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Critical Rationalism and Growth of Scientific Knowledge in Africa

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Abstract

The entirety of African cosmology among all other things embraces their whole fields of sciences, metaphysics and arts but the point of concentration for analysis and clarification is on their sciences (Scientific knowledge). Going by the history of the western science, it appears that the tendency of nationalizing science could be justifiable depending on how one sees it. Science could be taken as objective and universal with respect to the goals it intends to achieve. But the approach could vary from one culture to another basically because it is a methodology. This implies that the growth of scientific knowledge is not limited only to the western world but inherent to every set of people irrespective of the color or race. This paper, however, is of the view that there are sciences of which African scientific knowledge represents a phase in the progress of science; and that the western science and that of the African science are on equal race of achieving the truth. We also assert that both scientific knowledge of African system and Karl Popper's philosophy of science operate on the same epistemological foundation. Thus, we shall use the modern terms and ideas of Karl Popper to argue that African methodology of attaining the truth is a science in its own right and that it has also helped them to advance in their knowledge.

Keywords: African Science, Critical Rationalism, Knowledge, Rationality, Science.

Introduction

Just as ancient western rationalistic thought advanced the growth of western science, so also the ancient African rationalistic thought informed and continued to inform the scientific discoveries of African science. It is so imperative to note that all human race (in as much as they are all rational beings) whether black or white have many ancient and classical philosophers and scientists in their own rights. We talk of African scientific tradition or thought because even at the primitive stage, science is rationalistic and inductive. It may look nonsensical to talk of African science since much of the concept of science is so dependent upon the western philosophical and scientific framework. But then, all about science generally is the art of knowing and the quest for truth. The problem of the African scientific knowledge is its limitation of universality. Yet, the sense of universality in science is also undergirded by rationality. If rationality is the fundamental basis for the progress of science and all the technicalities and experiments accompanying it are to arrive at mutually agreed truth, then African scientific knowledge is not left out. But the western and the African science have a common aim of exploring truths. Both struggles to unveil the truth but with different methodologies. It is on this ground that we wish to elucidate on the notion of African scientific tradition. The point is that African scientific knowledge on its own methodology remains valid as long as one is justified to talk of African philosophy. Just as modernity has not been able to uphold rationalism and empiricism as the only means to a unified knowledge or truth, the history of philosophy and science (from ancient to the contemporary) has not discarded the fact that there are many truths as there are many ways to them. This justifies what is now known as African scientific methodology because of its unique approach to scientific knowledge. The context in which reference is made to the African science is drawn from the jiggered and critical rationalism which covers the conjectures and refutations of the scientific claims in the western worlds through which, in turn has advanced the growth

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of their the scientific knowledge. Emphasis is also laid on Popper's scientific methodology that has spanned commonality between the western scientific knowledge and that of the African scientific knowledge.

Methodology

This study adopted descriptive, analytical and the library research method. It employs the use of both descriptive and analytical methods to describe and analyze the rationality of African science, its modus operandi and the level of its operation in attaining scientific knowledge. Through library research, materials and information as regards to the nature of scientific knowledge in Africa were collected and synthesized. Moreover, the birth of critical rationalism introduced in the study was used to draw the analysis of the jiggered history of western science. That western science did not come up at once but has gone a rigorous process before it got to the current standard. Thus, African science is not exceptional. The research also made use of case study approach, focusing on Karl R. Popper whose critical analysis of rationalism is scientific through his falsifiability and testability of theories. In that, it was used to juxtapose and justify that African methodology of arriving at the truth is a science in its own right.

Results and Discussion

The scientific knowledge in Africa (which can as well be referred as African science or epistemology), and which has been fundamentally given to esoterism by the non-Africans probably because of the African panpsychic conception of the universe, is in this study put to be discussed for better understanding. Just as it is well known that the work of science is not exclusively consisted in creation but also in the discovery of true thought. Having seen science as "a discipline that is anchored in the pursuit of wisdom and knowledge in the ability to question the nature of being and the critical investigation of cause-effect connections"(1), this study acknowledges that science as a field of human enquiry is not personal nor owned by a certain set of people. The method of arriving at the truth is universal only that this pursuit of wisdom and knowledge is culture-bound such that different cultures have different methods of arriving at the truth. This is why Jonathan O. Chimakonam defines African science as "a body of organized knowledge concernewith enquiries into all shades of reality in African world view supported with rational explanations" (2). Thus, this study upholds that there are sciences and that African science is one of them. Just as we can as well talk of Western science, Chinese science etc., and the aim of these sciences is to discover truths. The difference that exists in them is that African science is not empirical and verifiable as that of the western science. Maduabuchi Dukor made it clearer when he says:

> Western science largely emphasis physical reality or objective reality. But one discovers that some propositions of western science have nothing to do with physical or objective reality. For African science (or magic), the emphasis is on both physical and non-physical reality, but most of the times it has non-physical reality as the immediate cause of the consequent physical reality; with some other physical or objectives phenomena as the remote cause of the consequent physical reality. In African thought, a non-physical cause of an effect must have as its reference points some physical or objective phenomenon (3).

