to experience this calm for long, as things suddenly changed and rivalry arose in optics concerning the corpuscular and wave theories of light. This rivalry took place between Brewster on the one hand and Airy, Hamilton, Lloyd, and Fresnel on the other hand (Worral, 1978). The problem raged on in Maxwell's electromagnetism, Planck's hypothesis, and it is finally persisting in quantum physics, where rival interpretations of formalisms reign.

Hence, quite apart from logical, mathematical, and mathematical logical acumen, the human person wants to be able to control his environment and subdue it by being able to understand and predict it. The only assurance of achieving this purpose is the possibility of a basis for justification and the method for attaining justifiable knowledge of the universe. The possession of such a basis and method is the possession of rationality. Hence, a rational process is a justifiable and methodical one. It is this rationally founded knowledge that is the main concern of human investigation. Science claimed to have such knowledge, or at the very least the means to obtain it. Problems arise here. The first is that if science claims to be in possession of justifiable knowledge, then science also claims to be rational. If science is rational, what is the criterion for rationality in general? The question presupposes that the scientist's claim to be in possession of justifiable knowledge is predicated on his/her knowledge and possession of the criterion for justification or rationality and the actual application of that criterion. Attendant to that problem is one concerning what the basis and method of the justification of scientific knowledge claims is. Alternatively, on what ground is the rationality of science established?

The second aspect of the problem questions the theoretical construction that arises from the former. Such constructions are in the form of assumptions such as these: science is progressive; scientific theories change. The problem attendant to the first has to do with the rationality of claiming progress for science. The second problem is to uncover the underlying logic behind the practice of changing from theory to theory.

The Primary Focus of the Discourse

The problem set down in the above analysis could be divided into five major types, namely:

1. What is the meaning and the condition of rationality in general?

2.a On the basis of the above definition, can modern science be said to be rational, or is there a separate rationality for science?

2.b. If there is a separate test of rationality for science, what is the basis for the claim of that rationality?

2.c Is the scientific rationality criterion justifiable in the general metaphysics of rationality?

3. Is the claim to scientific progress justifiable on the basis of the general criterion of rationality or on the basis of the scientific criterion of rationality?

4a. What is the underpinning logic of scientific change?

4b. Has a criterion for scientific change any relationship with the rationality of science (if any) or is it arbitrary?

5. Given answers to the above questions can modern science be said to be in general rational?

The domain of scientific research that will be considered in an attempt to answer these questions is modern science. The concept of modern science in this essay will be restricted to modern physics. The restriction is not arbitrarily imposed. It is premised on the fact that modern sciences are essentially concerned with microscopic research. The concern is an extension of influence from the domain of microphysics to other aspects like molecular research in biology and chemistry. Thus, to study the fundamental problems of microscopic research, it is important to start with physics and then inductively generalize.

The Problem of Rationality

The Idea of Rationality

The concept of rationality, in common parlance, is used to denote the reason behind an action or a statement. Thus, it is not uncommon to come across people talking about the rationality of an action, decision, or attitude. Technically, the notion of rationality is concerned with:"... the proper set of formal rules emerged from logical investigations" (Churchland, 1990, p59). Thus, "to be rational is to be guided by legitimate reasoning" (Cohen, 1993, p420). Rationality in this context means the norms of reasoning as action. What the norms or rules are has been a matter of serious debate in philosophical circles. Traditional Aristotelian thinking would necessarily have placed it in deductive logic. Aristotle thought that inductive logic was too weak for the exercise of justification. Classical physics appeared to depend on induction. But David Hume demonstrated the inadequacy of the method of induction. The situation above between induction and deduction, where the former is rejected, depends to a large extent on the idea of knowledge (as rational) held by the proponents. Proponents of deductivity are advocates of eternity, necessity, and universality of truth. Thus, the idea of what is sought determines the method of search. The goal and the method are put together in a logical-deductive framework where every action derives from or at least could be shown to be derivable from an already accepted norm to depict rationality. Rationality is the entire frame. It is not only about the goal or about the method. It is about both.

For instance, when the logical positivists set out to distinguish between meaningful and meaningless statements (i.e., between science and metaphysics), they had to design the framework for evaluation called the verification principle (Ozumba, 2001). Frame, in Karl Popper’s parlance, is the logic of justification. It is the basis for testing the reasonableness of a claim to meaningfulness. The principles themselves were the principles of rationality. Thus, rationality has to do with justifiability using accepted norms. It is important to note that formal deductivity, alluded to above as a frame for rational justification, is skeletal and therefore needs fleshing out. For example, the analysis does not address what constitutes accepted norms in a given context or how such norms are to be applied. A case for knowledge as justified-true-belief could do for an example. The claim that "all men are mortal" must have a logic of justification. The logical positivists would suggest that a conjunction such as "John is a man and John is mortal" is adequate for the justification.

