A HERMENEUTIC CONSIDERATION OF KARL POPPER'S FALSIFICATION THEORY.

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ABSTRACT

Karl Popper a scientist, mathematician and philosopher was deeply concerned with a theory that can distinguish science from non-science as well as developing a principle for deciphering truth in science. He rejected the verification principle of meaning because it does not adequately demarcate scientific statements from non-scientific statements, especially metaphysical, ethical, and theological statements. The outcome of this rejection is the formulation of the falsification theory. Karl Popper did not accept the general belief that science uses an inductive method to arrive at the truth because any experiment carried out in this manner is tentative. Hence, the procedure can only result in probability and never in truth; therefore inductive generalization is not justified. To show his contempt for induction, he argued that the theory of falsification should be used to test the truth of hypotheses and theories. The theory emphasizes that a scientific statement or theory is true if and only if it can be tested and conceivably proven false. Using a hermeneutic approach, the objective of this research is a continuous engagement to discuss the inherent problem of Popper's verification principle, show why Popper rejected it and why he introduced the theory of falsification as an alternative.

Keywords: Falsification, Inductivism, Verifiability, Hermeneutic and Theory

INTRODUCTION

Science and philosophy have always worked together to try to uncover truths about the universe we live in. Indeed, ancient philosophy can be understood as the originator of many of the separate fields of study we have today, including psychology, medicine, law, astronomy, art, and even theology. Scientists design experiments and try to obtain results verifying or disproving a hypothesis, but philosophers are interested in understanding what factors determine the validity of scientific endeavors in the first place. While most scientists work within established paradigms, philosophers question the paradigms themselves and try to explore our underlying assumptions and definitions behind the logic of how we seek knowledge. Thus, there is a feedback relationship between science and philosophy and sometimes plethora of tension and dichotomy.

Scientific method is procedural, that is, it adheres strictly to lay down principles through which an objective knowledge is obtained. (Ezebuilo, 2019: 14) conceives science as “the systematic enterprise of gathering knowledge about the universe by organizing and condensing that knowledge into testable laws and theories. These laws and theories are used to give explanations to natural occurrences and make further predictions about the future." It is widely accepted that empirical science is that discipline that employs inductive methodology in the formulation of hypotheses or theories by observing a limited number of instances. Induction therefore, is accepted by some philosophers as a valuable method and practice in the scientific enterprise. It was this method of doing science that Popper saw as problematic because, it relied on the problematic principle of verifiability for the determination of its truth.

The verifiability theory states that statements are cognitively significant or empirically tested if they can be conclusively verifiable by experience. Popper rejected this inductivists' criterion of truth because it does not adequately provide a distinguishing feature between scientific and non-scientific statements and on the reason that a theory can never be proven to be true by accumulating more and more positive observations. Hence, he postulated the falsification theory as a better alternative for determination of science from non-science. The falsification theory states that a statement is meaningful or scientific if it is falsifiable by experience or observation. It asserts that for any hypothesis to have credence, it must be inherently disprovable before it can become accepted as a scientific hypothesis or theory.

For example, someone might claim "the earth is younger than many scientists state, and in fact was created to appear as though it was older through deceptive fossils etc." This is a claim that is un-falsifiable because it is a theory that can never be shown to be false. If you were to present such a person with fossils, geological data or arguments about the nature of compounds in the ozone, they could refute the argument by saying that your evidence was fabricated to appear that way, and is not valid. Importantly, falsifiability does not mean that there are currently arguments against a theory, only that it is possible to imagine some kind of argument which would invalidate it. Falsifiability says nothing about an argument's inherent validity or correctness. It is only the minimum trait required of a claim that allows it to be engaged with in a scientific manner. This paper will therefore, be concerned with the critical examination of Karl Popper's falsification theory.

Karl Popper's Rejection of Verifiability Criterion

After Francis Bacon's exposition in Novum Organum, inductivism as a theory of scientific method had been embraced by major scientists and philosophers of science for a few centuries. "Sir Isaac Newton's discoveries of the law of gravity and the three laws of motion in the eighteenth century, and the Vienna Circle's fierce attack on metaphysics in the early twentieth-century were all essentially based upon inductivism" (Friedman, 2013: xii). However, as the history of science always show, inductivism was eventually challenged by such critics as Karl Popper and Pierre Duhem as significantly inadequate, if not at all false. Popper, in particular, proposes falsificationism, his own alternative to inductivism, as both a theory of scientific method in response to conventional science, and a criterion for demarcating science from pseudo-science in response to verificationism. According to Popper (2002:34), "inductivism misleadingly represents scientific discovery as a rational process, during which scientists are able to follow some underlying logic."

