Animadversions against the Semantic View;
The Fundamental Problem with Contemporary Semantics;
and The Fundamental Problem of Semantics

Erik Curiel

Munich Center For Mathematical Philosophy
Ludwig-Maximilians-Universität

and

Black Hole Initiative
Harvard University

erik@strangebeautiful.com

The vague accuracies of events dancing two
and two with language which they
forever surpass

William Carlos Williams
Paterson, I.2

In theory, there's no difference between theory and practice.
In practice, there is.

Yogi Berra

Outline

The Semantic View in a Nutshell
(where it belongs)

Tarskian (Beth, . . .) semantics

1. a theory is (or is characterized by) a set of models: a domain of entities with a (set-theoretic) structure imposed on them
2. the meaning of the terms in any linguistic representation of the theory is fixed by a Tarskian interpretation based on the domain and its structure

virtues

- clarity, precision, rigor
- clean separation of epistemology ("analytic relation to truth") from methodology ("human concerns")
- captures "internal structure" of theory
- supports rich set of operations for analysis of intra- and inter-theory relations and structures

consequences

- all semantic content resides in individual models; models among relations cannot encode semantic content
- all formal quantities and relations always have same semantic content irrespective of context
- cannot investigate/discuss physically meaningless "quantities"
- no distinction in semantic kind among different propositions
- theories tell us what the world would be like if the theory were true of it, nothing more and nothing less

inter-model relations with semantic content

- whether the equations of motion have a well set initial-value formulation (*e.g.*, stability of solutions under small perturbations), a relation among solutions (models)
- global structures on the space of solutions (models) to the equations of motion, encoded in relations among solutions (models)
  - the natural affine structure on space of solutions to Newton's Second Law encodes kinematic link between configuration and velocity, *i.e.*, the definition of dynamical derivatives
  - the Poisson brackets in Hamiltonian mechanics defines the symplectic structure

the semantic view cannot account for such semantic content for **Tarskian semantics does not allow semantic content to accrue to inter-model relations**

Even more: one cannot even formulate the dynamics, cannot even check whether a given system satisfies the equations of motion, until one has these global structures in place.

same predicate, different physical significance

momentum in Newtonian mechanics represented by a vector in 3-dimensional Euclidean vector space; addition means different things in different contexts:

- result of physical interaction (*e.g.*, particle collision)
- calculation of factitious quantity (*e.g.*, center of momentum)

the semantic view does not allow one to distinguish between them, but vector addition in the two cases has, respectively, a profoundly different semantic content (meaning)

$$(\mathbf{v} \cdot \mathbf{x})\, \mathbf{a} \times \mathbf{v} \times \mathbf{x}$$

two choices

1. if not included as a "predicate" in the model, the semantics does not allow me to say why it is physically meaningless (I can't even "refer" to it in the semantics)
2. if included, the semantics does not allow me to say why it is physically meaningless (no higher-order predicate "is physically meaningful"; no predicates allowing me to express, *e.g.*, it has meaningless physical dimension; *etc.*)

I take a prediction to be something that a theory, while meaningfully and appropriately modeling a given system, can still get wrong. Newtonian mechanics does not predict $\mathbf{v} = \dot{\mathbf{x}}$; rather it requires it as a precondition for its own applicability. It can't "get it wrong". If such propositions ("kinematical constraints") required by a theory do not hold for a family of phenomena, that theory cannot treat it, for the system is of a type beyond the theory's scope.

If the equations of motion are not satisfied, that may tell one only that one has not taken all ambient forces on the system (couplings with its environment) into account; it need not imply that one is dealing with an entirely different form of system. Even in principle, one can never entirely rule out the mere possibility that the equations of motion are inaccurate only because there is a force one does not know how to account for, not because the system is not accurately treated by those equations of motion.

This can never happen with a kinematical constraint. It is either satisfied, to the appropriate and required level of accuracy given the measuring techniques available and the state of the system and its environment, or it is not. No external force, no coupling of system with environment, can alter it.

Example: Navier-Stokes Theory

- predictively inaccurate for fluids near turbulence or not near thermodynamical equilibrim
- all quantities it attributes to systems (fluid velocity, pressure, shear-stress, heat flux, *etc.*) still well defined
- all kinematical constraints satisfied (symmetry of shear-stress tensor, heat flux orthogonal to fluid flow, *etc.*)
- Navier-Stokes still meaningfully applicable to such systems for, *e.g.*, characterization of quantities (and their break down) and guidance in design of probing instruments

the semantic view cannot explain or even accommodate this, for **Navier-Stokes has no Tarskian model of such systems**

BUT inaccurate schematic representations, which are not Tarskian models, have important semantic content: it is surely part of the meaning—the semantics—of the theoretical term ‘pressure’ that its significance does and does not break down under certain conditions.