The above case has double implications. The first is the presupposed empirical basis, which in Bayesian analysis will serve as evidence. The second is the method, which is an actual observation of an individual instance that serves as evidence. Thus, the fact and the method for the positivist are adequate grounds for justification. Such justification establishes a statement as true or false. The foregoing analysis upholds something about itself. If rationality is a body of principles, then the rational process is an action. It is here, therefore, that a given system of action or investigation could be called rational or irrational. An instance of such a system is scientific research. How is science as a research project rationally justifiable?

Rationality, Truth and Justification

Science lays claim to the production of knowledge. Knowledge is known to be "true-belief with account" (Plato, 1996, p333) right from the times of Socrates. A. J. Ayer, in his *Problem of Knowledge* (1956), argued that "the necessary and sufficient conditions for knowing that something is the case are first, that what one is said to know be true. Secondly, that one is sure of it, and thirdly, that one should have the right to be sure. Both presentations are representations of the same idea.

There are four things central to this analysis. Roderick Chisholm puts it this way:"... a person can be said to know something if he believes it, if it is true, and he is justified in the sense that his belief is reasonable or accepted (cited in Omoregbe, 1998). The key ideas are belief, truth, justification, and rationality. The last (i.e., rationality) has already been addressed. The first (belief) will be presumed, but truth and justification need serious attention in the investigation of the rationality of science. If science claims to be in possession of a method that generates justifiable truth, then what is truth and how is it justified? The rational principles are the basis for the claim to truth and they constitute the system of justification.

According to Hetherington, knowledge entails truth (7). Ozumba adds that for knowledge to be knowledge, it must be true (Concise, 2001). Due to its intrinsic relationship with knowledge, the problem of truth is one of the central problems of epistemology. Traditional epistemology has presented many theories of truth, ranging from the correspondence theory to the relativist theory.

The traditional definition of the correspondence theory is that "truth is the quality of being the case, of being factual, and of being correct and right as a pictorial category" (Ozumba, Concise 68). The mediaeval presentation of the view was the argument that: "adaequatio rei ad intellectum" (i.e., the adequation of the thing to the intellect, where intellect would mean proposition, assertion, or statement). Within the correspondent theoretical framework, the logic of justification or the principles of rationality could be stated as follows: (1) truth as picture of reality (2) justification as finding the pictured (3) knowledge as a function of the object pictured. Carefully considered, there are inevitable complications arising from the analysis. The most prominent one is the search for the necessary, eternal, and universal entity in nature, to which theoretical statements refer. Here, one can no longer undermine the value of Platonism. But the moment the matter is driven toward Platonism, it loses all scientific appeal. The objective realm referred to here is non-existent. Philosophers speculate on it, and scientists ignore it. It has been argued elsewhere that the picture theory is based on the cognitive autocracy of the object and its attendant semanticism in epistemology (Akpan, 2005).

The difficulties experienced in the above theory of truth are believed by some scholars to be remediable by the coherence theory of truth. Truth, according to the coherent theory of truth, is the conformity of statements with other already established bodies of statements. Coherence as the basis for justification has serious limitations. Although the theorists suggest that the basic statements be considered as self-evident, it is difficult to establish what the basis for the term self-evident itself is. Besides, where no such basis is required, like in Peano’s mathematical system, where the basis could be arbitrarily decided or simply meaningless, two possibilities open up. The first is the infinite regress of demonstrations, and the second is the infinite possibilities of interpretations or modelling. Those problems will not only face Peano, they faced David Hilbert as well (Korner, 1971).

The pragmatic theory of truth as presented by Susan Haack has two versions. One is due to Peirce. The other is due to James and Schiller. Peirce, according to Haack:

> The truth is identified with the hypothetical final upshots of scientific inquiry and the real with the object of opinion. "Truth is that concordance of a... statement with the ideal limit towards which endless investigation would tend to bring scientific beliefs." "Any truth more perfect than this destined conclusion, any reality more absolute than what is thought in it, is a fiction of metaphysics (Haack, 1995, p.353).

James and Schiller, however, are more particular in their argument that "truth... is satisfactory, useful, in the way of belief; true belief works." (Haack, 1995, p.357). Both versions of pragmatism tend towards relativism in the sense that workability or usefulness is only determined in terms of defined or human need. Peirce hinted at this when he argued that "any reality more absolute than what is thought in it is a fiction of metaphysics" (Haack, 1995, p. 353). The individual who defines usefulness also defines truth. Objectivity is lost. The only thing that remains is relativism, dependent on individual creation.

On such a basis, too, and given the difficulty of inter-subjectivity, the relativists argue that truth is relative. Professors Alozie and Ozumba in Nigeria have recently championed this position in discussions at seminar presentations.

These scholars derive their justification from the idea of non-locality in quantum mechanics to argue for the relativity of truth. If the observer creates reality, then what he/she seeks is the truth. Professor Ozumba seems to have moved away from his initial position in *Understanding the Philosophy of W.V.O. Quine* (2002) to imbibe the relativist criterion of truth. In the above publication, he argued for a language-independent reality. He used it to refute Quines’ linguistic epistemology. But he seems to have left this position for what he calls the *relative correspondence theory of truth.* Professor Alozie’s position moves towards solipsism. Thus, he agrees with Feyerabend that science and philosophy are not different from literature or the history of the human imagination.