However, what matters most is that in the search of reality, the truth is known whether physical, non-physical, objective or not. This is why this study acknowledges both as species of sciences. Despite the fact that African science is not yet systematized and quantified as that of the western science, it is still a science within its own modus operandi. It has its own method of enquiry which is culturally based. And not only that it has a phase in the progress of science; it has also helped Africans significantly to advance in their own scientific research.

Rationalism – Origin and Tenets

Rationalism in philosophy could be traced back to the pre-Socratic periods though not in a systematic form. These philosophers did not make rationalism assume a philosophical implication as it later bore in the 15" century with the arrival of Rene Descartes who was regarded as the father of modern philosophy. In earlier philosophers like Pythagoras, Anaxagoras, Parmenides, we can see traces of rationalism. In the classical period, many

people bothered about the 'stuff that is the base of everything, they pined it as something that is rooted in materiality - but such early nationalists like Pythagoras, Anaxagoras and Parmenides came up with something that is not material. For example, Pythagoras considered such stuff to be numbers while Parmenides held that there is no other way of catching knowledge except through reasoning. Plato was the first to systematize a classical rationalism. For him, object of knowledge is independent of time and space and cannot be perceived by senses. He also says that one can only get at ideas through concepts which are stored in us even before our birth, these accounts for this treatment of the notion of recollection (meno). Rationalism can be traced to a point in Aristotle. In De Anima, he says that reason is Divine. The stoics, Epicureans have these tendencies of reason too. The same applies to Plotinus. In the medieval period we have rationalist views in the philosophy of Avicenna. Rationalism as a matter of fact reached a serious philosophical level with Descartes who came and doubted everything except the doubting self which he discovered through reason. From here, he established the existence of God and the external world. Among those in Descartes line of thinking are Leibniz and Spinoza. They are being referred to as continental philosophers. Summarily, rationalism is a philosophical concept which states that reason alone is the only way to knowledge. (The word came from Latin ratio – meaning reason). As a matter of fact, all real knowledge comes from reason. The emphasis of rationalism is on the rational capacity of the human mind. The rationalists believe that one need not appeal to any supernatural source in order to have knowledge of the real word. Faith has no place in rationalism; the only source of truth is reason. Rationalism has a definite aim - to discover the real indubitable truth of the universe. They want to formulate clear rational principles that would be organized into a system of truth from which accurate information about the world could be deduced. As earlier pointed out, the rationalists maintained that sense knowledge can be shown to be uncertain and untrustworthy.

Birth and Doctrine of Critical Rationalism

Critical rationalism was born when the dogmatic tendencies of rationalism were being questioned. (Rationalism was embedded in dogma). The claimed superiority of reason over experience was put to question. The first to question reason was a well-known German philosophical giant Immanuel Kant. Kant wrote a voluminous work with the tittle 'Critique of Pure Reason where he questions the claims of pure reason. In this work, he discovered the limitations of pure reason. Thus, reason cannot validly claim to be the sole way to certain knowledge, its universality notwithstanding. Thus, Kant is tagged the father of critical rationalism. His critical rationalism, and its opposing current of thought - empiricism, gave rise to his meditation and the birth of synthetic a priori judgment which is, superior to both analytic (rationalism) and synthetic (empiricism) judgment. This synthetic a priori judgment enjoys the universality and necessity of analytic judgment without being tautological and possesses the fecundity of synthetic and posteriori judgment without being restricted to the particular being existing in the empirical world e.g. (7+5= 12). In as much as we give Kant the honor of giving birth to critical rationalism, we must not fail to say that critical rationalism reached its zenith or apogee in the hands of Sir Karl R. Popper whose critical analysis of rationalism is scientific and more practical than that of Kant. Popper was regarded as a critical rationalist because of his falsifiability and testability of theories. Thus, he was not satisfied or better, interested in 'given' truth or dogma but in subjecting this truth to test, to falsify it and draw perhaps a better truth from it. There is nothing he prized in this system than falsifying truth and building better ones which in turn progresses knowledge. Popper believes that the more a sentence or proposition can be falsified, the more truth content it has and the less probable it will be authentic truth; thus, he says: "...if growth of knowledge means that we operate with theories of increasing content, it must also mean that we operate with theories of decreasing probability"(4). It is the truth of the case with Popper that when the informative content or empirical content of a sentence is minimal then the probability of such sentence is high and less falsifiable it will become. Thus, more information less probability and less information more probability, it is inversely proportional. For instance, that it will rain next year has a high