Tarskian models do not exhaust the representational capacity of the theory, and the theory gains non-trivial semantic content from everything it can signicantly represent, whether in all accuracy or not; alternatively, the set of possible worlds picked out by the obeying of the equations of motion is not a rich enough family of worlds to express or encode all the information the theory can give us about the possibilities of the actual physical world; the theory tells us more about physical quantities like pressure in the actual world than there would be to learn about it in a world the theory would be true of.

It is exactly because we can distinguish between, on the one hand, necessary preconditions of applicability of the theory (the analytic kinematical constraints), which themselves yet have non-trivial semantic content, and, on the other, the theory's predictions that the theory can be appropriately used to represent systems it is predictively inaccurate for.

the semantic view is **not adequate** as an account of the semantics of physical theories

perhaps a formal extension or modification would work, but I doubt it; I think we need a new approach altogether

All these problems boil down to the use of essentially truth-conditional semantics ("...to understand a sentence, to know what is asserted by it, is the same as to know under what conditions it would be true." Carnap, *Introduction to Semantics*), in conjunction with *designation* as the fundamental semantic relation.

Tarskian semantics assumes a kind of Fichtean direct intellectual grasp of the world by our representational systems: the posited relation between our symbolic systems and the "objects in the world" (irrespective of whether one is a realist about such things or not) is unmediated by the actual state of our knowledge and by the practices and techniques we have for probing, experimenting on, and more generally investigating the world.

Have we learned nothing from Kant? What sense is there in trying to articulate "truth conditions" that are forever beyond our cognitive grasp?

(I blame Quine and Lewis)

What was wanted was an account of “meaning” analytically connected to truth, completely divorced from human concerns. But this is self-defeating, for such a conception *eo ipso* completely divorces, unbridgeably separates, semantics from the *fundamental sources* of empirical knowledge—experimental knowledge—which in the end must ground the empirical content and significance of our theoretical representations.

Magical relations of “direct designation” serve—can serve—no philosophical or foundational purpose. They can tell us nothing about meaning. They are vacuous chicanery, nonsensical chimeræ.

This criticism implies (assumes) a link between semantics and knowledge *in all its human forms*: as achieved state; as mediator of evidentiary relations and provider of epistemic warrant; and as ground for the successful continuation of the scientific enterprise, the extension and deepening of the first kind by application of the second.

I think this must be right, that there must be such a link between semantics and real human knowledge. A semantics completely divorced from our actual state of knowledge (as achieved state, as provider of evidentiary relations for epistemic warrant, as guide to future investigation) and from the ways we have of improving our epistemic state is utterly useless.

These criticims do not apply to the use of Tarskian semantics in logic and mathematics, where one cannot cleanly and unambiguously separate our symbolic systems from the objects they purport to represent; or, at least, the kind of access we may have to such objects, is mediated only by the symbolic systems, not by experimental practice.

We must expel from philosophy the myth of a "human-free" semantics.

All aspects of scientific knowledge, not just the "ontological", should be reflected to at least some degree in a theory's semantic content, and most of all that knowledge ultimately grounding the semantic content—and that is indubitably, inextricably, inexorably experimental in large part.

This view may entail a blurring of the lines between the traditional conception of semantics and pragmatics (in the sense of semiotic), but that, I think, is all to the good, since the traditional notions are (*pace* Carnap, Suppes, *et al.*) appropriate for mathematics, not the empirical sciences. In any event, I am not convinced that one needs to lose a sharp distinction between semantics in a formal sense and pragmatics in order to ground the kind of view I advocate—one needs only to characterize semantics in a way that is not wholly "ontological".

(*Cf.* Stalnaker on being able to formulate a sensible account of the semantics of a language only after one characterizes the pragmatics.)

Much of what the Tarskian view by its nature must leave to the pragmatics does not properly belong there. That addition of momenta in different contexts means something different does not turn on the fact that this or that individual investigator employs it differently. The two uses differ in intrinsic physical significance, the sort of thing, if anything, a semantics ought to capture.

Return to Carnap

Divorcing semantics from real human epistemology means that we lose the capacity to analyze in a principled way how epistemic warrant accrues to scientific propositions, and, more importantly, to investigate how different amounts of warrant accrue to different propositions, and how much warrant a given proposition should have. This must be based on our understanding of the connection of theory with experiment.