There are many other theories of truth. But it is important to note that all derive from the above and therefore share their weaknesses. It is on the basis of this that the truth shall be viewed in this essay: "from the point of implicative referential semantics of constative sentences, taking into view the definite linguistic permutations of ontology as the basis for recursive interpretations of theoretical statements of science (Akpan, 2011). Hence, "truth" can be defined as: "the correspondence of a statement and its referent to the foundational linguistic permutations of ontology coordinately in a recursive structure, bearing in mind the fact that statements are functions of the cooperation of the subject and object" (Akpan, 2011, p.77). The above definition is perfect and thus entails the limitations found in all other definitions**.** No activity regarding the truth could succeed without its presumption.

Consequently, when science claims progress by pragmatism, it does so in a framework where the criteria or principles of usefulness are satisfied correspondingly by the theory, in a certain recursive structure, in which definition is satisfied by the defined and the defined could generate definition in its exactness. With this definition in mind, as a standard, we shall accept to go with the view that the pragmatic theory of truth is the rule of science, and the justification of this theory depends on the realization of its predictions. That defines rationality, truth and justification in science.

The Idea of Rationality of Science

The goal of science is the production of true explanatory and predictive theories. According to Stephen Hawking, a good theory satisfies two requirements. "It must accurately describe a large class of observations on the basis of a model that contains only a few arbitrary elements, and it must make definite predictions about the result of future observations" (1988, p.10). The aim of explanation is to predict the universe. This seeks to understand the laws that would reveal how the universe changes with time (Hawking, 1988, p.12). Hence, the goal of science is pragmatic truth. Truth as understood here emphasizes the pragmatic value. It is important to note that the pragmatic idea of truth is also captured by the general theory of truth as defined at the end of the immediately preceding section. The idea of workability, as mentioned above, is satisfied by the predictive ability of a theory.

But is predictability an adequate basis for the rational justification of a theory as a body of knowledge? Science is not only predictive. It is also explanatory or descriptive. Hawking notes that "the eventual goal of science is to provide a single theory that describes the whole universe" (Hawking, 1988, p.11). "It turns out to be very difficult to devise a theory to describe the universe all in one go. Instead, we break the problem up into bits and invent a number of partial theories"(Hawking, 1988, p.12). Thus, prediction, as such, presupposes explanation. It is a product of explanation.

Scientific explanations have not been shown to be very successful. Hence, scientists have reverted to and remained content with some basic criteria such as accuracy, consistency, scope, and fruitfulness (predictivity). Given the initial goal of science as true explanatory and predictive theories of the universe, it becomes questionable whether science is rationally justified in such a restricted view of its concern. Alternatively, can scientific claims be termed knowledge in the light of the restrictive characterization of the standard for justified scientific theories? This problem could be called one that has to do with the external relations of scientific goals to the accepted paradigm for knowledge. What is revealed here is that the combined weight of true explanation and precise predictions cannot be borne by science. Hence, it has reverted to the latter, and its goal is thus viewed as strictly pragmatic. It is also from this pragmatic concern that the rationality of science will be discussed in the essay.

However, Karl Popper and Imre Lakatos have, however, argued for what they call a more actual goal, which for them is verisimilitude. The problem with this goal will be revealed when their system is studied. Thomas Kuhn understands the goal of science to be a theory possessing the properties of accuracy, consistency, scope, orderliness, and fruitfulness to a higher degree than existing theories. Kuhn also understands that what constitutes these conditions is somewhat *formal* *(Essential 321-22). The Kuhnian analysis gives more weight to the fruitfulness of theories as the basis for the determination of anomalies. Thus, in the final analysis, the pragmatic value of a theory is the rational principle for theory acceptance or rejection in science.

What such pragmatic appeal loses is the theoretical understanding of the universe. The predictability of the universe is not synonymous with its understanding. Thus, the so-called scientific method, which begins with observation and continues through experimentation to theory, becomes rationally inconsistent with the goal of practical science. The inductive method is aimed at the provision of explanatory truth and prediction. But as long as the pragmatic value supersedes the correspondent truth-value of the theory, the inductive method becomes redundant. The second problem is that of internal relations within a theory. But should we argue for the Popperian approach? Can there be consistency in that system? The method of conjecture fits the pragmatic framework. But the act of refutation is not the goal of pragmatism. So, the Popperian system in its totality is inconsistent with practical science. The situation could better be described as one of conjecture and experimentation (to see if the world will behave as predicted by our theories). But then, that would imply a return to positivism.

The other aspect of the internal relations of the rationality of science has to do with the determination of whether: (1) the assumption of scientific progress is consistent with the goal of science; (2) the logic of scientific change is in line with its goal.

The Rationality of the Claim to Scientific Progress

The essay discussed issues concerning the general standards of justification and showed that the pragmatic model, as the practical drive of science, has lost touch with the true explanation of the universe. This analysis was designated "external relations of the rationality of science. The second aspect or method of analysis, designated internal relation of rationality, seeks the justification of the scientific method in relation to its practical goal. The internal relations will continue the study of the rationality of the claim to scientific progress.

