From Carnap via Kuhn to Stegmüller
–
The Development of Structuralist Philosophy of Science

HOPOS 2012
Halifax, Nova Scotia

Thomas Meier
LMU Munich
Doctoral Fellow
Munich Center for Mathematical Philosophy

June 21st, 2012

Main Thesis:

- Carnap's program of logical reconstruction of concepts from the *Aufbau* is analogous with the structuralist program of logical reconstruction of scientific theories.

- Kuhn's ideas are precisely reformulated in a formal framework with the Sneed-Stegmüller structuralist approach.

Content

1.Carnap: Structural descriptions in the Aufbau

Carnap's *Aufbau*:

- A program for logically reconstructing our knowledge of the world in structuralist terms. This means that the descriptions of our knowledge are structural descriptions.

- What would be the connection between the *Aufbau* and structuralist philosophy of science?

- Moulines (1991):

  To be more precise, the use of Carnap's Aufbau I propose here consists in reinterpreting Carnap's "Konstitutionstheorie" as a formal explication of the notion of an ideal observer, i.e. an epistemic subject provided with the essential constituents of an ideal "observational language" to check any empirical statement made in theoretical science (ibid: 265).

- In structuralist philosophy of science, the primary aim is to provide a program for analyzing science. This concerns issues of logical reconstruction of theories, but also intentions of describing the social phenomena of the scientific enterprise. There is no ideal observer in the sense of Carnap, but there is also the motivation of applying logical tools in order to reconstruct our knowledge of the world.

In the *Aufbau*, §16, Carnap introduces his structural descriptions of knowledge. Following him, only such descriptions guarantee objectivity:

- Carnap (1928): *Every scientific statement can in principle be so transformed that it is only a structural statement. But this transformation is not only possible, but required. For science wants to speak about the objective; however, everything that does not belong to the structure but to the material, everything that is ostended concretely, is in the end subjective. From the point of view of constitutional theory this state of affairs is to be expressed in the following way. The series of experiences is different for each subject. If we aim, in spite of this, at agreement in the names given for the objects constituted on the basis of the experiences, then this cannot occur through reference to the completely diverging material but only through the formal indicators of the object-structures.*

Furthermore, in §66, Carnap gets more concrete:

- *How should science come to objectively valid statements, if all its objects are constituted by an individual subject? . . . the solution to this problem lies in that of course the material of the individual streams of experience is completely diverging . . . but certain structural features agree of all streams of experience. Science has to restrict itself to such structural properties, since it aims to be objective. And it can restrict to structural properties, as we have seen earlier, for all the objects of knowledge are not content, but form, and they can be represented as structural entities.*

- The *Aufbau* is an outline of the epistemological program of early logical empiricism. This is a view which is different from structuralist philosophy of science.

- Nevertheless, in the *Aufbau*, as in structuralism, there is in both **the emphasis on structural descriptions of our knowledge of the world**. In structuralism, this description is made of our empirical theories, when in Carnap's program, structural descriptions are provided directly of our knowledge.

- Still, both share the view that our knowledge should be best described in form of structures. When Carnap starts with structurally describing our knowledge of the world, structuralism describes this knowledge indirectly, through the structural description of our empirical theories.

2. Kuhn's conception of theory change

- A scientific community is a group of people that shares and uses the same paradigms.
- **Normal Science:** Scientific activity as "puzzle-solving". Scientific research is guided by a paradigm. Anomalies can occur, this can lead to a crisis in a certain field. Such a crisis can, but must not lead to extraordinary science.
- **Extraordinary Science:** One paradigm is substituted by a new one. A scientific revolution occurs. The scientists which were applying the old paradigm cannot successfully communicate with the scientists obeying to the new paradigm.

- **The four components of a paradigm:**

1. **Symbolic generalizations:** In order to comprise knowledge, certain symbols are introduced and generalized. A concrete example are equations as symbolic generalizations.

2. **Models:** There are heuristic models and ontological models. Heuristic models are mere fictions, the ontological models do correspond partially with the world. Example: We imagine that planets and stars are actually round, only for practical reasons.

3. **Values:** The methodological values shall guide the scientific research and raise questions of technological applicability, ethic questions and also questions of the coherence of the research. Example: Certain research areas might not be addressed for ethical reasons (genetic engineering, nano-technology, etc.). Or: We accept the methodological value of theory-simplicity.

4. **Exemplars:** These are the paradigmatic applications, the concrete instantiations of a paradigm. Such concrete cases show, how a paradigm actually works. These are the especially well-working intended applications of a paradigm.

