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THEORY-LADEN OBSERVATIONS AND EMPIRICAL EQUIVALENCE OF THEORIES

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The paper examines Dickson's (1999) question how it is possible to hold the theory-laden observation thesis and, at the same time, to uphold the thesis of the empirical equivalence of theories. After the elucidation of several semantic distinctions we propose the definitions of empirical equivalence of expressions and theories, respectively. In the next step, we scrutinize the theory-ladenness thesis more closely and propose three distinct, but related, specifications of it. Finally, we reconsider the two theses in question order to show that they could be interpreted as fully compatible.

Keywords: The theory-ladenness of observation thesis – The empirical equivalence of theories thesis – The underdetermination thesis – Referent – Observation

1 Introduction. The thesis that every (scientific) observation is 'theory-laden' or 'theory-informed' is widely accepted by different philosophers and theoreticians. However, at the same time, the same philosophers and theoreticians accept also the thesis that there can be empirically or observationally equivalent theories which, if taken together, are not consistent (or, at least, they are not non-observationally equivalent).[1] To say of any two theories that they are empirically or observationally equivalent usually means, given certain auxiliary assumptions, that the theories entail the same observation-statements (or, simply, observations). But acceptance of both of the two theses is in need of an explanation. As Michael Dickson puts it in his (1999, 48): "How can theories be observationally equivalent if, as many believe, observations are 'theory-laden'?" More explicitly, there seems to be a conflict between saying that there are at least two *different* but *empirically* or *observationally equivalent* theories which say equivalent things about 'the world of observables' and saying that every observation (or observation statement) is laden by theory. That is, how is it possible that a set of observation statements belongs to a set of empirically equivalent (although still different) theories, if those predictions (observations) are strongly mediated by these theories?

Moreover, the thesis that there are empirically equivalent theories is usually conceived as one of the supporting reasons for another well-known thesis: the underdetermi-

[1] The definition of what does it mean to assert of any two formulations that they are non-observationally equivalent will be provided later.

nation of theory by data thesis. Okasha (2002) brings together those three theses (the theory-laden observation, the underdetermination, and the empirically equivalent theories) and asks – rather extensively – whether one can hold them all consistently: "The suggestion that the theory/data distinction cannot be drawn in a principled way is a corollary of the idea that all data are 'theory-laden'… It is undeniable that some such distinction is presumed by the underdetermination argument. For the argument asserts that there exist theories which are empirically equivalent, and which are therefore undecidable by all possible empirical data. The empirical equivalence of two theories is normally defined as the identity of their empirically testable or 'observational' implications. But if the distinction between what is and what is not empirically testable cannot be drawn, then the concept of empirical equivalence is obviously suspect, and the underdetermination argument is in trouble. Without a principled distinction between theory and empirical data, we cannot sensibly ask whether the latter underdetermine the former or not" (Okasha 2002, 315).

Here I neither follow the very problem of underdetermination of theories by empirical data (or evidence), nor the attempts to solve it.[2] Rather, the aim of my paper is to examine the tenability of holding together the empirical equivalence of theories thesis on the one hand and the theory-laden observations thesis on the other. In what follows I will try to look more closely at those two theses and propose several conceptual distinctions which can be useful in searching for an answer to Dickson's original question.[3]

2 Intermezzo: Observation. Let us stop for a while and consider various concept(s) of observation, which are standardly used in this context. It may be helpful for sake of our later considerations to mention several distinctions.

First of all, philosophers sometimes make a conceptual or epistemic distinction between 'seeing' and 'observing'. As Machamer puts it: "Whatever one's analysis of seeing, it is clear that one can see things and not be able to say anything about what he is seeing on the basis of his seeing." And he continues: "Simple seeing is not a sufficiently strong condition to guarantee the possibility of communicating (information) about what is seen. I shall use the word 'observation' in such a way that this possibility becomes a necessary condition for observing something" (Machamer 1970, 189-190).

The difference between seeing and observing may be expressed also as a difference between 'seeing *X*' (simply, seeing) and 'seeing *X* as *being F*' (that is, observing) where "X" denotes an entity and "F" denotes some of its characteristic features. Observation of an entity, thus, requires that the observer can put information about the observed object into an observation sentence. (As Machamer recalls, infants and animals see but do not observe.)

[2] For the criticism of the underdetermination thesis see, for example, Laudan – Leplin (1991), or Norton (manuscript).

[3] I have to acknowledge that I do not find Dickson's (1999) own answer satisfactory because his explanation relates only to theories which share a common (mathematical) formalism. Such an answer excludes the unformalized theories as being sufficiently explained as theories which are both empirically equivalent and the observations of which are theory-informed.

