Ian Hacking on Repeatability of Experiment: Instrumental Implication for African Science

By

Christian C. Emedolu, PhD
Department of Philosophy
University of Port Harcourt, Nigeria
+2348035517505
(dongaphilsemd@yahoo.com)

Abstract

The concept of replication of scientific experiment has been there right from antiquity. The usual understanding of it is to do or try what has been done before in exactly the same manner. But Ian Hacking has a different orientation to it. For him, repeating an experiment involves deploying or trying different approaches or using more improved instruments to yield the same result. The paper adopts Hacking's viewpoint as precisely offering Africans a better way of conceiving replication in African science. The paper calls for improvement or advancement in the practice of African experimental science. It argues that crudity should not be considered as the trade mark of Africa science. Since the paper has little or nothing to do with any real-time experimental investigation, the method of content analysis was adopted.

Key Words: Replication, Experiment, African Science, Instrument.

Introduction

Creation of phenomena is the fundamental character of scientific experiment. For Ian Hacking, a phenomenon is a noteworthy event with a high degree of regularity. It is actually in the creation of phenomena or effects that experiment shows its autonomy. This implies for most scholars that any experiment that fails to create a phenomenon is no experiment at all. Charles Sanders Peirce offers a supportive bite to the recurrence of experimental phenomena in these words:

> Indeed, it is not in an experiment, but in experimental phenomena, that rational meaning is said to consist. When an experimentalist speaks of a phenomenon ... he does not mean any particular event that did happen to somebody in the dead past, but what surely will happen to everybody in the living future who shall fulfill certain conditions (Lindberg 2001, p.16).

Also important is the fact that any experiment that cannot be replicated should not be regarded as worthy of any significant consideration in the scientific community. For if a particular experiment cannot be repeated by other members of the scientific community, then there is no basis for considering it as a useful tool for refuting or corroborating a theory (to borrow Karl Popper's terminology). Before the wake of Hacking, the trending belief was that the same process can always be repeated several times over to yield similar results. But Hacking has a different orientation to it. According to him, repeating an experiment has nothing to do with doing the same thing or following the same process over and over again.
Now, the issue of replication of experiment has remained an unquestionable dogma and part of the orthodoxy in western science. Following from this, African experimental science has been strongly accused as being non-repeatable. The idea that African scientific theories are not well-formed or properly articulated is as clear and evident as the light of day. But what about the idea that African scientific operations are clearly not repeatable? Indeed, no thought or logic could be further from truth than this.
Therefore, in what follows, I shall present Hacking's idea of replication of scientific experiment. I shall also try to disentangle African Science from Western criticisms. This will then lead to the examination of the necessity of instrumental upgrade in African science, and finally lead to conclusion.

Hacking's View on Replication of Scientific Experiment

Hacking's reaction to the question of repeatability of experiment is very striking as it is memorable. Hacking plainly asserts that, talking about replication of experiment "works out as something of a tautology. Experiment is the creation of phenomena; phenomena must have discernible regularities – so an experiment that is not repeatable has failed to create a phenomenon" (1983 p.229). Viewing this against the backdrop of scientific revolution, it is somewhat obvious that a phenomenon may manifest itself at the initial trials of an experimental test, thereby creating an illusion of success. However, the picture might change with subsequent instrumental refinement or sophistication that can adequately take care of accumulated anomalies. After any theory change it is purely unwarranted for anyone to claim that there were no phenomena created in the old order or paradigm (to borrow from T.S. Kuhn). The clear fact is that what is phenomenal today may amount to nothing or nonsense in future.

Now, before I go further, I must first hack at the base of Hackinian presumption. I stress that it is not all the time that experiments create phenomena. Such experiments that fail to create phenomena may not in the strict sense be considered as *failed* experiments *per se.* But unfortunately that is even what scientists usually call them. I urge rather that they be referred to as *negative* or *silent* experiments. ***Negative*** should stand for one which produces a different result or point toward another phenomenon or effect, and ***silent*** should represent the experiment that yields *null* result, i.e., producing practically no phenomenon or effect. This ***negative*** (or ***silent/null-result***) experiment is nearly always a sign of failure of any theory under scrutiny. For me, such an experiment is in itself a huge success, at least if only to the extent it leads to the revision or refutation of theory under review or investigation. Therefore, *pace* Hacking, an experiment that does not create a phenomenon may after all be repeatable, in the sense that we can try it again (with or without some modifications) to prove our case or position. But this may drag the paper too far into the semantics and pragmatics of "repeatability".

