TRUTH AND EMPIRICAL ADEQUACY AS EPISTEMOLOGICAL CRITERIA.
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MIEKE BOON
Department of Philosophy, University of Twente, Enschede, The Netherlands

How scientific questions arise – how philosophical questions arise.

Scientific questions often are 'why' or 'how' questions. However, really asking these questions in a sensible way requires a bit more than just say 'why ..'. Imagine that it is autumn, and you and your friend walk on campus to your philosophy of science class. Your friend looks at all these beautiful big trees with golden-yellow or dark reddish leafs that shine out in the morning-sun, and asks, "do you know why leafs turn brown in autumn?". You say, "Well, that is simply because they are dying. Leafs that are dying turn brown, or yellow, or so!" This kind of answer is a common-sense response to such questions. If we would be satisfied with that, we would never have entered the domain of science. But your friend happens to have an investigative mind, and is not really satisfied. She says, "OK, but *why* is that. What is the cause that the green colour disappears, or the green turns to yellow? There must be some kind of chemistry responsible for it."

The movie, "The double helix", which is about the discovery of the structure of DNA, starts with a similar scene. The young American scientist James Watson is visiting an archaeological site in Greece, together with his sister, in the early 1950's. While looking at this impressive old temple, Watson turns to his sister and asks, "Look, you look like Mom, and your children look a kind like you. Why is it that? There has to be something that knows. Something that doesn't die when you die. A piece of immortality. It has to be in every living cell. It has to be a protein. It has to be nucleic acid. I say it is the acid. It is the DNA. Life reproduces life. How?!"
http://profiles.nlm.nih.gov/SC/Views/Exhibit/documents/doublehelix.html

The character of raising these kinds of questions is that they go beyond the obvious – beyond our common understanding of such phenomena. In responding to such questions we tend to shrug our shoulders. We become a bit chafe under such questions. Probably, because we usually do not have a clue to the answer. Watson is excited the questions he raises, partly because he sees a way of investigating it.

Philosophical questions arise in a similar manner. Your friend asks, "Why do we believe scientific knowledge." You reply, "Well, because it has been proven by scientists."

Truth is an epistemological criterion.

An epistemological criterion is the *property* that theoretical knowledge must have in order to be accepted or believed. This means to say that, "a theory is accepted *iff* (if and

only if) it is true." Yet another way of putting this is: "we accept a theory *because* it is true." This is not to say that *truth* is the only possible epistemological criterion for the acceptance of knowledge. In fact, truth is a very problematic notion. In this hand-out, we will first explore why this is so. Next, I will explain the need, or usefulness, of an alternative epistemological criterion, to wit, *empirical adequacy*.

This latter possibility implies that the use of 'empirical adequacy' as an epistemological criterion must be similar to how 'truth' (or yet other epistemological criteria such as 'reliability'), are used in statements such as: 'a theory is accepted *iff* it is true', or, 'a theory is accepted *iff* it is empirically adequate', or, 'a theory is accepted *iff* it is reliable.'

The crucial question is then <u>how</u> we know that a theory is true or empirically adequate or reliable. In other words: How do we <u>justify</u> that a theory has this epistemological property? In order to clarify this further, I will use Van Fraassen's (1980) approach to the meaning and justification of the truth of scientific theories.

Van Fraassen's point of departure is Tarski's semantic definition of truth according to which truth is a property of a sentence, which tells us something about the relation between the sentence and the real world. Van Fraassen's *definition* of the truth of a sentence or a theory, "T" is (slightly rephrased for my purpose): The truth of "T" means that what T says is literally the case – that is, "T" literally tells what the real world is like. Subsequently, a methodological criterion is needed that determines whether "T" literally tells what the world is like. Van Fraassen's much debated criterion is that the truth of statements or 'stories' can only be determined about directly observable state of affairs and occurrences. In other words, the story told by "T" must be observable.

