The Logic of Scientific Discovery

K.Popper

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This is the book that made Popper's reputation. Not the book which made him a reputation, that came later and did not have to do with Science but with Society - The Open Society and its enemies. The fame it brought him provided him with the fruit that fame is good for, namely the fruit of attention. His book from the thirties was translated into English and added to extensively. It provides a contrast to his more mature books on philosophy. It is more naive, more sincere and also more technical. It is the work of a young man trying to get attention, learning on the way, getting occasionally mired in irrelevant technicalities.

Popper was not of the Vienna Circle, he did not agree with the positivists program, on the other hand the philosophy of the positivists centered around the same problem which occupied him. Namely the problem of the demarcation of metaphysics from science. Thus he inevitably got to engage with them closely, and they agreed to publish a book of his. Philosophy outside this concern did not particularly interest him, in particular the concerns of so called continental philosophy he disdainfully rejected as mere gibberish. Thus hardly surprisingly they dismissed him in their turn as a mere positivist, an accusation he would deeply resent.

Popper rejects induction. For this he has received much criticism. To make sense of the notion of induction we need to consider the nature of knowledge.

There is standard division of knowledge, going back at least as far as Kant namely, into analytic and synthetic. Analytic knowledge is concerned with our own thought and the ways we cannot help but think. The ultimate characterization of analytic knowledge is one of mere tautologies. The one who has no access but to analytic knowledge is trapped in a small closed self-sufficient world. The implication is one of claustrophobia. Mathematics is conventionally thought of as a purely analytic endeavor, and hence ultimately according to Russell and Wittgenstein it reduces to tautologies. In mathematics we rely on deduction. Synthetic knowledge on the other hand is knowledge that goes beyond our own thoughts. It is knowledge about the real world out there. And the real world out there is infinite and full of surprises and appeals to our boundless curiosity and never will it ultimately disappoint us, there will always be new phenomena to discover. While the tool of analytic knowledge is deduction, that of synthetic is induction. Deduction allows us to go from the general to the specific, while induction allows us to go from the specific to the general. Thus while deduction never reveals any new knowledge, all of it is at least implicitly contained in the assumption, induction truly extends our horizons. And so is the conventional wisdom[1]

[1] Whether everything in a sense is implicit in the axioms and deduction does not reveal anything new, can of course be made true by a suitable definition of what is 'new' and what is the information content of axioms. But this is just an analytic stratagem, empiricism does enter into mathematics as well, although Popper was not really aware of it in the early 30's, and tended not to accord mathematics much interest.

There is of course a problem of induction, how do we justify it and how do we employ it in practice? The latter problem is more pressing while the former is more fundamental, but only through getting acquainted with the practical problem can we truly appreciate the first more philosophical. Induction means finding singular events and from them deducing a general universal rule. But how do we go about it? How do we formulate a general rule given singular events? In fact just as to ever finite sequence of numbers there are an infinite number of rules which produce them, to every set of data we can in principle concoct an infinite number of theories which predict them. Conversely say that a simple and obvious rule has been found, how can we verify it? We need to do so if induction will serve the same role in the synthetic category as deduction does in the analytic, in short if induction should serve as an epistemological tool. If you think about it seriously you realize that any definite answer is going to be absurd. Are there numbers to be determined that tell you how many singular instances are required to allow you to draw the conclusion that the inductive jump is valid? And what do you count as a singular instance? The standard way out of this is to speak about probability. We can never verify by induction but we can at least derive from it that something is very probable, that something is true barring unreasonable doubt. If we do not agree on that, we can never proceed if we allow ourselves to be stalled by unreasonable expectation of rigor. The bottom line is of course that we can never verify a universal statement, which potentially involves an infinite number of cases, by inspecting a finite number. To justify inductive reasoning on the fact that it has worked in the past is to invoke the principle of induction itself, be it of a higher order, something that already Hume pointed out. In other words we have the choice of either an infinite regress or to postulate an *a priori*. To a serious thinker, that is like choosing between pest and cholera. Now the standard way out of this dilemma of instead only postulating probable truths lands you in exactly the same dilemma that Hume already pointed out. Now one may remark that deduction is not the same as induction, so big deal. It is a big deal if you are concerned with the philosophical problem of epistemology. The radical solution proposed by Popper is that we should once and for all abandon all ambitions of verification. There is no such thing as a scientific truth, all laws of nature are hypothesis which we can never ultimately verify. All scientific knowledge is tentative. Popper replaces the notion of probable with approximate. What characterizes a scientific truth is that it can be wrong, that it can be falsified. Thus a hypothesis that cannot be falsified is not a scientific one. The nature of this has nothing to do with truth per se. An indubitable truth, such as a mathematical statement would not be scientific, because it has nu synthetic, i.e. no empirical content. Other statements are not scientific because they cannot be falsified for other reasons, because they are phrased in such vague terms that they cannot be pinned down. A statement such as 'God exists' is not scientific, because we cannot falsify it, there is always the possibility that God is somewhere else to be found. While a hypothesis to the effect that 'God does not exist' is scientific because it can be falsified[2]. This points out to an asymmetry between different kinds of statements, thus disposing of the silly argument that Poppers distinction between verification and