Semantics must ground analysis of epistemology, and be grounded in turn by our grasp of it.

NOT

$$\begin{aligned} \text{semantics} &\approx \text{ontology} \\ \text{pragmatics} &\approx \text{use} \end{aligned}$$

RATHER

$$\begin{aligned} \text{semantics} &\approx \text{epistemology, methodology} \\ \text{pragmatics} &\approx \text{acceptance, choice} \end{aligned}$$

The Slogan

Meaning comes before truth.

A necessary condition for a collection of (possible) physical systems to hang together in the right way, to share a common structure, to form a unified kind, in the sense of being adequately treated by a single theory, is that they all share a common breakdown scale: a "place" where all the dynamically relevant structures of the theory break down all at once, in the sense that the theory becomes inadequate for an appropriate, accurate treatment of any of the systems in the collection. This place is not characterized by anything internal to the theory, but is rather always external to the theory, not a proper part of it, determined by empirical investigation.

It can't just be a single numerical scale. (Navier-Stokes theory becomes inadequate for different fluids at different energies and spatial and temporal scales.) It can't just be a measure of a single quantity (always an energy scale, always a spatial scales, *etc.*): classical Maxwell theory, *e.g.*, breaks down when the ratio of the amplitude to the frequency approaches $\hbar$ (action). It can't be that there is always a single characteristic scale for each theory. (Navier-Stokes theory fails in the approach to turbulence, and also when the fluid is too viscous, and also in the regime where it tries to specify behavior at time scales comparable to equilibration time after disturbance.) Breakdown scale is rather something like the following: a measure of or function of or relation among kinematical and dynamical quantities.

Regime of Propriety

The physical regime bounded on all sides, in all ways, by all the breakdown scales of a theory. In that regime, the theory's representational resources are apprpriate for modeling the kinds of system at issue.

The regime of propriety must be included as part of the semantics—at least so far as a real semantics of a real physical theory goes, not just a formal semantics of a formal theory: if I don't know the class of actual (and *physically*, not mathematically) possible systems the theory applies to, I don't, by the ontological semanticists' own lights, know the semantics; but if I don't know the regime, I don't know that class; and nothing in the formalism of the theory itself can tell me the regime.

A real semantics must indicate how empirical significance accrues to theoretical representations, and since the metaphysics of bare truth conditions cannot do this, we need a semantics that shows how and where the formal structure of theory is adapted to make substantive content with experimental knowledge, so as to be informed by it.

By it's very nature, anything like a Tarskian semantics cannot include the representation of actual experiments as part of the semantics, in the sense that the modeling of the experiment itself informs the semantic content of the theory.

Because the meaning of scientific terms and propositions must rest on the knowledge we have of the physical world, and most of all on the knowledge we have gained through controlled observation and measurement, that is, through experiment, semantic content accrues to a scientific theory in no small measure through the successful construction of representations of physical systems in the theory's terms. At bottom, then, what secure semantic content a scientific theory has must rest on the meanings expressed in the sound articulation of experimental knowledge.

This requires at a minimum that we be able, at least in principle, to construct appropriate representations of actual experiments and observations in the frameworks of our best scientific theories, that is, representations of physical systems and experimental apparatus in relation to each other as required by particular, actual experiments, not just representations of physical systems *simpliciter*, in abstraction from actual experiments.

Schematic representation of experiment is needed in order to capture *all* aspects of scientific knowledge in the semantics of a theory, *viz.*, also that part manifested and embodied in experimental practice—including, *inter alia*, the representation and analysis of the results of experiments.

(Compare Suppes' "hierarchy of theories and models".)

. . . we have no language at all in which there are well-defined logical relations between a theoretical part that incorporates fundamental physics and any observational part at all—no framework for physics that includes observational terms, whether theory-laden or not. . . . I cannot think of any case in which one can honestly deduce what might honestly be called an observation. What can be done, rather, is to represent . . . "schematically," within the mathematical structure of a theoretically characterized situation, the position of a "schematic observer," and infer something about the observations such an observer would have.

Howard Stein
"Was Carnap Entirely Wrong, After All?"

We do not have a formal semantics of the theories of theoretical physics even minimally adequate for any account of their actual empirical application; this is not to say that such applications in real scientific practice have no foundation or are unjustified, only that we have no adequate comprehension of the process. Forget how we get the theory into or out of the laboratory—how do we get the laboratory into the theory? This, I think, is the fundamental problem one must address in trying to give an account of the semantics of scientific theories.