probability of happening than that it will rain on the 26th June by 4.00p.m. next year. The latter has more empirical content than the former; therefore, it has less probability than the first. Because it has less probability, it is more falsifiable. The more falsifiable, the more scientific and the less falsifiable, the less scientific. Our interest, therefore, in science is centered on statement with condensed informative contents. We shouldn't busy ourselves with statements that have low contents. This should not be obtained among scientists. Statements with low informative contents like: there will be rain next year practically tells, nothing. These should be found among mad men and fools. Science busies itself with high empirical statement and therefore, low probability which nevertheless come close to the truth or the statement that is closest to reality or truth, the fact that they are highly falsifiable makes them also highly testable. Informative content which is inversely proportional to probability is in direct proportion to testability. The true statement with highest possible informative content would be a full specific and accurate description of the world. And every possible observation or experience constitutes a test, a potential falsification of it and the probability of it being true is unimaginably close to zero since the number of ways of which it is possible would be also high. Rationalism, right from the time of the early Milesian and Ionian philosophers has been a search for an ultimate truth or knowledge. With the arrival of Kant, the basic assumption of the school was questioned. Popper on the other hand is thriving towards the same goal - of finding truth but his type of truth is an objective truth. It is then objective truth that gives some knowledge. It could be argued that Popper was not interested in a given knowledge or truth but on truth that can be falsified in order to make advancement. Popper's stand may seem contrary to what the old rationalists were doing but that is not the case, he only wanted to sharpen their stand, make it more scientific to stand the test of time. Popper himself attests that "our main concern in science and philosophy is, or ought to be, the search for truth" (5). So, what Popper and followers attempt in science is to explain reality? The aim then of scientific activity is the production of explanatory truth, truth that is open to falsifiability or refutability and has a high empirical content, therefore, high probability of being falsified. And since a low probability means a high probability of being falsified, it follows that a high degree of falsifiability, or refutability, or testability, is one of the aims of science - in fact, precisely the same aim as a high informative content (4). Really, one can say while truth is the aim, ignorance is the game according to W.H Newton–Smith. Basically, the main doctrine of critical rationalism is the attainment of an objective truth or knowledge. Popper himself believes that we can't attain to the absolute truth but we can go nearer to it by method of falsification of theories. Thus, he invented the concept of verisimilitude - truth likeness, nearing the truth. As indicated above, the more we falsify existing truths or theories, the more they are nearer to what he calls the objective truth and it could not be thought that this truth would be permanent since another theory can easily falsify it. Popper drew a distinction between rationalism and empiricism and declares his stand. Those philosophers, whom he disagrees with, he calls the verificationists or the justificationist philosophers of knowledge. Those who agree with him are the falsificationists or fallibilists or critical philosophers of knowledge or of conjectures. The position of the empiricists is that whatever cannot be supported by positive reasons is unworthy of being believed, or even of being taken into serious consideration. While Popper's camp (the critical rationalists) say that whatever cannot (at present) in principle be over thrown by criticism is (at present) unworthy of being taken seriously; while what can in principle be so over thrown and yet resists all our critical efforts to do so may quite possible be false, but is at any rate not unworthy of being seriously considered and perhaps even of being believed- though only tentatively (4). Actually, there is no place for rigidity here or elsewhere in his system. Popper sees with the empiricists in fighting against traditional rationalism, a fight against superstition and arbitrary authority. They demand that we should accept a belief only if it can be justified by positive evidence. We should accept a belief if and only if, it can be verified or probabilistically confirmed. Popper claims that his camp (the falsificationalists) has something which overpowers the verificationists, that we can never give positive reasons which justify the belief that

a theory is true. About what is it that they have which nullifies the verificationists, he proudly says:

> But, unlike irrationists, we falsifitionists believe that we have also discovered a way to realize the old ideal of distinguishing rational science from various forms of superstition, in spite of the breakdown of the original inductivist or justificationist programs. We hold that this ideal can be realized, very simply, by recognizing that the rationality of science lies not in its habit of appealing to empirical evidence in support of its dogma... but solely in the critical approach (4).

Popper's rationalism is termed critical because it is rooted in criticisms, constructive and not destructive or still we may say that his system is deconstruction, i.e. destroying in order to build. He does not criticize theories for the fun of doing that but in a pursuit of an objective truth that is not absolute but has a relative stability. Thus, he writes:

> For us, therefore, science has nothing to do with the quest for certainty or probability or reliability, we are not interested in establishing scientific theories as secure, or certain, or probable. Conscious of our fallibility, we are only interested in criticizing them and testing them, hoping to find out where we are mistaken, of learning from our mistakes and if we are lucky, of proceeding to better theories (4).

We have earlier on indicated that for Popper, the aim of science is to discover truth, but not a laid down one. Instead, the one that has falsification as its base. Popperian camp engages in celebration whenever their theory is falsified. That accounts for their tentative notion of truth because they hope that it will sooner or later be proven to be untrue.