In his *Conjectures and Refutations* (1963), Karl Popper declared that "science is one of the very few human activities—perhaps the only one—in which errors are systematically criticized and, fairly often, in time, corrected." In other fields, there is "change but rarely progress" (Karl, 1963, p.216)**.** *In writing* about Karl Popper, Stephen Hawking states as follows: "as philosopher of science Karl Popper has emphasized, a good theory is characterized by the fact that it makes a number of predictions that could in principle be disproved or falsified by observation" (Hawking, 1988, p.11). Again, Hawking argues that "any physical theory is always provisional, in the sense that it is only a hypothesis; you can never prove it." "On the other hand, you can disprove a theory by finding even a single observation that disagrees with the predictions of the theory" (Hawking, 1988, p.11). These quotations from Hawking raise a lot of issues about the claim to progress in science: if a previous theory is refuted on the basis of variance with evidence, what is the fate of the new theory? (a) If the new theory is to reign until refuted, can we lay claim to progress since we know our theories will necessarily be refuted at a future date?

Stephen Hawking will answer that we can. Philosophers, like Hawking, believe that precision in prediction is the hallmark of a good theory (Hawking, 1988). It is also his argument that a refuted theory could be modified into a new one with a precise prediction. Here he cites the modification of Newton's theory of gravity to get Einstein's theory of relativity (Hawking, 1988). But a problem arises in the very example given by Hawking. The same object which Newton's theory predicted with precision was the same object on which it later lost precision. Hence, can Einstein's theory claim to maintain its precision of prediction and for how long?

It is important to announce here due to Adolf Grunbaum that so far R.H. Dicke and H.M. Goldenberg (1967) have reported an imprecision in Einstein's theory, of general relativity that is four times that found in Newton, regarding the motion of Mercury. So, where is progress going to be situated here? How can we ever be sure that the theory we have now is better than the previous one?

These questions, when viewed from the pragmatic rationalist framework, could be answered by saying that the theory with the highest degree of predictions and wider scope is progressing. But that appears not to have answered the question, because the issue is that a new theory that assumed the status of progress has fallen below the standard of the previous one. So, is there a standard for determining whether or not definitive progress has been made? Is the pragmatic model adequate for the task of judging scientific progress?

This problem also arises in modern physics between the particle and wave theories of light. And it took the ingenuity of Max Born through the principle of transformation to show that the two mechanics were different interpretations of the same phenomenon. But one is yet faced with the question as to whether the predictions made with the cross evaluation of the two mechanics would attribute progress to physics due to the principle of transformation. If it does, on what basis? What happens if predictions now considered agreeable are falsified later, as in the case of Newton's and Einstein's theories of celestial motion?

In the face of deep-seated problems like claims to progress and the basis of theory choice, the inadequacy of the pragmatic rational model of science emerges. As mentioned earlier, science, like all human research, is aimed at the discovery of true explanatory and predictive theories. But unfortunately, it gradually moved *away* from the concern with explanatory truths to only predictive truths. But in complex cases like the examples given above, it is difficult to understand whether science is progressing or not. Besides, the rules for theory choice become difficult to delineate. Hence, some philosophers faced with this scenario have concluded that the situation, especially with respect to theory choice, is irrational. But some sober philosophers like Karl Popper and lmre Lakatos have argued that there is some rationality. The complexity of the situation is seen in the inconsistencies in their models.

The sciences begin with pragmatism on their model of rationality, but it seems in the present situation to have lost touch with their deductivity due to the limitations of their rational model. This is manifested in the choice of theory in modern physics between Albert Einstein and the quantum physicists, especially that of Niels Bohr. Thus, one can conclude that, from the point of view of the pragmatic tradition, the rationality of the claim to scientific progress is limited to the expansion of the scope of its predictability. Even in such circumstances, it is difficult to say whether rival theories with equal predictability manifest progress or not. Hence, the rationality of the claim to scientific progress still faces some doubts.

Rationality and The Theories of Scientific Change Karl Popper the Goal of Science

According to Karl Popper, the goal of science is the attainment of truth about the nature of reality. But Popper does not believe that science has ever attained this goal. He does not even believe that science can ever attain the goal. Thus, from the point of Karl Popper's scheme, the description of the state of science in relation to the truth is properly captured if the scientist is said to be ignorant of the truth. Popper argues that we can never know the truth of observational statements, let alone the truth of theoretical statements. The most meticulous use of probability based on induction, Popper argues, cannot assure the scientist of the truth of a theory. Thus, induction is incapable of establishing a true scientific hypothesis. The only description of the scientific programme is that it is a scene of conjectures and refutations (Newton-Smith, 1996). Popper believes that the legitimate method of science is the deductive method. Science is not evidence-gathering; it is rather conjectures and refutations. In his *Conjecture and Refutations* (1963), Popper describes the history of science. According to him, "the history of science, like the history of all human ideas, is a history of irresponsible dreams, of obstinacy, or error. But science has its own method of self-criticism. Criticism in relation to what if truth cannot be attained?