Second, speaking of observation is usually ambiguous. It is rather rare to find two major categories of observation-talk explicitly distinguished: one of them points to the method of, or the process of, or the act of observing; the other one refers to the product of, or the report of the observation procedure (i.e., observation sentence). As I will show later, those two conceptual categories bear upon the theory-ladenness in a different manner.

Moreover, some authors (e.g., Nola in 1986, 247-248) regard 'observation' as a more general process-product category covering not only seeing but hearing, touching, etc., as well. Nola's schematic example "R *observes* that the patient has *a heavy cough*" (my italics) is in this sense quite instructive. That means that observing implies seeing or hearing or touching. In what follows, I will not exclude this general understanding of observation. However, our consideration will be confined (almost entirely) to the observation-as-seeing relation.

3 Semantic Preliminaries. Our next considerations require few clarifications some of which have a semantic character. Let me briefly bring forward several distinctions which are crucial for the elucidation of different relations among theories and their relations to their observational consequences to be considered latter.

Below, I am not assuming a particular (intensional or hyperintensional) semantic theory. However, my considerations rely on this simple semantic schema:

Expression *expresses* its **meaning**
Meaning *determines* its **referent**
Expression *refers to/denotes* its **referent**[4]

In what follows, the referent of an expression may be an object (e.g. in case of proper names or descriptions), a class of objects (in case of property nouns, for example), or a state of affairs or a fact (in case of sentences). Here, I assume this kind of ontology without bothering with its complexities.

Let us suppose that we have two (simple or complex) expressions: E_1 and E_2. The expression E_1 has a meaning M_1 and a referent R_1. Similarly, the expression E_2 has a meaning M_2 and a referent R_2. Take as a further assumption that there are two theories T_1 and T_2 such that $E_1 \in T_1$ and $E_2 \in T_2$, that is, that E_1 is an expression of theory (formulation) T_1 and that E_2 belongs to theory (formulation) T_2. Finally, let us suppose that E_1 and E_2 have the same referent R (that is: $R_1=R_2$). We can consider three interesting configurations of E_1, E_2, M_1, M_2, and R, respectively:

a) $E_1=E_2$, $M_1\neq M_2$, R
b) $E_1\neq E_2$, $M_1\neq M_2$, R

[4] Here I use a slight modification of the Fregean semantic scheme. Moreover, when considering the relation between an expression and its referent, I abstract (for simplicity) from the indices such as possible worlds or time. I take a referent of an expression to be relativized to a given actual situation (possible world) and actual time.

c) $E_1 \neq E_2$, $M_1 = M_2$, R

(The case of $E_1 = E_2$, $M_1 = M_2$, R is redundant for our considerations.)

The situation a) is typical of the expressions which, although syntactically identical, have different meanings. Nevertheless, they (may) denote the same referent (or object) R. For example, let E_1 and E_2 be the term "atom", however, let E_1 be an expression of Rutherford's theory of atom (in this case T_1), the meaning (M_1) of which could be described as *a complex particle composed of tiny, dense, positively charged nucleus surrounded by lighter, negatively charged electrons.* On the other hand, let E_2 be an expression of Bohr's theory of atom (T_2), the meaning (M_2) of which can be put as *a complex particle composed of tiny, dense, positively charged nucleus surrounded by lighter, negatively charged electrons, orbiting at different energy levels*. Despite the fact that E_1 and E_2 differ in meaning, they refer to the same (kind of) object – the atom(s).

The case b) is characteristic of those expressions that have not only different meaning, but also a different coding. Still, those expressions (may) have the same referent R. If we changed a bit our previous example and considered E_1 as being the term "$atom_R$" of theory T_1 and E_2 the term "$atom_B$" of theory T_2, we would have an instance of the configuration b).

Finally, our last situation corresponding to c) is a classic representative of synonymy. If we generalize the distinction c) above to some or all of the terms of any two theories T_1 and T_2, we can characterize the case when these are just two distinct formulations of one theory. If we have two formulations of theories T_1 and T_2 that differ in, at least, one expression and for any expression of T_1 there is an expression of T_2 with the same meaning (and the same referent), and vice versa, then the set of expressions of T_1 is just a different formulation of theory T_2. In other words, one theory (that is, the meanings of theory expressions) can be expressed in various theory formulations.

Now, we can provide the definition of the equivalence of expressions E_1 and E_2:

(Eq) Any two expressions E_1 and E_2 are equivalent iff E_1 and E_2 have the same referent R.

Thus, E_1 and E_2 are equivalent, if one of the situations a), b) or c) obtains.

Moreover, if we add a further condition on referent R, we can give a definition of empirical or observational equivalence of expressions E_1 and E_2:

(EEq) Any two expressions E_1 and E_2 are empirically (observationally) equivalent iff E_1 and E_2 have the same referent R and R is observable (in conditions C).