Meanwhile, let me consider briefly those conditions under which one may say that an experimentalist has failed to repeat his experiment. One may regard it as an experimental failure when there is a huge disparity between the first calculable result and the second one. But some means can be devised in such cases to forcefully bridge or reduce the gap. At other times experimental or observational failure may not result from inability to produce a phenomenon but from the production of varied or inconsistent phenomena. A very handy example of this is the mighty telescope with a 6 feet aperture mirrors used by the Birr Castle astronomers (under the leadership of Rosse) in the first-half of the nineteenth century. In this particular case, the hope of replication was later discovered as untenable, because of apparent inconsistency of phenomena (resulting from certain aberrant feature of the lenses). In "Observations of Nebula", C. Parsons reports:

> Every time the speculum [i.e., aperture mirror] is removed from the tube and re-polished, the old figure, whether it be good or bad, is lost in the process, and a new one formed, whose merits in no way depend on those of the last, and the telescope, though in mechanism the same, is optically speaking a new one (Gooding, Pinch, & Schaffer 1989, p.113).

By way of comparison, incidents like these are not strange in experimental laboratories. It takes the technical skills of the creative experimentalist to hit the pivot of instrumental functionality and to judge the *mean* of accuracy in experimental design and/or instrumental set up. More so, it is part of the technique of the experimental trade to distort experimental set up and design: some times to fine-tune the instrument and at other times to vary the situation or condition of experiment. When a consistent phenomenon appears with minor or desired distortions, then the possibility of repeatability is guaranteed. On the on other hand, if the distortion is so bizarre or extraordinary, then reliability of such an experiment cannot be seen as possible. As it stands, in this case the experiment has *failed* not for

want of phenomenon but for a plentitude of phenomena. Once more, it is not always the case that an experiment which "is not repeatable has failed to create a phenomenon". Hacking cannot negotiate a recovery by insisting that he meant the failure to create a consistent and specific phenomenon. If he brings in *specificity* then it is quite a different case; but his words do not portend any such meaning, even though this meaning may be loosely read into it. His undoing is the indefinite article (***a***) he prefixed to "phenomenon".

But, then, let us get to a more radical and ironic position adopted by Hacking. More like in an unconscious drift, Hacking shovels in this startling idea that "no one ever repeats an experiment". Even in experiments that require measurements where several determinations or recordings are made and averaged out, "what is called for" in that domain "is a better experiment, not repetitions of less good trials on less good equipment" (Hacking 1983, p.231). Subsequently, Hacking invokes K. D. Froome and L. Essen's statement – in their discourse on *The Velocity of Light and Radio Waves* – to buttress his point. They wrote:

> We would repeat our philosophy of experimental measurement. The most important objective should be to increase the precision of measurement so that systematic errors can be measured and eliminated. Experience shows that extensive averaging process invariably leaves unsuspected systematic errors in the result. We see no advantage in taking a vast number of measurements as was done in the classical optical method and in some of the recent determinations. We also regard it as unsound to take the standard deviation of the mean instead of that of a single observation as residual systematic errors are not reduced by taking more measurements (Hacking 1983, pp.231-232).

This shows that Froome and Essen are seasoned and meticulous experts. They are not oblivious of the devious ***blind-double*** in any attempt to

replicate an experiment. Once there are systematic errors (still locked) in an experimental instrument, trying to repeat experiment several times over in order to cancel the error by way of probability calculus makes no sense. To be sure, elimination of errors is always a matter of gradual process as Hacking says:

> Typically serious repetitions of an experiment are attempts to do the same thing better – to produce a more stable, less noisy version of the phenomenon. A repetition of an experiment usually uses different kinds of equipment. There are cases from time to time when people simply do not believe an experimental result and skeptics try again (1983, p.231).

This reveals that Hacking is fully aware of the pragmatics of the conception of *repeatability.* Yet in spite of all his arguments against repeatability of experiment, Hacking never expressly took the absurd Heraclitian path of insisting that, in principle no experiment can be repeated since no one can step into the same river twice. This simple lesson could be gleaned from Karl Popper (kingpin hypothetico-deductivist), say, that experiments can actually (i.e., in practice) be repeated, at least for the purposes of criticism. Criticism is essentially at the foundations of the growth of scientific knowledge, for Popper. To that effect, *criticism* becomes a methodological *sine qua non* in the scientific enterprise. Therefore, if scientific experiments are not actually repeatable, then modern empirical science cannot in real terms be said to be *discursive,* hence criticism will not have any place in science. This does not in any way detract from Popper's staunch fallibilist position which holds that one crucial experiment is enough to knock-off any given theory. Carrying out further experiments adds little or nothing to the effects of crucial experiments. But as Hilary Putnam would tell us, "Things once refuted don't stay refuted forever" (Magee 1978, p.198).

