McGILL UNIVERSITY

Foundations and Philosophy of Science Unit

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Professor Carl G Hempel
6 Rumbold Road
London SW6 / England

Dear Professor Hempel

Thank you very much for your letter of January 23rd. It considerably clarifies in my mind your reasons for first upholding, then criticizing the "standard" conception of the semantics of science. I still think the arguments, pro and con, are relevant to an empiricist semantics not to a realist one. I believe it is possible to marry a realist semantics to an empiricist methodology. In any case here goes my reply to the points you make in your letter.

1 The semantic formulas (denotation rules and representation assumptions) of a factual theory are neither proposed not upheld arbitrarily but in the light of empirical evidence. When Dirac proposed that the negative energy solutions to his equation be interpreted as referring to protons and representing the states of the latter, he was promptly corrected. Someone pointed out that this (semantic) assumption conflicted with the explicit assumption that there was a single mass value involved, and somebody else proposed that those quaint solutions refer to, and represent, positrons, which were discovered shortly after Dirac's theory had been published. It is the whole theory, formalism <u>cum</u> semantics, that has a factual (not an observational) meaning and is subject to empirical tests. A battery of empirical tests may force changing (a) only the formalism, (b) only the semantic formulas, or (c) the whole thing. I presume case(a) is more frequent than case (b), which is in turn more frequent than case (c), i.e., revolution. But it is up to historians to say.

2 To say that the vector valued function E occurring in the theory of electricity refers to an electric field, and that its value E(f,x,t) represents the value of the field intensity at x and t , does not make the theory true <u>a priori</u>. A semantic assumption is as corrigible as an equation. Thus in Maxwell's time the tendency was to regard 'E(a,x,t)' as an elongation of an aether particle a at point x and time t. It is only since special relativity that we speak of fields without the support of either aether or particle. However, it might be that future developments force us to change our semantic assumptions once more. If we are to believe some physicists such a change has already occurred: we must regard E as concerning a virtual photon. (But I don't believe in virtuals.

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3 We must have interpretation statements (denotation rules and representation assumptions) in a scientific theory: otherwise only an ambiguous mathematical formalism would remain. Consider the equation

$$dF/dt = - kF$$

It occurs in practically every scientific field, but every time attached to its own set of semantic formulas. If 't' is interpreted as time and 'F' as the number of individuals in a population with fixed food supply, the equation gives a (rough) representation of the gradual dying out of the population. But if 't' is interpreted as distance and 'F' as light intensity, then the equation represents the gradual extinction of a light beam when traversing a transparent material. And so on and so forth. The point is that the semantic assumptions should be realist: they should associate constructs to things and their properties not to data. Among other reasons because data can never be gathered with the sole help of the theory of interest.

4 You worry about the possibility that, if enriched with interpretation formulas, a theory may become true by fiat. This won't be the case if the interpretation assumptions are regarded as being as corrigible as the mathematical formalism. But it will be the case if, following Suppes or Freudenthal, one claims that a theory defines its object - e.g., that Maxwell's theory constitute an axiomatic definition, not just of the concept of an electromagnetic field, but of the referents of the latter. (I call this view axiomagic.) That danger attends also the strict operationist interpretation of a theory. Thus most partisans of the Copenhagen interpretation of quantum mechanics claim that the eigenvalues of the dynamical operators constitute the possible experimentally obtained values of the corresponding physical quantities: the theory gives thus all the empirical items one may get in the laboratory - whence either the theory or the laboratory becomes redundant. None of these two extreme results occurs in a realist semantics.

5 As to the problem of understanding new theoretical terms, I agree it is an interesting one. But in my view this is a psychological (or pragmatic) problem not one for semantics. One should not care less if, in the beginning, nobody but Maxwell understood his field theory: semantics cannot be democratic. Moreover, the requirement that all theoretical terms be clearly understood (rather than determined by the theory in which they occur) may lead to disasters, such as banning relativistic theories because they are not intuitable. If someone does not understand a given construct that's his personal business, not semantics'. The only thing one can do is give him the standard advice: 'Study the theory, play around with it, apply it to a number of special problems, and understanding may come. If it does not, blame yourself not the theory.' An explicit semantics for every factual theory, yes; one within the grasp of everybody, no.

I hope you and Mrs Hempel are having a good time in old merry England. We'll spend next year in Europe, probably in Denmark, but I plan to visit you in Princeton.

Sincerely

Mario Bunge