If there are equivalent expressions the referent of which is not observable (under any conditions C), yet we assume its existence, we can call them *non-observationally equivalent* expressions.

Thus, any two expressions are equivalent iff they are empirically (observationally) equivalent or non-observationally equivalent.

4 Empirically Equivalent Theories. Now we can proceed to our main task: What does it mean to say that (any) two theories are empirically or observationally equivalent? As we have said earlier, (any) two theories are qualified as empirically (observationally) equivalent if and only if it is possible to derive the same observation consequences from them using some auxiliary statements.

Furthermore, since the distinctions made in the previous part, we can formulate the working definition of empirically equivalent theories:

(ET) Any two theories T_1 and T_2 are empirically equivalent iff for every (simple or complex) expression E^{T1} of theory T_1, the referent of which is observable (in certain conditions C), there is an expression E^{T2} of theory T_2, which is empirically equivalent to E^{T1}, and vice versa.

Similarly, we can specify the concept of non-observationally equivalent theories in the following way:

(NT) Any two theories T_1 and T_2 are non-observationally equivalent iff for every (simple or complex) expression E^{T1} of theory T_1, the referent of which is not observable (in any conditions C), there is an expression E^{T2} of theory T_2, which is empirically equivalent to E^{T1}, and vice versa.

To say of any two theories T_1 and T_2 that they are *equivalent* then means that they are *empirically equivalent* or *non-observationally equivalent*.

However, our working definition (ET) is only preliminary. As we have seen, the concept of empirical or observational equivalence of theories is usually accompanied with the concept of auxiliary statements which are (in many cases) necessary for derivation of the theory's observational consequences. It is, thus, useful to capture the role of auxiliaries in this context as well.

We can put it more formally as follows: Let T_1 stand for a conjunction of some theoretical statements (Theory 1), let T_2 be a conjunction of different theoretical statements (Theory 2), and let A_1 and A_2 stand for two (different) conjunctions of auxiliary statements. Finally, let O_1, …, O_n be observation statements, the conjunction of which is represented by O. Now, we can state that the theories T_1 and T_2 are empirically equivalent iff these two conditions hold:

i) $(T_1 \wedge A_1) \vdash O$

ii) $(T_2 \wedge A_2) \vdash O$

(It may be the case that A_1 and A_2 are the same statements.) Or we can put these conditions into a modified version (ET') of our previous working definition (ET):

(ET') Any two theories T_1 and T_2 are empirically equivalent iff for every (simple or complex) expression O^{T1}, which is derivable from theory T_1 with the help of auxiliary expressions (statements) A_1 and the referent of which is observable (in certain conditions C), there is an expression O^{T2} derivable from theory T_2 with the help of auxiliary expressions (statements) A_2, which is empirically equivalent to O^{T1}, and vice versa.

As an illustration of empirically equivalent theories we can mention van Fraassen's (1980, 44-47) example. Let TN stand for Newton's three laws of motion and the gravitation law. If we add to TN another Newton's belief, namely the hypothesis that the Solar system has a constant absolute velocity v=0 that is, however, a state of affairs observationally indistinguishable of the other values of v at the level of apparent motions, then both TN(0) and TN(v) of any other value v are empirically equivalent – they entail (with the help of auxiliary statements) the same observations of (apparent) motions of bodies. That is, theories TN(0) and TN(v) are empirically (or observationally) equivalent, although they are *not* non-observationally equivalent (because of ascriptions of different values to hypothesized (unobservable) constant absolute velocity of the Solar system).

Let me finish this section with a word of caution. When considering empirical equivalence of theories philosophers usually rely (as we do in this paper as well) on the concept(s) of observation statements or observational consequences. However, it is far from clear what it is to be accepted as an observational consequence of a theory in such a talk. For example, let us suppose that there is an observation consequence of a theory (and auxiliaries) such that there is an object *a* – the piece of sugar – that has a property *being dissolved in water*, and has been observed in certain conditions C. Then the question is the following: Are we willing to accept any logical consequence of this observation statement (the consequences such as "*a* dissolved in water or *a* was tasted by a murderer") as the observational consequence of the given theory as well? If 'yes', we should accept that any two theories have an infinite amount of observational consequences (because of an infinite amount of logical consequences of any statement). If there is an infinite amount of observational consequences of any two theories, then it is a hard job to find out which theories are and which are not empirically equivalent.

For now I'll put aside those considerations for another occasion and work further with a simplified scenario.

5 Theory-laden observations. To say of an observation that it is theory-laden or theory-informed (or theory-loaded) usually means that there is no such thing as a purely experiential observation or observation independent of any theoretical assumption.

