An Appraisal of Duhem-Quine's thesis on Crucial Experiments in Physics: An Essay in Philosophy of Science

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Abstract

The Duhem-Quine thesis on crucial experiment in physics states that the scientist can never submit an isolated hypothesis to experimental test because our statements about the physical world are inseparable and interconnected. Using the method of critical expository analysis, paper examines the plausibility of this thesis in relation to adequate description of the nature of science and its historical development. In doing this, the paper argues that the thesis is veracious because it captures the true nature of scientific inquires, debunks the existence of crucial experiments in science, unveils the underdetermination of scientific theories, punctures the hegemonic claims of modern science and in so doing encourages the use of different scientific methodologies in the attempt to explore, grasp, explain and exploit physical reality for human well-being. Consequently, the paper concludes that the Duhem-Quine thesis tends towards the conceptualization of science as a value-laden and culture sensitive enterprise and, as a result, rightly suggests that the falsification, nay condemnation, of certain knowledge claims as illegitimate and unscientific, using the canons of modern science, is inadequate and misleading.

Keywords: Duhem-Quine thesis, Underdetermination, Duhem, Quine, hypothesis or proposition

Introduction

The first sentence in Aristotle's *Metaphysics* is that: "All men by nature desire to know" (1). The implication of this is that the human person is a knowledge seeking being. Human beings have an irresistible urge to explore, penetrate, grasps, understand and explain reality. As rational beings, they always strive to demystify the mysterious, predict, manipulate and exploit nature to advantage. It is this natural human desire to know that makes human beings develop and adopt different methods that they think can help them to understand, explain, manipulate and exploit their complex, nay mysterious world better for the common good of humanity.

However, the development and adoption of different of methods of exploring and explaining reality by different groups of people interested in different aspects of reality has led to the emergence of different disciplines that can be broadly classified into three

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groups, namely; the humanities, the natural sciences and the social sciences. Among these groups, the natural sciences are of the opinion that the ideal method for understanding and explaining the physical world is universal, objective and ahistorical. This method is known as the scientific method. The scientific method is presented by the natural sciences as the only method that has the capacity to help man understand and transform nature presumably because of "its ability to epitomize reality in its pure form" (Asiegbu 2005, 117). The implication of this is that anyone, who hopes to acquire "authentic" knowledge, which physical sciences offer, necessarily to follow this scientific method" (Agbo 2004, 116). In otherwords, the scientific method is the "the very paradigm of institutionalized rationality" (Newton-Smith 1981, 1).

At this point, it is pertinent to note that the basic tenets of scientific method include empirical observation, the formulation of hypotheses, logico-mathematical explanation, prediction, experimentation and verification (Eboh, 94 – 95; Alozie 2003, 19 – 20). This statement implies that scientific method claims that true knowledge proceeds from facts given by the observation of natural phenomena. These facts must be objective and interpersonal in the sense that they are accessible to and indubitable for all normally equipped human observers. In addition the facts must be susceptible to logico-mathematical explanation and crucial experimentation. The acceptance of any of these facts as knowledge depends on the result of a series of tests and experiment they undergo. Any of the facts whose result is negative is falsified and rejected as a candidate for scientific theory. What this comes to is that knowledge in science is acquired piecemeal through observation, theory formulation and experimentation. "Therefore every new theory must be logically consistent with existing ones" (Alozie 2006, 214 – 15).

Contrary to this position, the Duhem-Quine thesis posits that no one can subject a single hypothesis derived from a given fact to experimental test independent of other facts (hypotheses) because our propositions, facts, hypothesis about the physical world/natural phenomenon are necessarily interconnected and inseparable.

In what serves as the outline, although still part of the introduction, the paper is divided into four sections. Section one is gives the general view of the thesis that prepares the audience for Section two. This section considers Duhem's formulation of the thesis himself. Quine's formulation of the thesis exposes the singularly unique contribution of Quine and how he imposed his signature on the thesis. The significance of the thesis and a critical evaluation of same, before the conclusion.

Duhem-Quine Thesis on Crucial Experiment

The Duhem-Quine thesis on crucial experiment in physics refers to the position of two different erudite scholars – from different continents, different disciplines and of different centuries – concerning the nature of crucial experiments in physics in particular and the natural sciences in general. These two renowned scholars are Pierre Maurice Marie Duhem and Willard Van Orman Quine. Pierre Duhem, as he is popularly known, was a French Physicist, historian of and philosopher of science. In spite of his relatively short life (1861-1916), his intellectual output was outstanding enough to immortalize his name in the annals of great theoretical physicists.

