

An Attempt to Formalize Popper's Logic of Scientific Discovery

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In 1935, Karl Popper published his famous book entitled “The Logic of Scientific Discovery.” In this book he proposed a general procedure of scientific discovery which contains the following key points.

1. A scientific theory consists of “conjectures” about domain knowledge.
2. Every conjecture may be disproved, that is, conclusions or predictions derived on the basis of it may be and must be subject to verification using the results of observations of human beings and scientific experiments on natural phenomena.
3. When the conclusions or predications contradict the results of observations or experiments, the theory is refuted by facts.
4. In this case, one should abandon those conjectures in the current theory which lead to contradictions, propose new conjectures, and form a new theory.
5. Every theory obtained in this way is provisional: it is expected to be refuted by facts any time. Truth in science is reached in the process of unlimited explorations.

The above procedure is given in the layer of Scientific Philosophy. In this paper, we provide a mathematical-logical framework for this general procedure. It consists of the following four parts.

1. Representability theory, that is, the theory of representing basic concepts such as theory, conjecture, provability, and refutation by facts, which are involved in the general procedure of scientific discovery, in first-order languages.
2. R-calculus, that is, a revision calculus for deleting conjectures refuted by facts or experiments from the current theory. It is a formal inference system about logical connective symbols and quantifier symbols and is sound, complete, and reachable.
3. Theory of version evolution, that is, the theory about version sequences, their limits, proschemes, and the convergency, soundness, and independency of proschemes.
4. I-calculus, that is, a calculus for forming conjectures. It is a formal inference system about contexts and involves the theory of rationality about conjecture calculus.

The above four parts constitute the mathematical framework for the logic of scientific discovery, which may be viewed as a formal description of “the logic of scientific discovery.” As examples, we will use this mathematical framework to give formal descriptions of the processes of Einstein’s discovery of “the special theory of relativity” and Darwin’s proposal of “the theory of evolution.” The difference between our mathematical framework and the general procedure of Popper’s logic of scientific discovery in the sense of scientific philosophy is: the former can be implemented on computer, so that the revision of scientific theories and evolution of version sequences can be accomplished via human-computer interactions and in the case where the current theory encounters refutation by facts, the computer can provide schemes for rational revision.