For the inductivist, it is the trend that an experimentalist should run several preliminary trial experiments or test runs. The more *ad nauseam* or umpteen times a particular type of experiment is conducted, the more credible and

valuable it becomes. Of course, such quantitative piles of repeated experiments are prevalent or prominent in college classrooms or laboratories. However, Hacking argues that, "The point of those classroom exercises is never to test or elaborate the theory. The point is to teach people how to become experimenters – and to winnow out those for whom experimental science is not the right career" (1983, p.231).

Unfortunately, it is not in my place here to take sides with any of the two popular theories of experiment, say fallibilist (hypothetico-deductivist) or inductivist (generativist/verificationist) theory. My primary interest has been to properly expose the idea of repeatability of experiment so as to ascertain its very nature and consequences and then to put African experimental science in proper perspective. Africans must learn from Hacking and, of course, his arch defender, Allan Franklin who argues that, "In some recent work, Colin Howson and I [1984] have discussed why 'different' experiments give more confirmation of an hypothesis than repetitions of the 'same' experiment" (1986, p.383). Henceforth, repetition of a scientific experiment does not imply, for Hacking, doing the same experiment in the same way, over and over again.

Disentangling African Science from Western criticisms

Against the claim of non-repeatability: the African science I conjecture is completely founded on the principle of "K' ihe emere n'ere" – "Let *that* which is performed be effective" – i.e., on Hacking's principle of causal effects (causalism), and creation of phenomena (or effects, in a more specialized term). As Hacking stipulated, a phenomenon is repeatable; in fact, it is "the landmark and pitch of every successful experimental demonstration" (Emedolu 2010, p. 52). Therefore, if African experimental science can create a phenomenon, then it is repeatable and, as such, very discursive.

Furthermore, some scholars assert that African science lacks the quality of *truth* because some of its propositions are superstitious, erroneous and unverifiable. But this smacks of naivety and can be deconstructed with ease.

Ernest Nagel (a logical empiricist) and his associate, Morris Cohen, have a better understanding of the core disposition of western science. They rightly maintain that, "it is an error to suppose as is often done, that science denies the truth of all unverified proposition" (Burr & Goldinger 1992, p.494). In African science verification belongs to the initiates. One baffling thing is that the western scientist believes in the bond of shared values within the scientific community and will not allow untrained personnel to referee his paper. But when it comes to African science, Western scholars often feel that everybody should be given the carte-blanche to nose into the affairs of the African scientist – expert or no. What double standard! Say what some such naive scholars may, the evidence of the senses shows that African experimental science can be rested on a sure pragmatic and verifiable ground.

An anecdote is contained in the literature, *African Witchcraft is not for Sale,* wherein a certain African steward (to an imperial/colonial master) rushes off into the bush on the spur of the moment to pluck some herbal remedy for convulsion to treat his master's child who has an attack. Incidentally, the child is made well again. But, then, the colonial master feels that his inability to elicit the formula from the Negro steward shows that the steward cannot explain anything nor repeat the same process if an urgent need arises once more (Emedolu 2010, p.60). Pretty clearly, this is a wrong attitude towards the African, his sensibility and mentality. It is pure *interpretatio Greca* (or *imperia* as it were): a typical misunderstanding of the open and secret gnosis or wisdom available to the African in his traditional milieu. Speaking generally, African reality is not so much a mystical and blind one. What the African steward did is not much different from what the western man calls protection of intellectual/patent/copy right. Without fear of contradiction, the western mind knows that some knowledge must be kept secret and not exposed to non-initiates. The list of some such specialized knowledge is endless. Consequently, it is the partial knowledge of what the African man does that always brings about the notion of non-discursive nature of African science.

Teleportation or the "ekiri" phenomenon is one perfect and commonplace example of how perfect experiment can be conducted. Some may call it a product of shamanism or pure demonism; but it is not. It has its own experimental design and instrumental set up. Everything must be put and kept in the right proportion or position. Otherwise, there would be null-result and/or disastrous consequences, namely the bleaching or burning of the skin, or even death. Of course, I have given a detailed account of the witch-doctor who got seriously wounded while trying out what he called "little experiment" on teleportation (Emedolu 2010, pp.56-57). The Dadaist, Paul Feyerabend, equally praises telekinesis in no uncertain terms when he declares thus:

> We have learned that there are phenomena such as telepathy and telekinesis which are obliterated by a scientific approach and which could be used to do research in an entirely novel way (earlier thinkers such as Agrippa of Nettesheim, John Dee, and even Bacon were aware of these phenomena). Phenomena such as telekinesis and acupuncture may eventually be absorbed into the body of science and may therefore be called 'scientific'. But note that this happens only after a long period of resistance during which a science not yet containing the phenomena wants to get upper hand over forms of life that contain them (qtd. Hacking 1981, p.161).