Following up on these ideas, I propose to explicate the use and meaning of epistemological criteria, and how it relates to methodological criteria in five systematic steps:

1. *The epistemological criterion*. An epistemological criterion, E, (e.g., truth) accounts for the *acceptance* of theoretical knowledge "T". This criterion is used as follows: An expression "T" is accepted *iff* "T" is E. In other words, an expression (e.g., a sentence or a scientific theory) named "T" and telling T, is accepted if and only if the epistemological property (e.g., truth) has been attributed to expression "T". For instance, A theory or law "T" (e.g., Newton's theory, or the ideal gas law) is accepted *iff* "T" is E (e.g., true).[1]
2. *A semantic conception of the epistemological criterion*. In this account, epistemological properties are regarded as semantic concepts. Semantic concepts deal with certain relations between expressions of a language and the object referred to by that expression (cf. Tarski, 1944). This means that epistemological concepts are regarded as properties of expressions in a language, and not as properties of objects in the world that these expressions refer to. Accordingly, an epistemological property (e.g., truth) is a property of theoretical knowledge "T" that

[1] Note that the epistemological criterion E is a necessary property for scientific knowledge to be accepted but may not be a sufficient criterion for acceptance, since other criteria, such as *relevance* or *explanatory power* may play a role as well. Van Fraassen (1980, 12-13) calls these additional criteria, pragmatic values.

specifies a certain relation between expression "T" (e.g., theoretical knowledge) and the real world.[2]

3. *A semantic definition of the epistemological criterion*. Characteristic of semantic concepts is that their meaning must be given by definition (and not, for instance, by designation). Hence, a semantic definition of the epistemological property E must be given. The form of this definition is: An expression "T" is E, means (or, is defined as) that what T says relates such and such to the empirical world. For instance, a theory or law "T" is true, means that what T says is actually the case.
4. *An operational definition of the epistemological criterion*. Characteristic of concepts introduced by means of a definition (rather than by means of designation) is that it also needs to be defined how to use that concept.[3] This can be called an operational definition of the concept. The semantic definition of E ("T" is E, means that what T says relates such and such to the empirical world), already entails the operational definition: "T" is E *if* what T says relates such and such to the empirical world. This latter form of the definition presents a criterion Q (e.g., is actually the case) for attributing the epistemological property E to a sentence "T". Namely, a sentence (or scientific theory) named "T" (and telling T about the empirical world) is E (e.g., true) if and only if what T says relates such and such to the empirical world. In brief, the operational definition of the epistemological criterion reads: "T" is E (e.g., "T" is true) *if* T is Q (e.g., what T says about the empirical world is actually the case).
5. *The methodological criterion*. Hence, the problem of how to justify that the epistemic property for the acceptance of theoretical knowledge applies (i.e., whether "T" is E), has been moved to the problem of how to determine that T is Q (i.e., whether T relates such and such to the world). This is where methodology comes into play. A methodology involves a methodological criterion M (e.g., observation), which is the property that a method must have (or be) in order to be accepted as a method by which it can be determined that T is Q. The use of this criterion is summarized as follows: "T is Q is justified *if* 'T is Q' is determined by a methodology that meets methodological criterion M." For instance, the claim that, 'what T says is actually the case', is justified *if* what T says can be directly observed in the real world. In brief, observation counts as a methodological criterion: A method

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[2] In this manner, a distinction is made between properties of the world (e.g., material entities in the real world) and properties of expressions of a language (including theories). For example, red is regarded as a property of material or physical objects (such as, the apple is red), whereas truth is regarded as a property of an expression (such as, "the apple is red" is true). Importantly, the way in which we learn their meaning is different. Usually, we learn the meaning of the properties of material objects by designation (e.g., by pointing at a red apple and saying, 'Look! The apple is red.'), not by definition. The meaning of semantic concepts cannot be learned by designation (e.g., by pointing at something and saying, 'Look! Newton's theory is true.'). Instead, the meaning of semantic concepts must be given by definition.