> ... The acceptance by science of a law or a theory is tentative only; which is to say that all laws and theories are conjectures. Or tentative hypothesis and that we may reject a law or theory on the basis of new evidence, without necessarily discarding the old evidence which originally led us to accept it (4).

One outstanding feature of Popper in this area is that he respects the defeated hypothesis. He does not throw them into the dust bin of history. He recognizes and acknowledges that the defeated theory is the bed rock, the 'to-be' of the new theory.

In their search for truth, they propounded what they call conjectures and thus, tirelessly work towards the defeat of this conjecture. Thus, Popper rightly says:

> I can, therefore gladly admit that falsificationists like myself much prefer an attempt to solve an interesting problem by, a bold conjecture, even if it soon turns out to false, to any recital of a sequence of irrelevant truisms. We prefer this because, we believe that this is the way in which we can learn from our mistakes; and that in finding that our conjecture was false, we shall have learnt much about the truth, and shall have got nearer to the truth (4).

He is of the opinion that they (falsificationists) attempt in science to explain reality and this fortunately is the aim of both scientists and philosophers since the beginning of learning. He and his followers are in dare search of truth which makes them to be "'negativist' in character while the verificationists are 'positivist'. They (falsificationists) are really scientific in the search for truth because they have scientific spirit, i.e., giving room for falsifiability and criticisms. By

creating the forum for the existence of these, their passion for the search becomes clear. He says that the notion of loopholes and fallibility involves the idea of an objective truth. Thus, he writes:

> ...it is only with respect to this aim, the discovery of truth that we can say that though we are fallible, we hope to learn from our mistakes. It is only the ideal of truth which allows us to speak rational critical discussion in search of mistakes with the serious purposes of eliminating as many of these mistakes as we can, in order to get nearer to the truth. Thus, the very idea of error – and of fallibility – involves the idea of an objective truth as the standard of which we may fall short (4).

As a matter of precision, he believes that truth is not the only objectives of science but truth that is interesting and very hard to come by. For Popper, verisimilitude hinges on the fact that if a theory is stated and later discovered to be false, that the second theory which nullified the first one is nearer to the truth than the first and in case a third theory defeats the second, than the third is still nearer. Verisimilitude in a nutshell, is the theory which states that always the later theory is nearer to the truth than the former. When we think of this set up, we shall observe an increment or growth in knowledge (scientific). He elucidates it by saying:

> Assuming that the truth - content and the falsity content of two theories t_1 and t_2 are comparable, we can say that t_2 is more closely similar to the truth, or corresponds better to the facts, than t_1 if and only if either (a) the truth - content but not the falsity content of t_2 exceeds that of t_1 (b) the falsity content of t_1 but not its truth content, exceeds that of t_2 (4).

Looking at this set up, one might be tempted to ask the following questions for the sake of clarity and distinctness- what are you up to when you affirm that t_2, has a higher degree of verisimilitude than t_1, and how do you know that t_2, has a higher degree of verisimilitude than the theory t_1, what is your yard-stick? A reflection on the above citation answers the first question. Simply put, t_2, has more informative or empirical content than theory t_1. It has a higher truth - value. The second question needs something more than mere observation. Despite this, Popper says that it depends on the first for its meaningfulness. The 'how' needs something practical. It has to be put into test or experiment. Analogously, he compares it to the following question about truth, "I do not know - I only guess. But I can examine my guess critically, and if it withstands severe criticisms, then this fact may be taken as a good critical reason in favour of it" (4). This confirms what we have stated before that anything we must take as truth must have been rigorously tested and survived the uncomfortable heat.

Requirements for the Growth of Knowledge

We have discussed before, that the main task of scientist is to find a theory which is nearer to the truth more than the previous one. This new theory is believed to explain what the earlier theory has done, explain what it has not explained and make it actually falsifiable. But this is not all. There are certain things that are needed for the theory to do this work effectively. These are what Popper calls three requirements for the growth of knowledge. It is required that the new theory will begin from some "simple, new, powerful and unifying idea about some connection of relation …between hitherto unconnected things … or facts … or new theoretical entities" (4). But conceiving this point of simplicity will seem dry to formulate. Our theory has to describe actually the structural properties of the world, an idea it is hard to think out without getting involved in an infinite regress because any idea of the particular structure of the world already presupposes a universal theory. Popper was of the view that one serious component of the idea of simplicity can be logically analysed. It is the idea of testability. The second requirement is related to the first one in that this new theory should be independently testable. This simply means that despite the fact that the new theory will explain all the explicanda which it was design to do, it ought to lead to the

forecasting of new phenomena, which has so far not been observed. Popper says that if this requirement is met., that the new theory "will represent a potential step forward, whatever the outcome of the new tests may be. For it will be better testable than the previous one, the fact that it explains all the explicanda of the previous theory, and that, in addition, it gives rise to new tests, suffices to ensure this." (4). Contemplative reflection on what has been said above dispels all inclination to doubt, an instrument of exploration. It suggests new experiments and whether this is later refuted is not the issue at stake here. One important thing is that our factual knowledge would have grown through the unexpected results of the new experiments. The third and the last one is merely an advance on the first two requirements. It is that this theory should have scaled through some new and rigorous tests. Popper regarded the first two as the formal conditions or requirements because they could be seen to be falsified or not, mainly by analyzing the old and new theories logically. The third requirement is the material requirement because it could be found to be fulfilled or not only by testing the new theory empirically. According to Popper:

> Even if a new theory should meet an early death, it should not be forgotten: rather its beauty should be remembered and history should record our gratitude to it –for bequeathing to us a new and perhaps still unexplained experimental facts and, with them, new problems; and for the services it has thus rendered to the progress of science during its successful but short life (4).

Having seen what the three requirements for the growth of scientific knowledge entail and their importance for the successful realization of the set objective, I incline to reason with popper that for a sure growth of science and its rationality, we shall not do away with the concept of refutation. This refutation, we shall understand has the same meaning and function with his falsification theory. If we cannot refute a stated theory, we shan't make any progress and the aim of science will be drawn to the ground. Succinctly, he writes:

> ...progress in science would become impossible if we did not reasonably often manage to meet the third requirement; thus, if the progress of science is to continue, and its rationality not to decline, we need not only successful refutations, but also positive successes. We must, that is, manage reasonably often to produce theories that entail new predictions, especially predictions of new effects, new testable consequences, suggested by the new theory and never thought of before (6).

Critical Rationalism vis-a-vis Scientific Knowledge in Africa

From the foregoing, it is quite clear that there is no specific criterion for attaining the truth. Instead, there are numerous methods for finding the truth. History has testified to it. By implication, the concept of pluralism has got not to be relevant only in economic and politics, but also in cultures, science and even technologies. Diversities are not only in culture but also in methodologies to truth. It means therefore, that science, culture and philosophies of people have faced different methodologies. History and philosophy of science, for instance, has shown that from ancient Greek period to the Renaissance era, science was not completely separated from philosophy. As at then, Philosophy and science was meant to be one thing. So also, there is no such separation in African case. Accordingly, Finch says:

> In Africa, scientific or technical ideas and religious ideas have never been separated. The vocation of scientific or engineering was never held distinct from that of Priest. The observations of religious rituals, the medicinal implications of horticulture, the construction of calendars

> following the observation of celestial phenomena, and above all the hope after life are representative of the innumerable links between science and religion inn Africa (7).

The focus here is that scientific knowledge in African co-exists with both physical and spiritual in a progressive approach for attaining the truth. However, the framework of African scientific worldview is in consonance with Gottlob Frege's declaration that "to discover truths is the task of sciences" (8). Science is a method of arriving at the truth. In as much as methods or ways of arriving at truths are influenced by culture, it implies that science is culture-bound. Having known that cultures are not exactly the same, sciences cannot be same as well. This is why Frege rightly says that science does not require ownership and sense – impressions. In agreement with Frege, if science should belong to a particular set of people or individuals, then it would remain subjective and dogmatic, hence, there would be no contradictions or controversies over it. In as much as this could not be the case, neither thoughts nor ideas are things in the external world. It needs no owner. Thus, Frege has it that:

> In thinking we do not produce thoughts, we grasp them. For what I have called thoughts stand in the closest connexion with truth … A fact is a thought that is true. But the scientist will surely not acknowledge something to be the firm foundation of science if it depends on men's varying states of consciousness. The work of science does not consist in creation, but in the true thought …Therefore, that truth cannot have come to be only upon its discovery (8).

Accordingly, it is not possible to have a thought as true today and false in the next years because thought is timeless. In contrary, the history of science has shown series of conjectures and refutations. Scientific findings are limited with time as the previous ones are being invalidated by subsequent ones. Correspondingly, this has been the case of scientific knowledge in African world. The development of scientific knowledge in Africa is never unilateral. We have old and new sciences varying from one culture to the other which means that African science also has a phase in the historical development of human thought. Science is concerned with the material universe, seeking to discover truths about it and to fit those truths into conceptual schemes called theories or laws that will clarify the relations among them (9). While technology is an extension of science, the fundamental aim of science is to seek the knowledge of nature as an end in itself or for the purpose of its application to the solution of human task. The implication here is that pure science discovers concept of nature and while technology undertakes the application of scientific laws and concepts in accomplishing problems. The indigenous people of Africa had different kinds of technology which must have come as a result of a methodical system otherwise known as art or science. This is in other words called African science. Some may have called it magic, but this is at best one of those methodologies of arriving at the truth. This is why Emedolu upholds that African experimental science cannot emerge from nowhere but must be relatable on the inherent magical tradition that exists within the culture of the people of the continent. He thus says this because "European science itself emerged out of its own magical tradition" (10). Therefore, African Science has its own unique alethic and epistemic modalities of arriving at the truth. For instance, in IFA tradition in Yoruba, a seed of alligator pepper like a nuclear bomb can be prepared to destroy cities. Among the Igbo and in most part of Africa, rainfall can be brought about by causing smoke to go up to the sky. Modern science may not take the above serious as scientific theories. Some have argued against it as not being rational and objective. Yet, Jarve and Agassi are not far from the truth when they said that: "Something is rational if there is a goal to which it is directed" (11). Likewise, a belief is rational if it satisfies some standard or method of rationality which has been adopted on good evidence, or is being reasonable doubt, or is held open to criticism. According to Popper, our view of the world is at any moment theory impregnated. African scientific method remained a paradigm that is seemingly modern and