The question of *replication* or *repeatability* of experiment is very much connected to philosophical discourse on *validity* of scientific experimental results. As such, it is a very important factor in determining a mature scientific investigation that has long passed the level of mere speculative hunch and hypostatization. Put in a more technical way, replication of experiment has often been conceived as a mechanism for validation of experimental results and guarantor of theoretical ideas or postulations. Now, African science may not have any well-formed theories, but this is not to insinuate that its investigations could not clearly be repeated or

replicated. What one needs to know is whether these assertions are right or not.

Every experimental demonstration within the African context can be replicated. As it stands, even ordinary beasts in the forest know in a very pathological way that they can always try out any process that guarantees their chances to finding more food and survival. The now familiar rat-in-a-maze experiment simply confirms this position. Having gleaned much from the foregoing and having established the fledgling facticity of African experimental science, one is now left with the task of suggesting ways of improving and perfecting the stride of African science.

The Necessity of instrumental upgrade in African Science

Given the rational Newtonian purport that things happen in such a repetitive manner (**regularity in nature**), one tends to see in theoretical schemes of African experimental science the same regularity (in the form of "K'ihe emere n'ere"). Some entities must be responsible for this in the experimental order. But my task here is not so much to discourse the functionality or types of theoretical entities in African science as to look at instrumentation in science.

Meanwhile, technology entered into modern science by way of instrumentation. Technology began with simple tools and reached its sophisticated heights in computer technology. Most technological instruments were crafted not specifically for experimental purposes, but for certain useful ends in man's day-to-day living.

In its evolutionary progress science (with its empirical approach to nature) discovered more and more the need to deploy technological instruments in its investigations and mastery of reality. In point of fact, science and technology did contrive the most perfect union in the seventeenth-century for mutual help. This means that technology came in full swing to supply science with instrumental aids for better and more enriched experimental research, which end result brought about rapid and accelerated advancement in modern technology. Put crudely, technology supplied

science with necessarily instruments to further sophisticate itself. Even in our time both science and technology are still benefitting from the marriage. Thus far, my task is to broadly look at the characteristic types of instruments used scientific investigations. This will certainly spur one to look at the entire gamut of the history of science, so to learn better how it stands with instrumentation in the long history of science. One pertinent thing that needs to be said about scientific or experimental instruments is that, instruments resolve themselves into various types. Hackmann broadly distinguishes them as *passive* or *observational* instruments and *active* or *phenomena-interactive* instruments; but he equally emphasizes that, "as trade in scientific instruments developed in the eighteenth century the makers distinguish between *mathematical*, *optical*, and *philosophical* instruments" (Gooding, Pinch and Schaffer 1989, p. 42). Jim A. Bennett confirms this categorization, in "A Viol of Water or a Wedge of Glass," when he says that, "from the seventeenth century instruments were conventionally classified into mathematical, optical and natural philosophical types" (Gooding, Pinch and Schaffer 1989, p. 105). The only disparity in the two accounts is that whereas Hackmann places the division at the eighteenth century, Bennett takes it to the seventeenth century. The most important thing is that their instrumental types tally with each other's categorization. On his own view, Harré classifies experimental instruments into three kinds. He writes:

> There is equipment for making measurements: clocks, meters, graduated rules and so on. Then there is the apparatus for extending the human senses: microscopes, telescopes, amplifiers, stethoscopes etc. But at the heart of the experiment is the equipment that enables an experimenter to isolate the effect he wishes to study and to separate the possible causes of it (Harré 1981:18).

Now, looking critically at Harré's own classification, one cannot fail to see the similarity with the previous categorizations. His measuring instruments correspond to the classical modern mathematical instrument; his sense-

extending instruments, like microscope and telescope, resolve themselves into classical optical instruments; and his instruments that enable the experimenter to isolate effects can be no other than the classical philosophical instruments. The only difference is that his sense-extending instruments go beyond the optical to include the acoustic, the tactile, etc. Though one may not be sure, the classical use of the term "optical" may, after all, be quite representative.