Willard Von Orman Quine (1908-2000) is regarded as one of the most influential American philosophers of his time. Out of the ninety-eight years he spent on earth, sixty-five were spent in the academic world of research, writing and teaching. This comparatively long career enabled him to contribute greatly to the development of different branches of philosophy notably in logic, epistemology, philosophy of language, philosophy of logic and philosophy of science. No wonder Ullian (2006, 270) argues that: "No one since Russell has contributed so much to both philosophy and logic as Quine. No major philosopher has given anything much to logic nor has any important figure in logic borne Quine's stature as a philosopher" (270). In a more elaborate manner, Gibson summarized the intellectual legacies of Quine's when he avers:

From the foregoing biographical sketch, one will understand that there is a big historical and theoretical gap between Duhem and Quine. Historically, Quine was only but eight years when Duhem died. Theoretically, Duhem was primarily a physicist while Quine was a philosopher. The point underscored here is that Quine neither met Duhem nor was he a student of Duhem. The only point of connection between Duhem and Quine, which can be deduced from our biographical sketch, is that they both had an interest in and contributed to the development of philosophy of science.

In this connection, their major, rather unique contribution in philosophy of science is what is today known as Duhem – Quine thesis. The thesis was, though, first conceived and developed by Duhem, it became more pronounced and popular in contemporary times due to its appropriation, further development and reinvigoration by Quine. Let us take a look at the original thesis of Duhem about science, on the one hand and then proceed to present Quine's version of the thesis, on the other.

Duhem's Thesis

The prevailing view about scientific knowledge during the days of Duhem is that every proposition or hypothesis about the physical world can be confirmed or falsified through experiment. Thus, after observation, a scientist documents and uses empirical observations to form an hypothesis about the observed phenomenon. But the hypothesis becomes a scientific theory/law when it is confirmed by crucial experiments. It ceases to be a scientific theory/law the day it is falsified by any empirical experiment. The import of this statement is that scientific knowledge is essentially objective, value-neutral and cumulative; therefore scientists can always detect and falsify an erroneous hypothesis whenever there is a conflict between a scientific theory and the result of an experiment.

Crucial experiment is the view that we can discover and falsify an erroneous hypothesis that is found to be in conflict with experience independent of other hypotheses, making up a given scientific theory. Contrary to this position, Duhem in his book, *The Aim and Structure of Physical Theory* stresses the holistic character of verification and falsification in physics and in the process debunks the existence of crucial experiment in physics. According to Duhem, "a single hypothesis cannot be tested in isolation, since other auxiliary hypotheses will always be needed to draw empirical consequences from. The Duhem thesis implies that refutation is a more complex matter than it might appear" (Blackburn, 110).

The crux of Duhem's original thesis is that our propositions about the physical world are essentially interconnected and, as a result, cannot be falsified singly by

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experiments. All that experiments tell us about a given scientific theory, which is in conflict with experience, is that something is wrong with the theory. Yet, it cannot help us to pin-point and falsified the specific proposition or hypothesis that is erroneous. The implication is that the Duhem thesis is originally concerned only with the non-falsifiability of physical propositions or hypotheses through empirical observation and experimentation. In line with this view, Ariel (2003) calls the original position of Duhem "non-fasifiability thesis."

The point envisaged here is that Duhem debunks the claim that we can refute any given proposition about the physical world in an isolated manner whenever they conflict with experience. This is because our propositions about the physical world are necessarily interconnected and inseparable. Thus, the attempt to falsify any given physical proposition necessarily affects other propositions about the physical world. This view was appropriated, further developed, reinvigorated and popularized by Quine. The question now is how did Quine appropriate, further developed, reinvigorate and popularized the Duhem thesis?

Quine's Thesis

Although different scholars can develop similar theories independently, even without knowing that their contemporaries are doing something similar. However, this case is not applicable to the Duhem – Quine thesis. Quine's appropriation of Duhem's thesis of non-falsifibility of isolated propositions about the physical world was acknowledged by Quine himself. In his famous essay "Two Dogmas of Empiricism", Quine uses the Duhem's thesis of non-falsifiability to buttress his rejection of reductionism as a mere dogma of empiricism that lacks empirical evidence. Hence, Quine writes,

> The dogma of reductionism survives in the supposition that each statement, taken in isolation from its fellows, can admit of confirmation or infirmation at all. My counter suggestion, issuing essentially from Carnap's doctrine of the physical world in the *Aufbau* is that our statement about the external world face the tribunal of sense experience not individually but only as a corporate body (41).

Anyone, who grasps the Duhem thesis of non-falsifiability as espoused in the preceding paragraph, immediately realizes that this citation from Quine is more or less a paraphrased repetition of Duhem's position. Of course, when one further discovers that Quine super-imposed the above citation with a footnote where he acknowledged: "This doctrine was well argued by Duhem" (41), then, our claim of Quine's appropriation of Duhem's thesis of non-falsifiability becomes indisputable. The Duhem-Quine thesis is therefore primarily the claim that the confirmation or falsification of our propositions about the physical world is a holistic enterprise.