adequate to formulate beliefs and theories about the universe and its objects. The more universal this beliefs and theories, the more susceptible they are to attack. It is through this process that our beliefs and theories are replaced by competing ones. Every science embodies epistemological frame-works, if the method is not understood; the scientific frame-work will not be understood. This is exactly the problem with African Science. It has been widely misunderstood and misconstrued because of the limitations of its methodology while it is under threat of extinction from western scientific paradigm. Popper has emphasized on the method of trial and error as a principal mode of arriving at scientific knowledge which is characterized by repetition, different and continues attempts until success is achieved. It is obvious that this method employed by Popper in his scientific enquiry has certain similarities with African scientific system. The practice of African science especially in the practical aspect like craft traditions, artisans, technology and other practical involvement in seeking a genuinely satisfactory solution to some problems has been characterized by trial and error method. The science of rain making is a typical example of such enterprise. The African indigenous people did not just go into the forest and got leaves whose smoke scatters the cloud to prevent the rain and whose smoke also connects the cloud to make the rain fall. So, they experienced some certain trials and errors, conjectures and refutations until they arrived at the specific leaves that could perform such actions. Similarly, the act of removing iron like bullet on the human body was done based on experiment through leaves such that when applied on the affected area the object will naturally come out of its own. Likewise, on the issue of amputation/bone setting, the African traditional healthcare personnel began with series of trials and errors in handling bone fractures before they were able to perfect on setting it. Therefore, African traditional scientific system is closely connected with Popperian principality of trials and errors in acquiring scientific knowledge. This scientific knowledge within the African context has empowered the indigenes with the abilities and capabilities of deploying practical techniques and skills in managing their environment. And this has sustained them to advance further even in technology and other practical knowledge. According to Schmidt, such advancement in technology was not learnt from the western science or from anywhere else because even the sophisticated iron making industry in Ancient Tanzania was fully dependent on experimentation. Thus, he maintains that:

> The Haya smelt had many distinctive features, including the preheating of the blast air, the efficient recovery of iron, the carbon boil, the formation of cast iron, and the formation of phosphorus rich cast iron. It is simply easier to believe that these many interlocking features arose from an incremental process of experimentation than to believe that they were learned as an ensemble by imitation. Moreover, reflecting on these innovations, one comes to realize that they are all, one way or another, adaptations to the chemistry peculiar to local materials: the limonite ores, the Mucwezi charcoal, the swamp reeds and the refractory tuyere clay (12).

The description given by Schmidt above shows that the advancement of these kind of practical knowledge of arts and craft in Ancient African metallurgy are solely based on a continuous repetition of experiments or the process of trial and error methods. Ozumba refers it as "improved species of African science, which is borne out of trial and error and the presence of cross-cultural scientific borrowings" (13). By implication, the advancement of African science through trial and error has certain commonalities with Karl Popper's philosophy of science which is also attributed to critical rationalism and trial and error methods. Emphasizing on the importance of that techniques, Chimakonam observes that the method of trial and error is still effective within the African institution whenever it calls for the search of scientific and technological knowledge. For him, in the African context, a scientist is also technologist since he is the initiator of both theory

and practical aspect of the knowledge. According to him:

> most times when an okwa-nka (the scientist) designs a project or articulates his hypothesis, he, like a foul scratching the earth in a disorganized form for some ant colony, goes about without prior knowledge and sometimes even without experience looking for how to develop the technology. It was basically a trial and error method (14).