The inaccessibility of truth as the goal of science prompted Popper to understand the actual goal of science as different from its ideal. The actual goal of science is to get nearer to the truth or a higher degree of verisimilitude (Newton-Smith 45). According to Karl Popper, evidence does not confirm or support a theory or hypothesis. What it does is that it either refutes or does not refute it (Newton-Smith, 1996).

The choice of verisimilitude is justified by Popper on the basis that the attainment of truth cannot be ascertained because there is no criterion for truth. He writes as such:

> By a criterion of truth is meant a kind of decision method: a method that leads either generally or at least in a certain class of cases, through a finite sequence of steps (for example, a test), to the decision of whether or not the statement in question is true. Thus, in the absence of a general criterion of truth, it may easily happen that we possess true theories and yet are unable to show, to our satisfaction, that they are true. What can also happen is that we are able to establish some statements as true by a sort of lucky coincidence rather than the application of a criterion of truth (which may not exist in the case in question) (Objective Knowledge, 1979, p.191).

Popper proffers two arguments against the possibility of the criterion of truth. According to him, scientific theories are universal and therefore apply to an infinite domain, whereas human investigations are limited and finite. Thus, the finite is an inadequate basis for carrying an infinite domain (Newton-Smith, 1996). Popper argues equally that the truth of observation statements cannot be ascertained because all observation statements presuppose some implicit theory (Newton-Smith, 1996). Hence, the basis of the observation statement is a theory. Because a theory cannot be justified, the observation statement cannot be either. So, there is no criterion for truth. Observation statements are not needed to test a theory. Popper argues that what he calls "basic statements" are sufficient. Even though they assert existence in space-time, they are not evidence for the theory. They are what a theory must have to work out if it is to be scientific at all.

The Method of Evaluation of Theory

The method of science that fits verisimilitude according to Karl Popper is conjectures and refutations. It is "bold conjectures and the critical search for what is false in our various competing theories' (Objective Knowledge, 1970, p.319). Popper believes that we should give creative reign to our imagination to design theories which we later endeavor to destroy (Newton-Smith, 1996). Thus, for a theory to be scientific, it must be falsifiable. It must make statements that can be tested. The theory must have adequate content, which exposes it to the danger of criticism. If a theory withstands severe testing, it is said to be corroborated. Corroboration is the report of the past performance of a theory, with respect to the severity of the tests it has undergone and the way it has stood up to those tests. Corroboration is not forward-looking. It does not lead to verisimilitude. Thus, the link between the method and the goal is a problem in the Popperian scheme.

In his discussion of the test of theories, Karl Popper seeks to overcome this problem of link. The one with more truth content and less falsity content is said to be corroborated. Again, if a theory explains the way the world is better than its predecessors, with accurate predictions, then it could be argued that it has more truth than its predecessors. In both cases, corroboration leads to verisimilitude. The theory with the highest degree of verisimilitude receives allegiance after a contest.

Imre Lakatos

The Goal of Science

The goal of science, for Lakatos, is the search for a true explanation of reality. He also accepts with Popper that it is difficult to inductively establish the complete truth of a theory. Thus, Lakatos accepts verisimilitude as the goal of science. Lakatos was actually a methodologist philosopher. Thus, he is concerned with a methodological criticism of the Popperian system.

Appraisal of Theories

Lakatos' primary objection is that Popper tends to represent the scientific endeavor as a two-concerned fight between a theory and an experiment, the only outcome of which is the falsification of the theory. Lakatos argues that the history of science suggests that

1. Test are - at least - three-concerned fight between rival theories and experiments and
2. Some of the most interesting experiments, prima facie, result in confirmation rather than falsification (Newton-Smith, 1996).

In the Popperian model, Lakatos argues that victory will always go to the world. No wonder the expected result is falsification, because there is no theory without anomalies. Lakatos argues that having a theory with an anomaly is better than having no theory at all (Newton-Smith, 1996).

According to Lakatos, the scientific enterprise should be understood as a fight between rival theories, with the world as a referee (Newton-Smith, 1996). Consequently, he suggests that we should regard a theory T_0 as falsified if and only if;

1. Another theory T_1 has excess empirical content over T_0, that is, it predicts novel facts, that is facts improbable in the light of, or even forbidden by T_0
2. T_1 explains the previous success of T_0, that is all the unrefuted content of T_0 is included (within the limits of observational error) in the content of T_1 and
3. Some of the excess content of T_1 is corroborated (Newton-Smith, 1996).

Lakatos strikes two important points here. According to one, no theory having something going for it should be abandoned except in favour of a better theory. The other is that "the relative merit of competing theories should be delayed until proponents of the theories have had time to explore modifications in their theories which might make them better able to cope with anomalies" (Newton-Smith, 1996).