Besides, inductivism also fails to offer a legitimate justification for its own principle. Instead, Popper's falsificationism replaces logical observation and justification with irrational conjecture and logical refutation. Furthermore, in terms of the problem of demarcation, the Vienna Circle, depending on inductivism, argued that the sole criterion should be verifiability. Against this idea, Popper's falsificationism follows the opposite line of thought and argued that the scientific attribute is contingent upon the fact that statements, hypotheses, and theories bear the risk of being falsified. On balance, according to Thornton, (www.stanford-encylopedia-of-philosophy.com/karlpopper: 12-05-2021): "Popper's falsificationism indeed represents a leap forward from inductivism and verificationism; nevertheless, it is not without its own shortcomings, on the basis of which several objections can be made."

The basic idea of inductivism is that science starts with observations, and moves on from them to generalizations (laws and theories), and predictions. In fact, inductivism as a theory of scientific method goes back to Francis Bacon. In Novum Organum, Bacon made it clear that "basic research in natural sciences would reveal all kinds of unknown phenomena which could be used as the basis for new technologies" Robertson (2011:36). When it comes to how scientific researches should be conducted, Bacon offered two possible methods. On the one hand, "there is what he refers to as "the anticipation of nature, meaning that scientists should have hypotheses ready in hand before empirical experiments and data collections. On the other hand, there is also the interpretation of nature, which means that scientific hypotheses should be arrived at after empirical experiments and data collections" (Robertson, 2011: 40). Robertson argued that "the former is actually a bad conjecture based on rash and premature speculation, and the appropriate method of scientific research should follow the latter, which is essentially the spirit of inductivism." That is to say, conjectures based on the logic of induction, or inductive inferences, should be regarded as scientific inferences that will (in principle) lead to scientific discoveries.

Various examples in the history of science, especially Kepler's discovery based on the careful observation of Tycho Brahe that planets move in ellipses with the Sun at one focus, seem to support the legitimacy of inductivism and inductive inferences. Later thinkers, such as Bertrand Russell, further developed the idea of inductivism and offered justifications for inductive inferences. According to Russell, there are such concepts as the uniformity of nature and the principle of induction. The uniformity of nature, which Russell originally thought to be the underlying premise of induction, is the belief that "everything that has happened or will happen is an instance of some general law to which there are no exceptions" (Robertson, 2011:40).

However, Russell soon realized that it is rather probability than certainty that should be sought in induction, which led to his famous formulation of the principle of induction, he said:

> When a thing of a certain sort A has been found to be associated with a thing of a certain other sort B, and has never been found dissociated from a thing of the sort B, the greater the number of cases in which A and B have been associated, the greater is the probability that they will be associated in a fresh case in which one of them is known to be present; Under the same circumstances, a sufficient number of cases of the association will make the probability of a fresh association nearly a certainty, and will make it approach certainty without limit (Bertrand, 2010:251).

Hence, Russell, similar to David Hume, justified inductivism by distinguishing scientific induction, which aimed at probability, from scientific deduction, which aimed at certainty. In a nutshell, the inductivists think that scientific discovery "proceeds by first collecting observations or data and then inferring laws and predictions from this data by induction" (Bertrand, 2010: 253). Although, this view was embraced by many, Karl Popper nevertheless saw the inadequacy of inductivism and offered his criticisms. To begin with, against the inductivists view that science begins with empirical observations, Popper argued that one cannot simply observe without a theoretical background; instead, "observation is always selective, and it needs a chosen object, a definite task, an interest, a point of view, a problem" (Bertrand, 2011:253). In other words, it is impossible to have theory-neutral observations, and any observations that are devoid of theoretical background are simply meaningless. Therefore, inductivism that embraces random observations as the beginning of scientific discovery is counter-intuitive.