It particularly posits "the non-separability and the non-falsifiability of single theoretical hypothesis" because empirical predictions can only be deduced from clusters of interconnected hypotheses (Soberg 2002, 3). To this extent, one may think that Quine simply repeated the position of Duhem, but when we dig further, one definitely realizes the unique contribution of Quine. The first fundamental thing Quine did to the Duhem's

thesis is to extend its scope. This is evident in Quine's position that:

> The totality of our so-called knowledge or beliefs, from the mist causal matters of geography and history to the profoundest laws of atomic physics or even pure mathematics and logic, is a man-made fabric which impinges on experience only along the edge or, to change the figure, total science is like a field of force whose boundary conditions are experience (42).

At this point, one can notice that while Duhem restricts the scope of his non-falsifiability thesis to theoretical physics, Quine extends the thesis to the whole edifice of human knowledge including mathematics and logic. In this sense, Quine's non-falsifiability thesis "respects no boundary" (Soberg 2002, 7). In addition to extending the scope of the non-falsifiability thesis, Quine also introduced the revisibility thesis thus,

> A conflict with experience at the periphery occasions readjustments in the interior of the field. Truth values have to be redistributed over some of our statements. A re-evaluation of some statements entails re-evaluation of others, because of their logical interconnections… But the total field is so underdetermined by its boundary conditions, experience, that there is much latitude of choice as to what statements to re-evaluate in the light of any single contrary experience. No particular experience is so linked with any particular statements in the interior of the field, except indirectly through considerations of equilibrium affecting the field as a whole…. Any statement can be held true come what may, if we make drastic enough adjustments elsewhere in the system… Conversely, by the same token, no statement is immune to revisions (42 – 3).

Quine makes the point that all knowledge is circumscribed by experience. Quine is of the opinion that if we wish to hold a particular proposition as true, come what may, we can always adjust other proposition. This position is uniquely Quinean. In this regard, Quine appropriates, further developed, reinvigorates and popularizes the Duhemian non-separability (non-falsifiability) thesis in relation to theoretical physics by applying it to the entire edifice of human knowledge and by introducing the revisibility thesis. It is against this backdrop that some scholars such as Barbosa (2008, 55) argues, "*There is no such thing as the Duhem-Quine thesis*. As famous as this "thesis" may be, Pierre Duhem and W. V. O. Quine held different points of view concerning natural science and how its theories affects other branches knowledge." The veracity of this claim lies in the fact that the position of Duhem and that of Quine are neither logically identical nor equivalent. For, although Quine's position necessarily incorporates Duhem's non-falsifiability thesis concerning crucial experiments in physics, Duhem's thesis does not necessarily entail Quines thesis concerning the non-falsifiability and revisibility of the totality of knowledge. Duhem did not claim that, when there is some conflict with experience, we can always make enough adjustment elsewhere in the theory. He simply claims that when there is some conflict with experience, what is disconfirmed is necessarily ambiguous

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(Arielo, 2013).

Notwithstanding the above acknowledged differences, the Duhem-Quinean thesis on crucial experiment in physics (see Pierre Duhem's *The Aim and Structure of Physical Theory)* and W. V. O. Quine's "Two Dogmas of Empiricism" argues that "a single scientific hypothesis cannot be tested in isolation, since other, auxiliary hypotheses will always be needed to draw empirical consequences from it" (Blackburn, 111). The thesis in this sense implies that refutation is very complex in nature. What this comes to is that scientific theories are necessarily underdetermined and value-laden. The claim of modern science to value neutrality, objectivity and external validity is therefore suspect. A scientific hypothesis can only be validly refuted holistically using its background theoretical framework and not isolatedly, independently and singly. Accordingly, Soberg adequately captures the crux of the Duhem-Quine thesis in a succinct manner thus;

> The Duhem-Quine thesis refers to the relationship between theory and evidence. In particular, the thesis posits the non-separability and non-falsifiability of single theoretical hypotheses (…). Non-separability means that empirical predictions can only be deduced from clusters of interconnected hypotheses. Anomalous evidence consequently implies falsity somewhere inside a theoretical network. In such cases non-falsifiability obtains because pure logic cannot pin-point the exact culprit(s) in a theoretical maze responsible for a false prediction. Thus, even if the evidence is indisputable, the thesis essentially questions whether any empirical assessment of theory can be conclusive (3).

Duhem-Quine thesis debunks the validity of crucial experiment in physics by insisting that scientific propositions about the physical world are necessarily interconnected, non-separable, and non-falsifiable. From this, we infer that all scientific hypothesis, or propositions about the physical world, are necessarily underdetermined by their theoretical background, and value-laden, and as such renders it impossible for pure logic to help us pin-point and falsify any recalcitrant proposition or hypothesis that conflicts with experience in isolation from its theoretical background. The question that is now left for us is the plausibility and significance of the Duhem-Quine thesis in relation to the nature and development of science.

