Studies in History and Philosophy of Science xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Studies in History and Philosophy of Science

journal homepage: www.elsevier.com/locate/shpsa

Scientific progress as increasing verisimilitude

Ilkka Niiniluoto

Department of Philosophy, History, Culture, and Art Studies, University of Helsinki, Finland

ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Fallibilism
Scientific change
Scientific progress
Scientific realism
Truthlikeness
Verisimilitude

ABSTRACT

According to the foundationalist picture, shared by many rationalists and positivist empiricists, science makes cognitive progress by accumulating justified truths. Fallibilists, who point out that complete certainty cannot be achieved in empirical science, can still argue that even successions of false theories may progress toward the truth. This proposal was supported by Karl Popper with his notion of truthlikeness or verisimilitude. Popper's own technical definition failed, but the idea that scientific progress means increasing truthlikeness can be expressed by defining degrees of truthlikeness in terms of similarities between states of affairs. This paper defends the verisimilitude approach against Alexander Bird who argues that the "semantic" definition (in terms of truth or truthlikeness alone) is not sufficient to define progress, but the "epistemic" definition referring to justification and knowledge is more adequate. Here Bird ignores the crucial distinction between real progress and estimated progress, explicated by the difference between absolute (and usually unknown) degrees of truthlikeness and their evidence-relative expected values. Further, it is argued that Bird's idea of returning to the cumulative model of growth requires an implausible trick of transforming past false theories into true ones.

1. Against the cumulative model of progress

According to Plato's classical definition, knowledge (*episteme*) is justified true belief. For Aristotle, understanding (*scientia*) is achieved by explanations with necessarily true premises. Late medieval and early modern philosophers realized that there are many new discoveries to be made, so that science as a collective enterprise of scholars is progressive.[1] According to the cumulative model, science grows by establishing completely certain new theories. On this foundationalist picture, shared by rationalists (like Descartes), empiricists (like Bacon), and positivists (like Comte), science makes epistemic progress by accumulating justified truths. As later theories entail their predecessors, scientific change is not an interesting topic for the philosophy of science.

The foundationalist view of knowledge was challenged by the skeptics already in the ancient Greece. If *episteme* is impossible, then science at best is just a succession of false theories. This inference, sometimes called the "pessimistic metainduction", seems to receive support from the revolutions in the history of science: many scientific theories have been rejected and replaced by new theories, and probably this will be the fate of our current theories (Laudan, 1984).

Various kinds of empiricists have accepted skepticism about scientific theories but at the same time tried to maintain the cumulative model on the level of observational knowledge. For the instrumentalists (like Duhem), theories are merely conceptual tools for observational systematization, and theoretical statements do not have truth values. Empiricist and instrumentalist views were attacked in the 1950s by the scientific realists (like Feigl, Smart, and Sellars) who argued that all scientific statements have truth values, truth is an essential aim of science, and it is possible to have knowledge about mind-independent reality beyond observations by means of scientific inquiry (cf. Niiniluoto, 1999).

A sophisticated anti-realist view was defended in 1962 by Thomas Kuhn in his *The Structure of Scientific Revolutions*. According to Kuhn, there is no theory-independent notion of truth.

E-mail address: ilkka.niiniluoto@helsinki.fi

[1] For a bibliographical survey of ideas about scientific progress, see Niiniluoto (2012).

http://dx.doi.org/10.1016/j.shpsa.2014.02.002
0039-3681/

However, a scientific community is "an immensely efficient instrument for solving the problems or puzzles that its paradigms define", and "the result of solving those problems must inevitably be progress". So during the periods of paradigm-based normal science, the scientists accumulate solved problems. Even though some old problems are banished in paradigm-change, new paradigms usually preserve "a great deal of the achievements of their predecessors" and also "permit additional concrete problem–solutions besides" (see Kuhn, 1970, pp. 166–170). In this way, the notion of progress can be saved by assuming that science is a problem-solving rather than a truth-seeking activity (see Laudan, 1977).

A middle way between foundationalism and skepticism has been sought by the epistemological tradition that Charles S. Peirce called *fallibilism* (see Peirce, 1931–35). The fallibilists acknowledge that complete certainty cannot be achieved in empirical science. Hence, even the best results of science may be false, but still they may be probable or approximately true. Against the pessimistic skepticism, Peirce maintained that the method of science is "self-corrective": new theories correct the mistakes of their predecessors and thereby bring us closer to the truth. The cumulative model of science is thus replaced by the view that science may approach or converge to the truth. In this sense, it is possible to be a fallibilist and a realist at the same time: even successions of false theories may progress toward the truth. This proposal, explicitly denied by Kuhn, was defended by Karl Popper (1963, 1979) with his notion of truthlikeness or verisimilitude which tries to make sense of the idea that a theory may be "closer to the truth" than another.

2. Truthlikeness: Logical and epistemic

Popper's technical definition of truthlikeness failed, when David Miller and Pavel Tichý proved in 1974 that it cannot be applied to compare any pairs of false theories. This problem was solved in a new research programme, based on the concept of similarity between states of affairs (see Niiniluoto, 1987; Oddie, 1986).