[3] For instance, knowing how to use the term "bachelor" (e.g., in saying, 'this man is bachelor'), requires an explication of how we determine whether this man is bachelor. Similarly, in order to use a semantic concept such as truth in saying, 'this theory or law is true', it needs to be explicated how we determine whether the theory is true. Importantly, a definition of a term (e.g., a definition of being bachelor) not only states its meaning (e.g., a man is bachelor, means that a man is unmarried), it also presents a criterion for whether the term applies (e.g., a man is bachelor *if* a man is unmarried).

justifies the (approximate) truth of a sentence or a theory or a law *if* what the sentence or theory or law says is actually or literally the case; whether what the sentence or theory or laws says is literally the case, must be determined by observation.[4]

For truth as an epistemological property of theoretical knowledge, and direct observation as the methodological criterion for attributing this property to theoretical knowledge, this schema results in:

1. (1^T) *Epistemological criterion for acceptance of theoretical knowledge*: "T" is accepted *if* "T" is true.
2. (2^T) *Semantic conception of the epistemological criterion*: Truth is an epistemological property of theoretical knowledge "T" that specifies a certain relation between "T" and the real world (namely, a relation between what the theory says about the real world and how the world really or literally is).
3. (3^T) *Semantic definition of the epistemological criterion*: "T" is true, means (or, is defined as) that what T says is actually the case.
4. (4^T) *Operational definition of the epistemological criterion*: "T" is true *if* what T says is actually the case.
5. (5^T) *Methodological criterion*: Direct observation is a methodological criterion for methods that determines whether what T says is actually the case. The use of the methodological criterion is summarized as follows: What T says is actually the case *if* 'what T says is actually the case' is determined by a methodology that is based on direct observation.

Clearly, if what our knowledge tells about the world is observable in an unproblematic manner, we would not call it theoretical knowledge. Yet, the character of theoretical knowledge, "T", is that what T says is not observable in an unproblematic manner. According to Van Fraassen (1980), if T tells something that is not observable in principle, we should refrain from attributing (approximate) truth to "T". In that case, this epistemological property does not apply and we need another property to account for, e.g., the acceptance, or the success of "T". As an alternative notion, Van Fraassen proposed "empirical adequacy", which is defined as: A theory "T" is empirically adequate *if* what it says about *observable* things in the world is true. According to the presented line of reasoning, a methodological criterion is needed for how to determine whether what the theory says about observable things is true. Van Fraassen (1980) and Suppe (1989) introduced as a criterion (partial) *isomorphism* between models that satisfy the axioms of the theory, on the one hand, and data-models produced in experiments and data-processing, on the other. For empirical adequacy as an epistemological property of theoretical knowledge, and (partial) isomorphism as the

[4] Clearly, observation as a methodological criterion for the acceptance of knowledge was only taken as a strict criterion in Hume's version of empiricism. Subsequently, other methodological criteria were proposed, such as induction, or verification (confirmation or falsification) by a hypothetical-deductive approach.

methodological criterion for attributing this property to theoretical knowledge, the former schema yields:

1. (1^{EA}) *Epistemological criterion for acceptance of theoretical knowledge*: "T" is accepted *if* "T" is empirically adequate.
2. (2^{EA}) *Semantic conception of the epistemological criterion*: Empirical adequacy is an epistemological property of theoretical knowledge "T" that specifies a certain relation between "T" and the real world (namely, a relation between what the theory predicts about the observable world and what can be directly observed of the real world).
3. (3^{EA}) *Semantic definition of the epistemological criterion*: "T" is empirically adequate, means (or, is defined as) that what T predicts about the observable world is actually the case.
4. (4^{EA}) *Operational definition of the epistemological criterion*: "T" is empirically adequate *if* what T predicts about the observable world is actually the case.
5. (5^{EA}) *Methodological criterion*: (Partial) isomorphism is a methodological criterion for methods that determines whether what T predicts about the observable world is actually the case. The use of this criterion is summarized as follows: What T predicts about the observable world is actually the case *if* 'what T predicts about the observable world is actually the case' is determined by a methodology that is based on (partial) isomorphism (i.e., partial isomorphism between models that satisfy the axioms of the theory and data models of real world systems; cf. Suppes, 1989).

In sum, methodological criteria (direct observation of a state of affairs in the case of truth, and isomorphism between theoretical models and data models of a system in the case of empirical adequacy) are needed to justify the attribution of epistemological properties (truth, and empirical adequacy) to theoretical knowledge.

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