However, according to Popper, there is an asymmetry between verification and falsification, which means that "although observations and deductive logic cannot establish the truth of a scientific generalization (or verify it), they can establish its falsity (or refute or falsify it)" (Popper, 1959:45). Therefore, adequate testing of theories and statements require attempted criticisms and refutations rather than verifications. In order to illustrate more clearly Popper's criticism of verificationism, it is helpful to proceed to Popper's criticism of verifiability as a demarcation criterion. Popper's falsificationism is not only a theory of scientific method but also a criterion of demarcation between science and pseudo-science. Based upon inductivism, previous philosophers of science applied verifiability according to observation and experiment as the sole criterion in demarcating scientific theories from metaphysical theories. An especially notable example is the Vienna Circle and its fanatic advocate of verificationism as well as fierce accusation of metaphysics as meaningless. Popper, on the other hand, argues that "the criterion of verifiability is in fact inadequate, and that falsifiability is a better demarcation criterion to distinguish between science and pseudo-science" (Popper, 2002:126).

In general, Popper maintained that the major problem with verificationism as a demarcation criterion is that "it did not exclude obvious metaphysical statements; but it did exclude the most important and interesting of all scientific statements, that is to say, the scientific theories, the universal laws of nature" (Popper, 2002:126).

Relatedly, verificationism failed in two respects. On the one hand, it failed to exclude some genuinely metaphysical statements. The reason for this is that verificationism essentially regards verifiability, rather than actual verification, as the line of demarcation. However, there are many verifiable statements, such as existential statements, that are also genuinely metaphysical. For instance, statements from Sigmund Freud's psycho-analysis and Alfred Adler's individual psychology have powerful explanatory power that makes them both verifiable in most cases. However, for Popper, they have "in fact more in common with primitive myths than with science, that they resemble astrology rather than astronomy" (Bird, 1998:67). On the other hand, verificationism also failed to include some genuinely scientific statements. The reason, according to Popper, is that theories are never empirically verifiable. Therefore, verificationism as the sole criterion of demarcation is inadequate. Falsifiability as a demarcation criterion, on the other hand, dealt with the above two problems more successfully. By maintaining that "testability is falsifiability," Popper regarded any theories that are not falsifiable, that is, not refutable by any conceivable event, as non-scientific.

This way of thinking makes positive use of the asymmetry between verification and falsification, and consequently works better to exclude pseudo-science and include science. To use Popper's own examples, the virtue that astrology and the two psycho-analytic theories have verifiable explanatory power would help them to be included as genuine sciences if following the criterion of verifiability. However, once falsifiability is adopted, their virtue becomes precisely their vice, because the impossibility of being refuted excludes them from the scientific domain.

Once falsifiability is adopted as the criterion of demarcation, it naturally follows that a scientific theory should in principle be able to produce bold predictions that bear the risk of being refuted and falsified later.

Karl Popper's Falsification Theory

Popper's early work attempted to solve the problem of demarcation and offer a clear criterion that distinguished scientific theories from metaphysical or mythological claims. Popper's falsificationist methodology held "that scientific theories are characterized by entailing predictions that future observations might reveal to be false" (Popper, 1957: 67). When theories are falsified by such observations, scientists can respond by revising the theory, or by rejecting the theory in favor of a rival or by maintaining the theory as is and changing an auxiliary hypothesis. In either case, however, this process must aim at the production of new, falsifiable predictions. While Popper recognized that scientists can and do hold onto theories in the face of failed predictions when there are no predictively superior rivals to turn to. He held "that scientific practice is characterized by its continual effort to test theories against experience and make revisions based on the outcomes of these tests" (Popper, 1957: 67). By contrast, theories that are permanently immunized from falsification by the introduction of untestable ad hoc hypotheses can no longer be classified as scientific. Among other things, Popper argued that his falsificationist proposal allows for a solution of the problem of induction, since inductive reasoning plays no role in his account of theory choice. It is worthy to underscore here that Popper's theory is prescriptive, and described what science should do and not how it actually behaves. He argued that science would best progress using deductive reasoning as its primary emphasis. His point is that, no matter how many observations are made which confirm a theory, there is always the possibility that a future observation could refute it.

Induction cannot yield certainty. Popper also argued that all observation is from a point of view, and indeed that all observation is colored by our understanding. The world appears to us in the context of theories we already hold, hence, it is theory-laden. Popper proposed an alternative scientific method based on falsification. For Popper, scientist should attempt to disprove his/her theory rather than attempt to continually prove it. Karl Popper believed that science can help us progressively approach the realm of truth but, we can never be certain that we have the final explanation.