However, the scientific knowledge of any people is a sine qua non to understanding the rationality of their thought. It is not even logical to argue that the so-called primitives were a kind of pre-rational. Rationality is natural and takes many and varied forms; there is no norm for rationality in general, likewise in science. African science is one such mode and western science is another, and each has criteria of rationality peculiar to itself. It therefore, follows that anything that counts as scientific knowledge or scientific methodology can only be understood and criticized in its own rationale. It is pertinent at this stage to note that African science and western science are all attempts to explain reality, and none will ever be perfect or above refutation. Instead, it would rather give room for falsifiability and criticism. This is the idea of falsifications as advocated by Karl Popper. He has it that the more a theory or statement is falsifiable, the more scientific it becomes. For him, scientific knowledge cannot be dogmatic or else, there will be no growth of human knowledge. Consequently, one who believes in African science and one who denies it are all attempts to explain reality, and they would be contradicting each other if reality is something independent of individual conceptions and culture. It means, therefore, that only one or none of the views would be right. In any case, some have denied African epistemic and alethic methodology a scientific status by characterizing it mystically, supernaturally, and ritualistically oriented. This notion is chiefly based on the argument that African methodology is not empirical and scientific. But Karl Popper has clarified this by saying that rationality is not restricted to the realm of empirical or scientific theories, but that is merely a special case of the general method of criticism, the method of finding and eliminating contradictions in knowledge without ad-hoc-measures. Besides, attributing African methodology as non-empirical and scientific is also one-sided. For anything to be scientific, it must first of all be based on common sense. The major difference between African science and western science are that the former is more mystical and ritualistic oriented and the latter is more empirical. But one thing common to them is that they are both based on common sense. African science has so far been established to an extent such that some truth or knowledge has survived the attempts of falsification and has been working for them. It is obvious that this tested knowledge when applied to the area of development enhances order and peace which are the bedrock of development project. Order, peace and development, according to Ishaya, is realizable when there is a basic transformation in the make-up of the individual's mode of thinking. And this involves changes in ideas, attitudes, values, policies, beliefs, and traditions that are enduring (15). Actually, these are some of the issues that critical rationalism seeks to deal with: the absolute liberation of the individual's mind from the shackles of ignorance and darkness to the light of critical knowledge which will enable the individual to articulate and understand reality for the individual and society. Another thing is that truth should define reality irrespective of the kind of reality, whether physical, objective or not. Any methodology or whatsoever, could be science, be it physical or non-physical, in as much as it arrives at the truth. Just as some certain principles have been established to be true. These principles are not physical, yet they are objective truth. Examples are pure mathematics and logic. They are concerned with a world of ideal objects, a non-physical reality. Similarly, the three laws of thought established by Aristotle (384 – 322BC) is another instance. The law of identity: A is A or P ≡ P. The law of non-contradiction: No statement or assertion can be true and false at the same time or ~ (PΛ~P), the law of excluded middle: Everything is either A or not A; PV~P (16). Critical rationalism holds that scientific theories should be subjected to criticisms and their empirical contents should be subjected to experiments with

the view to falsify them. Traditional epistemologists hold that knowledge is justified true belief. On the contrary, Popper advocates the direct opposite. Knowledge is unjustified untrue unbelief. It is unjustified because of lack of sufficient reasons. It is untrue because it is fraught with errors. Critical rationalism is opposed to justifications. This implies that no science is beyond criticism, since none is perfect. Even as the records of the progress so far made by western science in terms of methodology and achievement, it is still open to criticism and has room for the development of alternative to the established body of theoretical tenets. While the African scientific knowledge is objectively developing, their theoretical tenets should not be held sacred as there would be no room for criticism and the development of alternatives. Those who have criticized African science have done marvelously well. We encourage constructive criticism. Since every element of human thinking should be open to potential criticism as Popper believed, but must have to be careful of criticism that would come about threat to the growth of knowledge. This paper is in line with Popper that one should demonstrate openly a new form of theoretical thought. Popper has acknowledged the importance of being cautious in action. He rejects any ambitious act that seems to be perfect. We, therefore, call for constant openness in the reformation of our practices. This however should take a gradual process. In any change that occurs we must expect criticism. The possibility now remains that some past reform of ours will henceforth be judged as a misstep (17). Popper's emphasis on rationalistic virtues of openness and criticism accentuated by falsifiability and critical rationalism, acknowledges the development of a new standard of science that is neither fundamental nor relative but pluralistic. Hence, the African scientists should endeavor to accept properly the critical attitude of science and make use of Popperian falsifiability model of testing ideas as this would make African science to fully become a legitimate science. Moreover, African scientists and technologists should be empowered to conduct high-quality research and communicate their findings and recommendations to all stakeholders and among themselves in open-access platforms. And with the help of decentralized assistance from the leadership and management models of government parastatals and non-governmental organizations, hundreds and thousands of them can collaborate in different projects. Building on the above foundation will further establish and advance the momentum of scientific knowledge in Africa.