Leaving aside the ambiguity of what the term 'theory' means in such locutions, I claim that behind the thesis of theoretically laden observation we can distinguish, at least, three different although related (sub)theses which have been used in philosophical discussions of the kind:

(A) The observed thing is not identical to the concept of what is observed. Or, to express it rather differently: the referent of an observation expression (or statement) is not identical to the meaning of that expression.

(B) The subject-matter as well as the evaluation (of significance) of every observation is determined by a certain theory (or a problem that is rooted in a theory).

(C) The very conditions of empirical testing (e.g., observation, experimentation) are determined by a theory.

We can find different philosophers of science subscribing to one or more of the above theses. Popper (2007/1959, chap. 5) is an example of proponents of thesis (A). He explains vividly that to describe certain situation such as 'Here is a glass of water' is (besides other things) to apply a universal (a concept) to a certain particular experience and that the universal (concept) outreaches that very experience. For, there is a micro "water-theory" underlying the application of this concept to a particular case.

Moreover, if we recall the distinctions made in part 2 of this paper, we can say that thesis (A) is standardly related to 'the product-concept of observation' rather than to 'the process-concept of observation'.

Moving to thesis (B), it is Popper again who endorses the position. But there are many other philosophers subscribing to this view. Hempel (1966, chap. 2), for example, emphasizes that gathering of scientific data is determined by a very theory or hypothesis: "Such hypotheses determine, among other things, what data should be collected at a given point in a scientific investigation" (Hempel 1966, 13).

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This time thesis (B) seems to be related to both of the observation concepts: the product-concept and the process-concept. There are, on the one hand, theories which do affect the selection of certain data as relevant for an observation procedure. On the other hand, there may be a particular theory which helps to analyze (standardize, classify) the observed data when the process of observation is accomplished.

Finally, position (C) is contained in the basic schema of hypothesis-testing:

$$(T \wedge A) \vdash O$$

Many times it is the auxiliary hypotheses or statements, necessary for derivations of observational consequences that are parts of other (well-established) theories. Those auxiliary theoretical components may, for example, determine the reliability conditions of observation or testing in general, or the working mechanisms of optical devices in particular. Moreover, they may simply assert some initial (antecedent) conditions of observation. In many contexts of hypothesis-testing, identifying observational

data relies, rather heavily, on some theory that describes or explains the structure (or some mechanism) of a given testing device. It is this position that represents the core of The Duhem-Quine thesis (cf. Duhem 1954/1914; Quine 1951). Moreover, this last thesis is more closely tied to 'the process-concept of observation'.

The list of the three (sub)theses of theory-ladenness is not aimed to be exhaustive. Nevertheless, we should find it sufficient for our main task to which we now move.

6 Both theses accepted? If observations are theory-laden, how can theories be observationally equivalent? – This has been the question we had started with. The distinctions made in previous sections can now shed light on the answer. Let us compare those three (sub)theses with our definitions of empirical equivalence of theories as specified in definitions (ET') and (ET), respectively.

First, if the theory-laden observation thesis is construed mainly as thesis (A) and if we accept that there could be (different) expressions of different theories with different meanings, but, still, having the same referent – such as in cases a) or b) from section 3 (or as in case c) that presupposes that there are different expressions of different theories with the same meaning and the same referent) – then it is evident that the theory-laden observation thesis is not only compatible with definitions (ET') and (ET) respectively, but that it may even be incorporated into our definitions.

Second, if theory-ladenness is interpreted as thesis (B), it means only that either the selection or the evaluation of the referents to be observed may be motivated by some theory – either by the very theory, expressions of which denote the observed referents, or some other, accompanying theory. Moreover, if we accept that thesis (B) is compatible with thesis (A) and that thesis (A) is compatible with definitions (ET') or (ET), then we can see that thesis (B) is compatible with those definitions as well. In other words, definitions (ET') and (ET) do not say anything about the motivation that leads us to observe some particular object (a referent). Nor does it say anything about an epistemic or a pragmatic evaluation of an observation report.

Finally, if we take thesis (C) as our candidate for a specification of the theory-laden observation thesis, we see that our definition (ET') completely incorporates its core idea. Thesis (C) simply says that there are some auxiliary statements of theory which are necessary either for the derivation of an observation statement (or prediction) or for the explanation or evaluation of mechanisms behind the observation process. And it is obvious that our definition (ET') works with this component fairly-well.

7 Concluding remarks. If our construal of the empirical equivalence of theories is correct and if, at least, one of our specifications of theory-ladenness is plausible, the compatibility of those two theses is plausible as well. And, if both of the theses are compatible, then the menace of underdetermination is not undermined as Okasha maintained in (2002); that is, the empirical equivalence of theories still may serve as one of the reasons for the acceptance of the thesis that observation (data, or evidence) underdetermines theory.

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