According to this analysis, the unit of appraisal is not a single theory but a sequence of theories. He calls this historical entity the "Scientific Research Programme" (Lakatos, 1978). The Scientific Research Programme has a history during which theories are replaced by other theories.

The programme has three components, namely;

1. The hardcore
2. The negative heuristics
3. The positive heuristics.

It is important to note that the above scientific research programme is a methodology set forth to achieve the desired goal, which for Lakatos is verisimilitude. The hard core is a set of theoretical assumptions that are presupposed by every theory that is part of the scientific research programme. The negative heuristic is a methodological principle stipulating that the components in the hardcore are not to be abandoned in the face of anomalies (Newton-Smith, 1996). The positive heuristics "consists of a partially articulated set of suggestions or hints on how to change, develop the refutable variants of the research programme, how to modify, sophisticate the refutable protective belt (Lakatos, 1978). When a theory is tested, it is not just the predictions that are tested. It is the whole theory, plus its auxiliary hypothesis, that faces the tribunal of experience. In the face of anomalies, the theory is not rejected simply because it is falsified. What is done is that the auxiliary belts are modified to help them cope with the anomalies. The hardcore is the most crucial part of the scientific research programme. Lakatos argues that there is a convention among scientists that the hard core is held to be true irrespective of anomalies. The application of the notion of convention to the hardcore explains the notion of continuity in science (Newton-Smith, 1996).

The goal of science, as mentioned above, according to Lakatos, is the production of true propositions. Lakatos believes that these theories are produced within units of research programmes, which have a life history. An appraisal of a theory is an appraisal of the programme as a whole. Because the programme cannot be abandoned, scientific practise is actually a continuous modification of theory to cope with anomalies. Within these modifications, rival programmes are judged with respect to the relative size of classes of successful predictions and successful explanations of known facts (Newton-Smith, 1996).

The Irrationality of Verisimilitude

The argument in this section is lifted verbatim from Akpan (2011, p.39). The goal of science is the attainment of true theories. Popper argues that the goal cannot be met. What the scientist can only hope for is that he is getting warmer or nearer to the truth. The inability to attain the goal is because of the absence of the criterion. Thus, in relation to the goal, the scientist is described as being ignorant. Consequently, Popper argues for a more actual goal, which he calls a higher degree of verisimilitude. He tries to define verisimilitude, relatively, between two theories. The theory with higher truth content is nearer to the truth. Lakatos accepts this position with Popper to also argue that the goal of science is verisimilitude.

The above analysis raises a lot of issues. In the first instance, if there is no way to determine the truth, what is the basis for establishing truth-likeness? Truth-likeness or verisimilitude can never be known, because truth is unknown.

The following illustration will suffice to establish the point. Let the destination A be the attainment of truth. Let the destination B, be a case of the indeterminate. Let C represent the destination of falsehood. Let it be that the achievement of each of the three goals comes at the completion of an infinite course of passing several tests. Thus, let the discovery of the status of the theory lay at $a_{infinite}$, $b_{infinite}$ and $c_{infinite}$**.** Let each of the moments of the tests be numbered like a_1, a_2, a_3, a_4 . . . $a_{infinite}$ or b_1, b_2, b_3, b_4 . . . $b_{infinite}$ or c_1, c_2, c_3, c_4 **. . .** $c_{infinite}$. Let the path to A be marked p, B be marked q and C be marked r. Let the theory be represented by a dot at the point O. Refer to a graphical expression of this analysis in Akpan (2011, p.39).

If the above theory at point O is false and if the obstacle that will disclose its falsehood is not at c_1, c_2, c_3, c_4... c_n, (where n is any finite number of tests) but at $c_{infinite}$. As long as the obstacle is not yet met, the Popperian model will make the scientist believe that his degree of verisimilitude is getting higher while, in effect, it is decreasing. But until the obstacle is met or the truth is known, it can never be known whether corroboration increases or decreases verisimilitude. Hence, the case for verisimilitude is as bad as that of truth.

The problem becomes even deeper at $c_{infinite}$. At $c_{infinite}$, it will be completely difficult to determine whether the theory has been refuted or not. The reason is that a false statement implies all statements are both true and false. Hence, a false statement is a negation of a true statement. But since a true statement cannot be known, thus, whether the theory is refuted at $c_{infinite}$ or not, it can never be known. To assume, therefore, that there is no criterion of truth in a scheme and that theories could also be shown to be false in the scheme is to assume internal contradiction. Any science using the model would be irrational.

But following the development of Popper's work, one can argue that there is an implicit acceptance of an unstated criterion of truth. This conclusion could be drawn from his method of conjectures and refutations in relation to the goal of science as verisimilitude. If the non-refuted statement increases verisimilitude, then the truth is an irrefutable proposition. If Popper had made that assertion, his whole system would have logically been shown to be consistent. Everything falls into place, namely:

1. The truth can never be known because it is impossible to state for sure whether what we have at hand is irrefutable or not. We can never know unless we become gods.
2. The much we can hope for is to continue with conjectures and refutations, believing that in that way the irrefutable will arise.
3. The non-refuted at the instance of a test is getting warmer or nearer to the truth as long as our theory remains non-refuted (i.e., our theory is beginning to look true). After all, the truth is ultimately irrefutable. Hence, we can make do with verisimilitude.