Conclusion

Both African and western sciences are epistemologies – the ways of arriving at the truth. The difference between the two worlds scientific views border on the fact that traditional African Science co-exists with both physical and spiritual in a progressive approach for attaining the truth while western science is based mainly on physical via empirical observation, experimentation and methodology. Apart from the fact that the African science is not as systematized and quantified as western science, this paper recognizes neither that science as a field of human enquiry is not personal nor a universal method of arriving at the truth. Its method of enquiry is culturally based. In other words, different cultures possess different methods of arriving at the truth. It is based on this ideology that we uphold African Science legitimately as that of the western science. Besides, if there is African philosophy, why not African science? Irrespective of the nature and the stage of African Science (not being objective and universal) in the modern-day world, it still has significant relevance to the growth of science. Just as Popper holds that even though that falsification is one single method that can serve as a criterion for all the sciences, it does not mean that metaphysical inquiry or anything outside science can never emerge as a way of scientific inquiry. One should not condemn the metaphysical attitude in science because it could be the necessary step that would keep the new science on the swift progress (7, 18-20). Thus, African Science should not be condemned in toto because it has come to be on its own right and has been helping the Africans to advance in their own scientific realm.

Abbreviation

Nil.

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Author Contributions

Dr. Bonaventure Ikechukwu Ozoigbo conceived the idea and wrote the birth and doctrine of critical rationalism, and requirements for the growth of knowledge. Dr. Christian Sunday Agama wrote the introduction, results and discussion, and critical rationalism vis-à-vis scientific knowledge in Africa. Dr. John Ezenwankwor wrote methodology, and rationalism – origin and tenets while Dr. Jude Chukwuma Onyeakazi sourced materials and assisted in writing the conclusion.

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The authors declared that there was no conflict of interest among them.

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References

1. Nnabuchi MN. Introduction to Science and Technology. In: Okeke PN and Ekpe OE, editors. Science for Man. Enugu: Rejoint Communication Services Ltd. 2005; 1(1): 1-15.
2. Chimakonam JO. Towards a Theory of African Science: Methods and Justification. IOSR Journal of Pharmacy and Biological Sciences. 2012; 3(1): 33-41.
3. Dukor M. Rationality of African Science. Journal of Oriental and African Studies. 1995; 7(1):116-140.
4. Popper K. Conjectures and Refutations: The Growth of Scientific Knowledge. Routledge: London and New York. 1963;2:218-243.
5. Popper K. Objective Knowledge London: Oxford UniversityPress.1972:319-321. https://www.scirp.org
6. Popper K. Remark on the Problems of Demarcation and Rationality. In: Lakatos, I. and Musgrave, A, editors. Problems in the Philosophy of Science. North-Holland: Amsterdam. 1968:93-98. https://philpapers.org
7. Finch C S. The Star of Deep Beginnings; the Genesis of African Science and Technology. U.S.A. Khenti, Inc. 1998 Nov 2: ix -5. https://aalbc.com
8. Frege G. Logical Investigations. Great Britain: Basil Blackwell. 1977:1-125. https://www.amazon.com
9. Awachie MN. Science, Technology and Invention. In: Introduction to Natural Sciences. Edited book, new crest publishers. 2001; 2(1): 26-38.
10. Emedolu C. From Magic to African Experimental Science: Toward New Paradigm. Filosofia Theoretica: Journal of African Philosophy, Culture and Religions. 2015: 4 (2): 68 – 88.
11. Jarvie IC. And Agassi J. The Problem of the Rationality of Magic. In: Bryan RW, editor. Rationality. Oxford, Britain: Basil Blackwell. 1977:363-383.
12. Schmidt P. Iron Technology in East Africa. Bloomington: Indiana University Press, 1997 Jun: 127-130. https://iupress.org/97802321109/iron-technology-in-easta-frica/
13. Ozumba G. Analytic and Synthetic Dimensions of African Science. Sophia: African Journal of Philosophy. 2002; 2(2): 19-26.
14. Chimakonam J. Introducing African Science: Synthetic and Philosophical Approach. Bloomington: ArthurHouse. 2012Aug20:417-27. https://www.everand.com/book/387270044/
15. Ishaya SO. Comparative Analysis of Rationalism and Critical Rationalism. Aquino Journal of Philosophy. 2021;1(3): 1-11.
16. Nwanegbo-Ben John. Logic (2). In: Nwanegbo-Ben J and Ozoigbo, BI, editors. An Introduction to Philosophy and Logic. Owerri: Applause Multi-Sectors Ltd. 2019;1:289-93.
17. Popper K. The Open Society and its Enemies: The High Tide of Prophesy; Hegel, Marx, and the Aftermath. London: Routledge and Kegan Paul. 1945:122-27.
18. Popper K. The Logic of Scientific Discoveries. London Routledge: London and New York. 1959:19-252. https://www.scirp.org
19. Bartley WW. Theories of Demarcation between Science and Metaphysics. In: Lakatos, I. and Musgrave A, editors. Problems in the philosophy of Science. North-Holland, Amsterdam. 1968A:47-54. https://www.journals.uchicago.edu
20. Bartley WW. Reply to Karl Popper. In: Lakatos I and Musgrave A, editors. Problems in the Philosophy of Science. North-Holland, Amsterdam. 1968B:115-118. https://www.journals.uchicago.edu