Evaluation and Conclusion

A critical look at the Duhem-Quine thesis, in relation to the historical evolution of modern science, shows that it is a valid and veracious thesis. The historical evolution of modern science shows that every scientific proposition is always a product of a given logically interconnected theoretical matrix. Hence any attempt to falsify any given scientific proposition or hypothesis necessarily affects, if not usurps, the entire background theoretical framework. Hence, if scientists have been using crucial experiment to falsify scientific hypothesis as they claim, science would have remained static, sterile and dogmatic. The growth of modern science is predicated on the fact that scientists do not strictly adhere to the dictates of their methodological rules in practice.

For as Kuhn (1970, 77) "No process yet discovered by the historical study of scientific development at all resembles the methodological stereotype of falsification by direct comparison with nature." The off-shot of this is that the Duhem-Quine thesis captures the true nature of science.

Indeed, the emergence of Quantum theory in physics clearly substantiates the plausibility and veracity of the Duhem-Quine thesis. This is the case because Quantum theory led eminent modern scientist to the conclusion that scientific propositions are relative to the theoretical framework of the observer; hence, their acceptance of the non-separability and non-falsifiability of scientific propositions and by extension the non-existence of crucial experiments. The prevailing interpretation of quantum theory is known as the "Copenhagen interpretation". It is called the "Copenhagen interpretation" because it was in Copenhagen, the capital of Denmark, that Nobel winning physicists namely, Werner Heisenberg, Niels Bohr, Wolfgana Pauli and a few other eminent physicists met, deliberate and present what they consider to be a suitable interpretation of Quantum theory. A succinct presentation of their view will help to make our position more vivid. Accordingly, Alozie did a nice job when he writes:

> We can summarize the Copenhagen interpretation of Bohr and Heisenberg by saying that Quantum theory of relativity is statistical and oppose to determinism and objectivity, as we know it. Copenhagen interpretation makes the point that it is meaningless to talk about the physical properties of quantum entities without precisely specifying the experimental arrangement by which we intend to measure them. Quantum reality is in part an observer-created reality, and human intention influences the structures of the physical world (Physics, 113 – 4).

The point envisaged here is that the prevailing interpretation of Quantum theory shows that theoretical physics, the core of the natural sciences, is fundamentally probabilistic, indeterministic and subjective. And it is impossible to talk of crucial experiment in a place where there is neither objectivity nor determinism. The import of this is that scientific propositions and hypothesis are essentially non-separable, underdetermined, non-falsifiable and value-laden. Progress in science is therefore revolutionary did not evolutionary. "The normal scientific tradition that emerges from a scientific revolution (that is, after the conflict between theory and experience) is not only incompatible but actually incommensurable with that which has gone before" (Kuhn, 102).

Consequently, the significance of the Duhem-Quine thesis is that it helps us to understand the true nature of scientific knowledge in contrast to the ideological propaganda of the scientific community dictated and peddled by Western powers (Alozie Critical Rationalism, 218 – 19, Kanu, 285). In this connection, the Duhem-Quine thesis saves us from the unnecessary attempt to falsify, negate, eliminate and discard important knowledge claims, beliefs and propositions simply on the ground of crucial experiment as dictated by the procedural rules of a particular Western oriented, nay empiricist inspired scientific method. The corollary of this is the decentralization and liberation of scientific

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knowledge so that every human culture and society can seek, devise and use any method at their disposal to explore, penetrate, exploit and harness nature towards meeting their existential needs, transform their societies and ensure their well-being. Against this back drop, one can argue that the logical conclusion of the Duhem-Quine thesis is methodological anarchism in science as buttressed and authenticated in Paul Feyerabend monument of a book, *Against Method: Outline of Anarchistic Theory of Knowledge.*

Our contention here is that Feyerabend's philosophy of science is in-line with the Duhem-Quine thesis and that their major significance is the liberation of knowledge from the devastative canons of scientific method in order to encourage the unlimited progress of human knowledge. Owing to this, we conclude that the Duhem-Quine thesis just like Feyerabend's philosophy of science entails that every proposition about the world is essentially interconnected with its theoretical background. Therefore it challenges and allows every culture including the African culture to justify its propositions nay hypothesis or knowledge claims about the world from its unique theoretical framework. And as Ojong rightly wrote: "the challenge to develop African science with an alternative methodological approach is not an impossible task" (221). This challenge is very valid albeit possible and indispensable for Africa's scientific renaissance and development because the theoretical framework of African science and that of modern science and fundamentally different.

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