4. Corroboration would eventually become forward looking, thus, the ad hoc strategies of truth contents and the whiff of inductivism would have been unnecessary.

Unfortunately, Popper did not make the assertion. Therefore, the ensuing logical implication that would have made induction unnecessary cannot be granted to him. Lakatos did not also make the assertion. The indeterminacy of the criterion of truth and verisimilitude leaves scientific practise in the dark. Hence, science is not different from fiction, games, or magic. It is, therefore, in the Popper and Lakatos models of truth, irrational.

The Tradition of the Irrationality of Science
Thomas Kuhn on Paradigms in Science

Kuhn is not a perfect rationalist. He has more anti-rationalist elements than the two discussed above. The image of science that he "has in mind is the one in which the scientific community is pictured as a paradigm of institutionalised rationality" (Newton-Smith, 1996). Institutionalization is a situation whereby a considerable number of things are held in common by the members of a community. The particular things that Kuhn wishes to isolate as things held in common include: shared symbolic generalisations (i.e. basic theoretical assumptions held in common); models (i.e. agreement on what heuristics would guide research); values (i.e. what the nature of theories should be, e.g. accuracy, consistency, etc); metaphysical principles (i.e. agreement on certain untestable assumptions); and exemplars or concrete problem situations (i.e. what constitutes the problem) (Newton-Smith, 1996). Kuhn believes that this situation is set in important science textbooks. Thus, the programme of science is propagated through textbooks. Hence, Kuhn argues, that the shift from theory to theory has no objective standard. It is completely determined by the community through propaganda. It implies that personal fiat and communal decisions play a major role in the acceptance or rejection of a theory.

The rejection of a theory is gradual. It begins when the failure of the theory increases despite modifications and allegiance. Kuhn does not believe in any internal relation between the theory and the experiment as the basis for justification. According to him, there are instances where graduate students will find results that are contrary to the reigning paradigm, but the results will be abandoned for the theory. Due to the sociological relativity of paradigms, Kuhn initially rejected the idea of commensurability of paradigms and therefore comparison. He argued that: "the normal scientific tradition that emerges from a scientific revolution is not only incomparable but often actually commensurable with that which has gone before" (Kuhn, Structure, 1970, p.94).

Nevertheless, he weakened his thesis of incommensurability with the acceptance of general conditions represented in all theories. The five conditions include;

1. A theory should be accurate within its domain, that is, consequences deducible from a theory should be in demonstrated agreement with the results of existing experiments and observations.

2. A theory should be consistent, not only internally or with itself, but also with other current accepted theories applicable to related aspects of nature.
3. It should have a broad scope: in particular, a theory's consequences should extend far beyond the particular observations, laws, or sub-theories it was initially designed to explain.
4. It should simply bring order to phenomena that in its absence would be individually isolated and, as a set, confused.
5. A theory should be fruitful of new research findings: it should, that is, disclose new phenomena or previously unnoted relationship among those already known (Kuhn, Essential, 1977*)*.

Despite these generalities, the degree of their satisfaction could establish the superiority of rival theories. Kuhn argues also that the sociological factor is the most predominant. All cases concerning the objective standard for truth are rejected.

Feyerabend's Absolute Scepticism

Feyerabend argues that there is no such thing as a scientific method that is valued for all research. His contention is that science is an ideology or a tradition like all other traditions. It is simply like astrology, witchcraft, and traditional medicine (Newton-Smith, 1996). Feyerabend contends that the investigation, which seeks to discover a unique method for all research, is fraudulent. It inhibits progress. The only principle that does not inhibit progress is that "anything goes" (Feyerabend, 1975, p.23). As an ideology, there is no reason to talk about truth or falsehood. There is no basis for commensuration. So, the comparison is fraud. Rationality is untenable. The only way out is if anything goes wrong.

The Incommensurability Thesis

The situation above, especially with respect to Kuhn and Feyerabend, opens the way for incommensurability of theories. Incommensurability means that there is no rational ground for comparison of theories. Hence, there is no organised reason for paying allegiance to theories. Three reasons have been proffered. The first thesis argues that theories are incommensurable because of the invariance of value between rival programmes (Newton-Smith, 1996). This position is due to Kuhn, who argues thus:

What it should suggest, however, is that such reasons (accuracy, simplicity, fruitfulness, and the like) function as values, and they could be differently applied, individually and collectively, by men who concur in honouring. If two men disagree, for example, about the relative fruitfulness of their theories, or if they agree about that, but disagree about the relative importance of the fruitfulness and, say, scope in reaching a choice, neither can be convicted of a mistake. Nor is either being unscientific.

Incommensurability could also be promoted by radical standard variance. The idea of radical standard variance has to do with the variance of principles of evaluation within different theoretical schemes. This is due to the position of Feyerabend. If there is no standard method of evaluation, then anything goes. It is impossible to talk about the comparison of rival theories.

