Syntactic Characteristics of Empirical Substructures —Summary—

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Abstract

I show that van Fraassen's semantic conception of the relation theory and observation based on empirical substructures has a direct syntactic formulation and even formulations based on the bipartition of a theory's vocabulary into theoretical and observational non-logical constants. The direct syntactic formulation relies on the relativization theorem and allows the application of Craig's theorem to empirical substructures.

Formulations based on a bipartition of the vocabulary can be given in at least three ways. First, one may simply double the vocabulary, keeping the original vocabulary as theoretical constants. The direct syntactic formulation can then be used for the observational constants, which are identified with their theoretical counterparts. Second, one can reformulate the theory to capture its empirical substructures as a pseudo-elementary class. Third, one can double the vocabulary and restrict the identification of the observational and the theoretical constants to the domain of the empirical substructures. All three formulations allow the Ramsey-elimination of theoretical constants.

In the so-called received view of scientific theories, a theory is given by a set of sentences T in a theoretical vocabulary $\mathscr{T}$ and a set of correspondence rules C that connects $\mathscr{T}$ to a disjoint observational vocabulary $\mathscr{O}$.

This bipartition of a theory's vocabulary $\mathscr{V}$ into $\mathscr{O}$ and $\mathscr{T}$ may be the most controversial aspect of the received view. Van Fraassen (1980, § 3.6) criticizes the bipartition and concludes that "[t]he syntactically defined relationships are simply the wrong ones" to describe the theory-observation relation, and he states that observational vocabularies, Craig's theorem, Ramsey-eliminability, and other devices of the received view "were one and all off the mark—solutions to purely self-generated problems, and philosophically irrelevant." The passage can be read as denouncing only the $\mathscr{O}/\mathscr{T}$-bipartition or syntactic descriptions of the theory-observation relation in general. Van Fraassen's arguments support only the former, but his mention of Craig's theorem and his other remarks suggest the latter, stronger reading.

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Criticisms like van Fraassen's have lead to the demise of the received view and the use of syntactic methods in the philosophy of science. Instead, the so-called semantic view, which focuses on structures rather than on sentences, has become almost the new orthodoxy.

In my talk, I show that van Fraassen's own conception of the relation of theory and observation has a syntactic counterpart and even a counterpart based on an $\mathscr{O}/\mathscr{T}$ bipartition. My arguments rest on some well-known results in model theory; hence my talk can be seen as a case study of the fruitful application of logic and model theory to disputes in the philosophy of science. In this case, it leads to a vindication of the received view.

Van Fraassen's semantic view of scientific theories is meant to be language independent in that the specific vocabulary does not matter. He suggests instead that a theory be described by a class of structures ("the models of the theory"), which is closed under isomorphism and can be given in vastly different vocabularies. To describe an empirical theory, each structure of the class has to have a distinguished substructure, its "empirical substructure". Observations are described by a single structure. Van Fraassen's core relation between theory and observations is empirical adequacy, which holds iff one of the empirical substructures of the theory is isomorphic to the observational structure. Since the class of structures of the theory is closed under isomorphism, this is equivalent to the observational structure being an empirical substructure of the theory.

The problem with the denouncement of language and vocabulary by van Fraassen and other proponents of the semantic view is that model theory relies on a vocabulary for the definition of 'structure', and consequently 'isomorphism' and 'substructure' are not defined for structures without vocabularies. I give an explication of structure that is less language dependent than typical explications within the semantic view, and I show that even under this explication, structures can be associated with vocabularies in a way that the relations between structures without vocabulary hold iff the normal model theoretic relations hold.

In my talk, I will assume that the class of structures is given as the class of models of a set of sentences, so that structures can be described at best up to elementary equivalence. The semantic view describes structures directly in the metalanguage, and can thus be more fine-grained because it can describe theories up to isomorphism. However, this is not the topic of my talk: I am only interested in the relation of a successfully described theory to the successfully described observations, not the conditions for the success of their description.

Since an empirical theory T has designated empirical substructures, it has a predicate O designating observable objects and it fulfills the admissability conditions for relativization to O. The relativization theorem (Hodges 1993, theorem 5.1.1) then shows that all empirical substructures of T are models of $T|_O := \{\varphi : \varphi \between (\varphi)^O, T \vDash \varphi\}$, where $(\varphi)^O$ is the relativization of φ to O. Conversely, maybe all observational structures (i. e. models of $\forall x Ox$) that are models of $T|_O$ are empirical substructures of T, but this is a matter of further investigation. Until then, it can be stated that some observational structure of a set of observation sentences Ω is an empirical substructure of a theory T iff $T|_O \cup \Omega$ is consistent. This then gives a syntactic description of empirical adequacy. It is noteworthy that Craig's theorem is applicable to $T|_O$, that is, if T is axiomatizable, then $T|_O$ is also axiomatizable. Van Fraassen's view does not render Craig's theorem irrelevant.

Since the core of the received view is the $\mathscr{O}/\mathscr{T}$-bipartition, I note that a theory T can easily be given a bipartitioned language by designating T's vocabulary as $\mathscr{T}$ and introducing a new theory $T \cup C$ with the correspondence rules C containing identity statements between the names in $\mathscr{T}$ and the names in a new set $\mathscr{O}$. The models of T and $\mathrm{Cn}(T \cup C)|\mathscr{O}$ (the implications of $T \cup C$ that contain only $\mathscr{O}$-terms) are identical up to the renaming of the constants, and some observational model of Ω in $\mathscr{O}$ is, after renaming, an empirical substructure of T iff $T \cup C|_O \cup \Omega$ is consistent.

For a stronger result, one can use the model-theoretic fact that any class of empirical substructures $\{\mathfrak{A}|_O : \mathfrak{A} \vDash T\}$ of a theory T is a pseudo-elementary class $\{\mathfrak{A}|\mathscr{O} : \mathfrak{A} \vDash T^*\}$ for some theory T^* with at most as many non-logical constants as T (Hodges 1993, theorem 5.2.1). T^* can be seen as a rational reconstruction of T that allows for the analyses given within the received view. Thus T is empirically adequate in light of observational structure $\mathfrak{O}$ iff $\mathfrak{O}$ can be expanded to a model of T^*, which is just the Ramsey-eliminability of the $\mathscr{T}$-terms. Van Fraassen's view does not render Ramsey-eliminability irrelevant.

A last possibility to accomodate van Fraassen's concept of empirical adequacy in the received view uses a set of correspondence rules C that identify the constants of $\mathscr{O}$ and $\mathscr{T}$ only over the extension of O. This allows a syntactic definition of something very close to empirical adequacy whenever the observation statements do not restrict the number of non-O objects: Under this condition, $T \cup C \cup \Omega$ is consistent iff the relativization of a model of Ω to O is, up to renaming, an empirical substructure of T.

The upshot of these results is that the semantic conception of the theory-observation relation proposed by one of the most vocal opponents of the received view and syntactic conceptions in general can be captured both syntactically and even within the received view. This allows for the application of results obtained within the received view, and hence is both a vindication of the received view and a contribution to the semantic view.

References

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