Critique of Popper's Falsification Theory

While Popper's account of scientific methodology has continued to be influential, it has also faced a number of serious objections. These objections, together with the emergence of alternative accounts of scientific reasoning, have led many philosophers of science to reject Popper's falsificationist methodology. One criticism of falsificationism involves the relationship between theory and observation. Gray (2013:11), among others, argued that "observation is itself strongly theory-laden, in the sense that what one observes is often significantly affected by one's previously held theoretical beliefs" (Because of this, those holding different theories might report radically different observations, even when they both are observing the same phenomena. For example, Kuhn (2002:34), argued that "those working within the paradigm provided by classical, Newtonian mechanics may genuinely have different observations than those working within the very different paradigm of relativistic mechanics." Popper's account of basic sentences suggest that he clearly recognizes both the existence of this sort of phenomenon and its potential to cause problems for attempts to falsify theories. His solution to it, however, crucially depends on the ability of the overall scientific community to reach a consensus as to which statements count as basic and thus can be used to formulate tests of the competing theories.

This remedy, however, looks less attractive to the extent that advocates of different theories consistently found themselves unable to reach an agreement on what sentences count as basic. For example, it is important to Popper's example of the Eddington experiment that both proponents of classical mechanics and those of relativistic mechanics could recognize Eddington's reports of his observations as basic sentences in the relevant sense that is, certain possible results would falsify the Newtonian laws of classical mechanics, while other possible results would falsify the one relative mechanic. If, by contrast, adherents of rival theories consistently disagreed on whether or not certain reports could be counted as basic sentences, this would prevent observations such as Eddington's from serving any important role in theory choice. Instead, the results of any such potentially falsifying experiment would be interpreted by one part of the community as falsifying a particular theory, while a different section of the community would demand that these reports themselves be subjected to further testing. In this way, disagreements over the status of basic sentences would effectively prevent theories from ever being falsified.

This purported failure to clearly distinguish the basic statements that formed the empirical base from other, more theoretical, statements would also have consequences for Popper's proposed criterion of demarcation, which holds that scientific theories must allow for the deduction of basic sentences whose truth or falsity can be ascertained by appropriately located observers. If, contrary to Popper's account, there is no distinct category of basic sentences within actual scientific practice, then his proposed method for distinguishing science from non-science failed. A second, related criticism of falsifiability contends that "falsification fails to provide an accurate picture of scientific practice. Specifically, many historians and philosophers of science have argued that scientists only rarely give up their theories in the face of failed predictions, even in cases where they are unable to identify testable auxiliary hypotheses" (Kuhn, 1978: 42).

Conversely, it has been suggested that scientists routinely adopt and make use of theories that they know are already falsified. Instead, scientists will generally hold on to such theories unless and until a better alternative theory emerges. For example, Lakatos described a hypothetical case where pre-Einsteinian scientists discovered a new planet whose behaviour apparently violates classical mechanics. Lakatos (2009:37), argued that, "in such a case, the scientists would surely attempt to account for these observed discrepancies in the way that Popper advocates, by hypothesizing the existence of a hitherto unobserved planet or dust cloud" In contrast to what he takes Popper to be arguing, however, Lakatos contended that the failure of such auxiliary hypotheses would not lead them to abandon classical mechanics, since they had no alternative theory to turn to. In a similar vein, Lakatos (2009:85).argued "that the initial widespread acceptance of Newtonian mechanics had little or nothing to do with falsifiable predictions, since the theory made very few of these. Instead, scientists were impressed by the theory's success in explaining previously established phenomena, such as the orbits of the planets and the behavior of the tides."