But whatever the class of instruments, it must be noted that all instruments must be constructed or designed in such a way that they should conform to the bounds or limits of human sensory faculties. Instruments may be quantitatively, mathematically or statistically designed; they may conform to the dictates of qualitative analysis; they may be optically designed to render photographic or live images; and they may be designed to serve the acoustic, tactile, olfactory, etc., sensibilities of man. But generally, in the design of any sophisticated experiment, using active or philosophical instruments, there is always a room created for the manipulation of variables – both *dependent* and *independent* variables. In fact, Harré hints at this when he explains:

> By careful design of an experiment it is possible to maintain constant all properties except those one wishes to study, the dependent and independent variables. A property, which is fixed in this way is called a 'parameter'. Fixing the parameters defines the state of the system within which the variables are to act…
>
> The need to separate the variable and to fix parameters seriously restricts the use to which experiments can be put. There are many phenomena, particularly in the world of human action, in which the practical separation of variables and parameters cannot be managed (1981:16).

This implies that the fixing of parameter sets the limits to which certain experimental setup could go. In the saturated vapour pressure experiment,

for instance, the parameter circumscribes variables like temperature and pressure. In the experiment, the volume of the liquid must be kept constant. While the saturated vapour pressure (Mm Hg) is dependent variable, the temperature (^{o}C) is the independent variable in the whole experimental series. Simply put, the temperature may be varied at will, and the outcome ultimately demonstrates that increase in temperature leads to a concomitant increase in pressure. However, Harré comments that this manner of stereotype control experiment may work in the natural or physical sciences but may not be always feasible in the social sciences. This is precisely because man is quite different from other objects/entities/denizens of reality.

Be that as it may, I need to talk a little more concerning the philosophical instruments. They play "the active role… in the exploration of nature". Joseph Priestley, in *The History and Present State of Electricity, with Original Experiments* (1775), describes philosophical instruments as those, which lead to scientific discovery. Bennett speaks on the historical emergence, certification and nature of the philosophical instruments thus:

> The instruments of natural philosophy raised further problems of definition. They were not optical, but were certainly related to natural philosophy rather than mathematical science; indeed some, like the air pump and the electrical generator, manipulated the natural world in an unprecedented way. Until the eighteenth century, unlike the mathematical and optical instruments, they had no clear craft location. Once this came, and the most entrepreneurial makers began to describe themselves as dealing in 'mathematical, optical and philosophical instruments,' they were using a classification which had been fashioned by the developments of the previous century, which reflects important intellectual and craft distinctions, and which historians must, therefore, be careful to preserve (Gooding, Pinch and Schaffer 1989:108).

Currently, the computer has become the philosophical instrument *par excellence*. In its various aspects and applications, it has become the veritable explorer and discoverer of nature. Today, the computer technology even enters into the ghostly depths of quantum or particles physics. With fibre updates and new technologies science has almost reached the apex of instrumental design in its experimentation.

Despite the progress registered over time in instrument making, the American philosopher, E. M. Mackinnon, clearly asserts that Albert Einstein supposed that,

> …the phenomena observed through our instrument must be explained through the underlying reality objectively responsible for the phenomena. The only way of representing such an underlying physical reality that has any hope of success is through mathematical forms that are simple, natural and aesthetically pleasing (Gribanov 1987:13).

Strictly speaking, Einstein remains correct in his supposition. Any time an experimenter is conducting an experiment he must be able to announce the sort of entity that is enabling his instrument to create a certain phenomenon. This is where the African scientist fails. Most of his instruments look very antiquated, crude and scary. He may not be able to point out any entity responsible for any given phenomenon, for it does appear he is always dealing with paranormal situation. But confronting any paranormal situation is not a problem. After all the teleportation machine fabricated by quantum instrument makers has shown clearly how Einstein's so-called spooky action at a distance is possibilized through the principle of quantum entanglement, which clearly explains the phenomenon of non-locality. This is exactly the direction I wish African experimental scientists to follow.

Conclusion

Having considered Hacking's view on repeatability of scientific experiment, and having tried to defend African science against some Western criticisms, I arrived at the urgency of improving on the crude instruments flaunted by most traditional African scientists. I believe that this is very important if African science would remain a formidable force in unveiling reality to the scientific world. It is not enough, though, for an African scientist to say that he can engage nature through the use of some scientific instruments.

The most important thing is for him to know the sort of entities he is manipulating. I say this because the issue of theoretical entities lies at the very heart of experimental manipulation. Whatever the design of experiment, whatever the type of instrument, ***art*** is constantly brought to an intimate interaction with certain entities of nature. Perhaps it is because real entities are exploited that every genuine phenomenon-creating experiment is repeatable. Admittedly, the paper did not focus on theoretical entities, precisely because of its pivotal importance in experimental discourse. Be that as it may, the utmost lesson of this paper remains that through learning from the state of affairs in the use of scientific instruments in Western science, Africans may become better-off on how to re-organize their own scientific or occult/magical/witchcraft practices as some are wont to call it.

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