Incommensurability could also be due to radical meaning variance. Kuhn called the attention of the scientific community to the fact that the existence of communal paradigms is the existence of a world view. The shift in paradigm is a shift in worldview. In the new domain, the scientist perceives things anew. Hence, there could not be a similarity of meaning because there is no similarity of reference.

Can Modern Science be said to be Rational?

The Domain of Modern Science

Modern science, as already mentioned in the introductory part of the essay, refers to research in the microscopic domain. It ranges from the cells of molecular biology to the quarks of modern physics. The present essay will, however, concentrate on the history of research in modern physics. This is premised on the authority of Heinz Pagels: that it was Erwin Schiodinger’s work that gave rise to research in molecular biology (1984). He argued further that trained physicists were those who promoted research in molecular biology that was foreign to biologists of the time. The new attitude led to the discovery of DNA and RNA (Pagels, 1984).

Microphysics research is traceable to the ancient concern with the atom (Dampier, 1968). But the modern idea is directly related to findings with respect to the emission of energy by heated bodies. Hence, it was Planck’s attempt to understand Raleigh’s experiment on black bodies in terms of energy quantization that led physicists to investigate the atomic world. Albert Einstein published his photo-electric hypothesis on the basis of Planck’s theory and argued that light was quantized. Heisenberg, Born, and Jordan tried to understand the new domain of physical reality in terms of their matrix mechanics. Due to the imprecision of measurements, matrix mechanics became a necessary tool for the understanding of the atomic domain. On the basis of Einstein’s notion of light as a particle and the previous argument that particles moving at the square of the speed of light are energies, coupled with the knowledge that energy undulates, de Broglie argued that light is also a wave. Erwin Schrodinger joined de Broglie to develop wave mechanics. The problem with the wave theory arose when scientists wanted to know what was waving. Schrodinger argued that it was a matter wave. It took the genius of Max Born to explain that the wave was the probability of finding an electron in a given experimental system.

Thus, the presence of an electron becomes a probability. Meanwhile, no one has seen an electron. Physicists are only familiar with vibrations. Thus, all theories of the electron became founded on metaphysical idealism. The problem arose as to which system to adopt between matrix mechanics and wave mechanics. Here, Born argued through his transformation principle that both are different interpretations of the same phenomenon. Thus, the cross correlation of the result of the matrix theory and wave theory was necessary for the prediction of the future behavior of a physical system. The matrix mechanics can only detect the exact position of the particle. In doing so, it interferes with its velocity. The wave mechanics could detect the velocity of the electron on the basis of wave frequencies but will fail to detect its exact position.

What was needed in the two domains was a complementation provided by Niels Bohr. Heisenberg interpreted the state of the experimental system in terms of a two-way uncertainty. Thus, the grasp of the position of an electron leads to the uncertainty of its velocity and vice versa. So both the mechanics are necessary.

The basic epistemological situation is the ignorance of the nature of the electron. Physicists have also argued that an experiment distorts the state of the physical system, thereby making the observer the sole determinant of its result. The problem of non-locality, whereby an action that takes place now affects every aspect of the universe, has also raised the question of the objectivity of truth in microphysics. Yet physicists fall back on the pragmatic rationalist model. The ideal of explanatory truth is lost to predictive truth. What is sought is simply a prediction. The actual picture of reality is idealistic.

The Rationality of Modern Physics

From the viewpoint of the external ideal of research, the continuation of research in microphysics would have been irrational. But internally, the ideal of predictivity makes the system of physical research rational. But there is also the problem of internal inconsistency in the programme, in the sense that contrary systems are capable of coexistence. This is evident in the coexistence of both wave and particle mechanics. The internal problem extends to the problem of theory choice. It was difficult and it still remains difficult for scientists to choose between the matrix and wave mechanics. The combination of the two for accuracy in prediction shows modular rationality but logical irrationality. Physicists appear to prefer modular rationality to any other.

But that has its own problems. There is an inherent difficulty here. It is not possible to know which theory to choose among two contraries or contradictories with equal predictive capacity. Hence, the goal of ordering them according to their degree of pragmatic predictability stands defeated. Besides, the so-called scientific method is inconsistent with modern science's practice. The insistence on prediction as the goal of science and the corresponding use of the inductive method are inconsistent. Induction is for both explanatory and predictive truths, and not for predictive truths alone. In short, given the nature of induction, explanatory truths are more fundamental.

Conclusion

It could be concluded that science, in terms of the ideal (knowledge) which it sets as its goal, is irrational because predictability is inadequate to capture the nature of knowledge as a justified true belief. Its confused model of theory preference in the face of contrary theories with equal predictive capacity makes the application of personalism and irrationality apt for science. In relation to the provision of knowledge for the understanding of the environment, hope appears to elude the human race because science's model of pragmatism is inadequate to determine (1) the attainment of explanatory truths, (2) the progress of research, and (3) the grounds for theory change. It lacks a sound criterion of rationality for its acquired obligation.

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