Hacking argued that "many aspects of ordinary scientific practice, including a wide variety of observations and experiments, cannot plausibly be construed as attempts to falsify or corroborate any particular theory or hypothesis. Instead, scientists regularly perform experiments that have little or no bearing on their current theories and measure quantities about which these theories do not make any specific claims" Lakatos, (2009 :

85). When considering the cogency of such criticisms, it is worth noting several things. First, it is worth recalling that Popper defended falsificationism as a normative, methodological proposal for how science ought to work in certain sorts of cases and not as an empirical description intended to accurately capture all aspects of historical scientific practice. Second, Popper does not commit himself to the implausible thesis that theories yielding false predictions about a particular phenomenon must immediately be abandoned, even if it is not apparent which auxiliary hypotheses must change. This is especially true in the absence of any rival theory yielding a correct prediction. For example, Newtonian mechanics had well-known problems with predicting certain sorts of phenomena, such as the orbit of Mercury, in the years preceding Einstein's proposals regarding special and general relativity. Popper's proposal does not entail that these failures of prediction should have led nineteenth century scientists to abandon this theory. This being said, Popper himself argued that the methodology of falsificationism has played an important role in the history of science and that adopting his proposal would not require a wholesale revision of existing scientific methodology. If it turns out that scientists rarely, if ever, make theory choice on the basis of crucial experiments that falsify one theory or another, then Popper's methodological proposal looks to be considerably less appealing.

A final criticism concerns Popper's account of corroboration and the role it plays in theory choice. Popper's deductive account of theory testing and adoption posited that it is rational to choose highly informative, well-corroborated theories, even though we have no inductive grounds for thinking that these theories are likely to be true. For example, Popper explicitly rejected the idea that corroboration is intended as an analogue to the subjective probability or logical probability that a theory is true, given the available evidence. This idea is central to both Popper's proposed solution to the problem of induction and to his criticisms of competing inductivism. Many philosophers of science, however, including Salmon, Jeffrey, Howson and Urbach, have objected this aspect of Popper's account. One line of criticism has focused on the extent to which Popper's falsification offered a legitimate alternative to the inductivist proposals that Popper criticized. For example, Jeffrey (https://doi.org/10.1007/BF00485298: 18-05-2021), pointed out that "it is just as difficult to conclusively falsify a hypothesis as it to conclusively verify it, and he argues that Bayesianism, with its emphasis on the degree to which empirical evidence supports a hypothesis, is much more closely aligned to scientific practice than Popper's program." A related line of objection has focused on Popper's contention that it is rational for scientists to rely on corroborated theories, a claim that played a central role in his proposed solution to the problem of induction. Urbach (1996:117), argued that, "insofar as Popper is committed to the claim that every universal hypothesis has zero probability of being true, he cannot explain the rationality of adopting a corroborated theory over an already falsified one, since both have the same probability (zero) of being true." Taking a different tack, Urbach (1996:121), questioned whether, "On Popper's account, it would be rational to use corroborated hypotheses for the purposes of prediction. After all, corroboration is entirely a matter of hypotheses' past performance—a corroborated hypothesis is one that has survived severe empirical tests."

Popper's account, however, did not provide us with any reason for thinking that this hypothesis will have more accurate predictions about the future than any one of the infinite numbers of competing uncorroborated hypotheses that are also logically compatible with all of the evidence observed up to this point. If these objections concerning corroboration are correct, it looked as though Popper's account of theory choice is either vulnerable to the same sorts of problems and puzzles that plague accounts of theory choice based on induction or it does not work as an account of theory choice at all.

CONCLUSION

Scientific research is a critical tool for successfully navigating our complex world but this will not be possible without a method because, we would be forced to rely solely on intuition, other people's authority, and blind luck.

While many of us feel confident in our abilities to decipher and interact with the world around us, history is filled with examples of how very wrong we can be when we fail to recognize the need for evidence in supporting claims. The goal of all scientists is to better understand the world around them. For many sciences, the idea of falsifiability is a useful tool for generating theories that are testable and realistic. Testability is a crucial starting point to design solid experiments that have a chance of telling us something useful about the phenomena in question. If a falsifiable theory is tested and the results are significant, then it can tentatively be accepted as a scientific truth. The advantage of Popper's idea is that such truths can be falsified when more knowledge, evidences and resources are available. Even long accepted theories such as Gravity, Relativity and Evolution are increasingly challenged and adapted.

Karl Popper made an important contribution and impact to philosophy of science. His falsifiability theory revealed and pointed out a lot of faults and problems that philosophers of science could not discover even though his analysis and definitions does not take into account the contributions of sciences that are observational and descriptive.