The basic idea of the similarity approach to truthlikeness is to represent theories as disjunctions of constituents, where a constituent is a complete theory or a maximally complete specification of a possible world within a conceptual framework L. The constituents of L are thus mutually exclusive and jointly exhaustive. In a semantically determinate language L, there is one and only one true constituent C^* in L. Truthlikeness can be then understood as distance from the target C^* which is the most informative true statement in L. The distance $d(C_i,C_j)$ between two constituents C_i and C_j can be defined by means of the "matches" in their claims, so that $0 \leqslant d(C_i,C_j) \leqslant 1$. For example, in a monadic first-order language L with one-place qualitative predicates, a constituent specifies which kinds of individuals (Q-predicates in Carnap's terminology) are exemplified in the universe and which are not, and the Clifford-distance between two constituents is the relative number of their diverging claims about the Q-predicates. For quantitative languages, constituents may correspond to points in a real space (so that their distance is defined by the Euclidian metric) or real-valued functions (so that their distance is defined by the Minkowskian metric).

If H is a disjunction of constituents, its degree of *approximate truth* is defined by 1 minus the minimum distance of the disjuncts C_i in H from the target C^*. Hence, this degree has its maximum 1 if and only if H is true. The degree of *truthlikeness* $\mathrm{Tr}(H,C^*)$ is a function of the distances $d(C_i,C^*)$ of the disjuncts C_i in H from the target C^*. Oddie (1986) uses here the average distance of these disjuncts from C^*, while Niiniluoto (1987) uses the min-sum measure which is a weighted combination of the minimum distance and the (normalized) sum of all distances. This measure balances truth and information factors, corresponding to our interests of finding truth and excluding falsity. The degree of truthlikeness $\mathrm{Tr}(H,C^*)$ is then 1 minus the distance between H and C^*.

For both the average and min-sum functions, truthlikeness has its maximum value 1 if and only if H is identical with C^*. Both allow that false theories may be compared for their truthlikeness, and the degree $\mathrm{Tr}(H,C^*)$ may be large even when H is false. But the main difference is that Oddie's proposal does not satisfy Popper's adequacy condition

(1) If H and H' are true theories, and H logically entails H', then H is at least as truthlike as H'.

This condition, which basically states that adding new truths to old truths increases truthlikeness, is satisfied by Niiniluoto's proposal.

Popper distinguished two problems of truthlikeness. The *logical* problem asks, given the true target C^*, what it means to say that a theory is close to C^* or closer to C^* than another theory. The *epistemic* problem asks, given available evidence E, but without knowing C^*, how we can rationally claim or estimate that one theory is close to C^* or closer to C^* than another theory. He claimed that there are cases where one theory "seems—as far as we know—to better correspond to the facts" (Popper, 1963, p. 232) or we have "strong and reasonably good arguments for claiming that we may have made progress toward the truth" (Popper, 1979, 58). However, his proposal that degrees of corroboration serve as fallible indicators of verisimilitude does not work, as such degrees are zero for any refuted theory. A theory may be highly truthlike, even if it is known to be false.

Niiniluoto's (1987) solution to the epistemic problem assumes that a probability measure P is defined for the language L, so that $P(C_i/E)$ is the posterior epistemic probability of constituent C_i given evidence E. Then the unknown degree of truthlikeness $\mathrm{Tr}(H,C^*)$ may be estimated by its expected value relative to the constituents C_i and their posterior probabilities given evidence E:

$$(2)\quad \mathrm{ver}(H/E) = \sum P(C_i/E)\,\mathrm{Tr}(H,C_i)$$

where the sum goes over all indices of constituents of L. Formula (2) defines the *expected verisimilitude* of H given evidence E. It is important that ver(H/E) may be high even when $P(H) = 0$ or $P(H/E) = 0$.[2]

Piscopo and Birattari (2010) complain that estimates of verisimilitude by ver(H/E) are not objective, as they depend on evidence E and (as Niiniluoto acknowledges) can be revised with increasing evidence. For this reason, they think that this measure should not have a "constitutive" role in theory selection. But, even though a realist admits absolute concepts of truth and truthlikeness (i.e., Tr), for a fallibilist all claims about the truthlikeness of theories are equally conjectural as claims about their truth. This concerns both retrospective applications, where ver(H/E) expresses our assessment of a past theory H in the light of our currently accepted theory-cum-observational evidence E (see Niiniluoto, 1984, pp. 171–173), and prospective applications, where ver defines the epistemic utility of an acceptance rule (see Niiniluoto, 1987, chap. 12). In spite of the wishes of infallibilists, this kind of uncertainty is characteristic to science. Even when ver(H/E) is high, our claim that H is really truthlike may be mistaken. The strongest sense of objectivity which can be demanded of a measure like ver is that, on

[2] See also Festa (1999). Other approaches to the epistemic problem of verisimilitude include Zamora Bonilla (1992), who defines directly the distance of a theory from evidence, and Kuipers (2000), who links the empirical success of a theory H with a "truth approximation hypothesis" about H.

Please cite this article in press as: Niiniluoto, I. Scientific progress as increasing verisimilitude. *Studies in History and Philosophy of Science* (2014), http://dx.doi.org/10.1016/j.shpsa.2014.02.002