[2] This obviously presupposes that God is a notion whose existence in principle can be certified. What about if the existence of God involves an infinite number of verifications, such that God is infinity manifested. Then the statement is no longer falsifiable.

falsification does not make sense by virtue of any falsification of a statement constituting a verification of its negation. This simple-minded analysis does not take into account the structure of a statement, whether it is a 'for all' statement or a 'there exists' statement. Those different types of statements are interchanged by the process of negation. Thus inherent in Popper's analysis is while acceptance of theories are always tentative, their rejections are definitive. It is by this process of elimination that progress is made. Popper believes in progress in the very specific sense that the quest of a scientist is to get closer and closer to the truth, and that this asymptotic approach to the truth is what science is all about. This is very close to the process of evolution (except of course that unlike science, evolution has no ultimate goal), that by elimination of the unfit, more and more elaborate structures evolve.

Popper's conception of science is not scientific. By rejecting induction as a methodological tool, he rejects any idea that there is some meta-rule that allows us to derive theories from data, and here he puts himself in a position very much opposed to Bacon, who taught that truth is manifest and that nature teaches you it, provided that you purify your mind of any preconceived notions. (Very much like a mystic empties his mind to make room for the insight of the divine, Popper remarks sarcastically.) Nature is not an open book, and nature teaches us nothing whatsoever on its own volition. We only get taught by nature when we put the questions, and the questions we put are those that jeopardize our convictions. To formulate a hypothesis has nothing to do with an open objective mind, it is a creative act of daring. The important thing is that the hypothesis comes first, the observation is inspired by the hypothesis, not the other way around. Thus science progresses by proposing bold theories, the bolder they are, the less likely they are to be true, and hence the more remarkable when corroborated. Thus Popper makes a very clear distinction between prediction and retrodiction. The whole point of trying to falsify a theory is to test it in hitherto unsuspected ways. The one who is most concerned with finding plausible theories will not make very much progress. The bold theory not only sticks its neck out more provocatively, it also suggests experiments and phenomena which have been truly unexpected. It proves its mettles by being corroborated by observations of which the creator of the theory has no control. On the other hand if you are mostly concerned with supporting your theory there is no end to corroborating observations. Our belief in a theory is a matter of subjective faith, only the testing is intra-subjectively objective. It is only in the testing, that objectivity enters in science, objectivity is not an issue at all in the forming of a hypothesis. To form a scientific theory is as creative as anything artistic, it differs from the artistic that it can be judged by criteria that go beyond its creator.

Popper's view of science is of course not falsifiable, it is thus metaphysical in nature. But Popper differs from the positivists in that he does not consider metaphysics to be necessarily a bad thing, on the contrary. When Darwin proposed his theory of evolution it was a metaphysical theory really, a suggestion as how order can arise out of chaos without the intervention of a designing intellect. This metaphysical idea has transformed the science of biology. With the advent of Mendel, which indicated a more specific mechanism for inheritance, Darwinism became more scientific, as it could start formulating more of its theories in a testable way. Still there are many questions as to Darwinism which we are as of yet unable to handle scientifically. To what extent does our higher faculties, such

as intelligence, depend on genes? It is part of the dogma of Darwinism, and everything that cannot be falsified ossifies, that one should always look for a genetic explanation. Darwinists show their scientific instincts if they are willing to hazard this dogma on specific experiments. Of course this has nothing to do with the issue of creationism, the latter is a scientific deadend. Another non-falsifiable aspect of original Dawinism is the survival of the fittest. The notion of being fit being defined in terms of survival and thus reducing it to a tautology. Nevertheless the idea is very fruitful and has shown itself repeatedly to be so. This goes to show the value of metaphysics, even if Popper tends to think of metaphysics as a proto-science, and thus ultimately justified by its eventual conversion. As another example of successful metaphysics in that sense he refers to the Atomic theory of the Old Greek. At the time it could not be falsified but it provided a a very useful perspective to think about matter, and was ultimately vindicated.

In a sense induction does enter into Popper's philosophy through the back door to the glee of many of his critics. But in a less restrictive sense than traditionally. As the Britsih historian and philosopher R.G.Collingwood puts it. Deduction compels a conclusion, while induction permits it (for the time being, Popper would have added.)

The book also contain some technical discussions, such as dimensions of parameter spaces of fitting curves, of the objective nature of probability in terms of frequencies[3] and a long winded discussion about the interpretation of the Heisenberg relation, of which I understood nothing.

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[3] here he is very much inspired by von Mises. He proposes the notion of a probabilistic sequence to be an infinite sequence, such that each finite subsequence occurs with the predicted probability. Thus in particular if tossing a fair coin, knowing n tosses should give you no clue as to the nature of the $n+1$. In other words all sequences of $n+1$ consequetive throws should be equally frequent