His idea is that no theory is completely correct, but if it can be shown both to be falsifiable and supported with evidence that shows it is true, then it can be accepted as truth tentatively. For example, Newton's Theory of Gravity was accepted as truth for centuries, because objects do not randomly float away from the earth. It appeared to fit the data obtained by experimentation and research, but was always subject to testing. However, Einstein's theory makes falsifiable predictions that are different from predictions made by Newton's theory, for example concerning the precession of the orbit of Mercury, and gravitational lensing of light. In non-extreme situations Einstein's and Newton's theories make the same predictions, so they are both correct. But Einstein's theory holds true in a superset of the conditions in which Newton's theory holds, so according to the principle of Occam's Razor, Einstein's theory is preferable. On the other hand, Newtonian calculations are simpler, so, Newton's theory is useful for almost any engineering project, including some space projects. But for GPS we will need Einstein's theory. Scientists would not have arrived at either of these theories, or a compromise between both of them, without the use of testable, falsifiable experiments. A theory that explains everything, explains nothing, so, instead of abandoning induction, abduction, deduction, Popper's hypo-deductionism or other models of explanation propounded by scientists and philosophers of science, it will be logical to apply those elements of strength in each of them for a worthwhile scientific endeavour, since no single method can account for all scientific activities. The tentative nature of scientific truth and its openness to revision warrants that the combination of different methods and principle will go a long way in improving the quality and standard of scientific research and progress its activities.

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References

Bertrand Russell, (2010). *Our Knowledge of External World as a Field for Scientific Method in Philosophy,* New York: Routledge.

Bird Alexander, (1998). *Philosophy of Science,* London: Routledge.

Boyd Richard, (2021). "Scientific Realism," Retrieved 21-05-2021 from www.stanford-encyclopedia-of-philosophy.com/scientific-realism.

Fayerabend Paul, (2010). *Against Method,* Third Edition, London: Verso Books.

Friedman C., (2013). *Reconsidering Logical Positivism,* Revised Edition. Chicago: Cambridge University Press.

Imre Lakatos, (2009). "Falsification and the Methodology of Scientific Research Programme," In *Criticism and the Growth of Knowledge*, Cambridge: Cambridge University Press.

Jeffrey Richard, (2021). "Probability and Falsification: A Critique of Popper's Program," Retrieved 18-05-2021 from https://doi.org/10.1007/BF00485298

J. M. Robertson, (2011). *The Philosophical Works of Francis Bacon,* New York: Routledge.

John Gray, (2013). "The Liberalism of Karl Popper," Journal of Life, *Liberty and Property*, vol II, No.9.

Hyginus Chibuike Ezebuilo,(2017). *Karl Popper's Theory of Piecemeal Social Engineering: An Analytic Approach*, Unpublished Doctorial Theses, in Nnamdi Azikiwe University, Awka.

Hyginus Chibuike Ezebuilo (2019), Popper's Piecemeal Engineering and Social Reform in Africa. International Journal of Advanced Engineering, Management and Science (IJAEMS) Vol, 5

Karl Popper, (2013). *Popper Selections*, Edited by David W Miller. Princeton: Princeton University Press.

Karl Popper, (1959). *The Logic of Scientific Discovery,* New York: Hutchinson & Company.

Karl Popper, (2002). *Conjectures and Refutations,* New York: Routledge.

Karl Popper, (2002). *Conjectures and Refutations*, Routledge Edition New York: Routledge Classics.

Martyn Shuttleworth, (2021). "Karl Popper Basic Scientific Principle," Retrieved 21-05-2021 from https://explorable.com/falsifiability.

Monk Ray, (1999). *Cambridge Philosophers XI: Bertrand Russell*, Cambridge: Cambridge University Press.

Nicholas Maxwell, (2011). *From Knowledge to Wisdom: A Revolution in the Aims and Methods of Science*, Fifth Edition, Oxford: Basil Blackwell Publishers.

Peter Urbach, "Is any of Popper's Arguments against Historicism Valid?" The British Journal for the Philosophy of Science 29 No. 2.

Salmon Wesley, (2010). The Foundation of Scientific Inferences, Reprinted (Pittsburgh: University of Pittsburgh Press.

Thomas Kuhn, (2012). *The Structure of Scientific Revolution, 3rd Edition* , Chicago: University of Chicago Press.

Thornton Stephen, (2021). "Karl Popper," Retrieved 12-05-2021 from www.stanfordencylopedia-of-philosophy.com/karlpopper