Kuhn (1976) recognizes explicitly the enriching contribution to his program provided by Sneed and in a more systematic way by Stegmüller:

> *To a far greater extent and also far more naturally than any previous mode of formalization, Sneed's lends itself to the reconstruction of theory dynamics, the process by which theories change and grow ...*
>
> *Sneed also suggests and Stegmüller elaborates the possibility that at least some cases of change of core correspond to what I have called scientific revolutions ...*
>
> *Though the Sneed formalism does permit the existence of revolutions, it currently does virtually nothing to clarify the nature of revolutionary change. I see, however, no reason why it cannot be made to do so, and I mean here to be making a contribution toward that end (ibid: 184).*

3. Structuralist philosophy of science

- Sneed's 1971 *The Logical Structure of Mathematical Physics* is the pioneer work of structuralist philosophy of science. The methodological tools of this view are developed there and applied to mathematical physics.

- Though Sneed's original proposal is mainly motivated in providing a logical framework in a *non-statement-view* for the description of the logical structure of physical theory, in chapter seven he mentions the field of theory dynamics. This part is what relates to Kuhn's philosophy of science.

- Stegmüller's *Theorienstrukturen und Theoriendynamik* (1973) can be seen together with Sneed's (1971) as the main work in the early development of the structuralist view. Stegmüller offers a detailed analysis of Kuhn's concept of paradigm.

Moulines (2008: 163) explains the methodological motivation of the structuralist view as follows:

Structuralism owes his name to the fundamental thought that the most adequate way of interpreting and understanding what a scientific theory is, does not consist in conceiving it as a set of statements, but rather in conceiving it as a form or collection of different types of complex structures, which themselves are built up of simpler structures.

- In **structuralist philosophy of science**, an empirical theory consists of its models, which are sequences of the following form: $\langle D_1, ..., D_m, R_1, ..., R_n \rangle$

- The D_i are so-called basic sets and the R_j are relations constructed on these sets. The elements of the D_i comprise the ontology of the theory, i.e. they contain the "objects" of which the theory is about.

- The R_j are usually functions. They usually are functions mapping empirical objects into the real numbers, or some other mathematical entities.

- An example (Balzer, et.al. 1987: 26-27), the *potential model* M_p of *Classical Collision Mechanics*:

(1) $M_p = \langle P, T, \mathbb{R}, v, m \rangle$

(2) P is a finite, non-empty set

(3) T contains exactly two elements

(4) $v : P \times T \rightarrow \mathbb{R}^3$

(5) $m : P \rightarrow \mathbb{R}^+$

P is a set of discrete bodies (that can be called "particles"), T is a set of instants. v is the velocity function, assigning to each particle p and point of time its velocity as an element of $\mathbb{R}^3$. Velocity is a time-dependent vectorial function whose range are triples of real numbers. It assigns a three-component vector (one component for each direction in space) to each particle at each time. m is the mass function, assigning to each particle its mass.

Sneed (1971) explicitly mentions the relation between his work and Kuhn's proposals:

> *We are now in a position to indicate how Kuhn's thesis, or our version of it for theories of mathematical physics, provides a means of remedying this . . . The idea is simple. It is certainly plausible to think that the initial successful application of the core of the theory is essentially the same for all those who have the theory. Different people who have the theory at a later time in its development may believe different statements. They may be more or less clever in seeing ways to extend the theory, and more or less successful in convincing their colleagues what evidence supports the claims they make with the theory. ...it is quite clear that Kuhn's thesis strongly suggests that we should modify our notion of what it is to have a theory of mathematical physics so as at least, to require that everyone who has the theory has it "because of" the same initial success (ibid: 292-293).*

Sneed later recognizes:

Again in Kuhn's terminology, we have said very little about "scientific revolutions" as they occur in mathematical physics. I confess, at the outset, that this is a subject about which I find it extremely difficult to say anything that is both precise and interesting. Nevertheless, the view of the logical structure of theories of mathematical physics I have been defending does appear to have some consequences relevant to such questions...(ibid: 296).

Stegmüller mentions a relativized a priori:

> *The reason that we may only speak of a relative a priori is that no core, be it ever so sophisticated and yield it ever so many successful expansions, can be guaranteed never to get caught in an a priori conflict with some future alternative and go down before it because this opponent can "deal with anomalies which it cannot"...*
>
> *...Kant claimed that his theory reconciled rationalism and empiricism, the a priori and the empirical components in the scientific process. The reconstruction of Kuhnian theory dynamics with Sneed's conceptual apparatus is perhaps a better candidate for this job (ibid: 218).*

- The relativized a priori, following Sneed-Stegmüller structuralism, is the theory-core K. What is subject to changes are the intended applications of a theory.

- Besides Stegmüller, Friedman (2001) also mentions a relativized a priori in the philosophy of science. His conclusion about a stable core which can also undergo changes, is very much alike to the view advocated by Stegmüller.

- Beside the methodological analogy between Carnap and structuralism about structural descriptions and the relative a priori, which Stegmüller advocates with reference to Kuhn, there is **one more point in common** between Carnap and the structuralist program:

$\rightarrow$ That is, the supposed neutrality of Carnap's constitutional system in the *Aufbau* concerning metaphysical questions of realism. This is also the "standard" position of the structuralist program, where no position concerning the realism debate is adopted.

- Several of the main representative figures of the structuralist view have pointed this out: Moulines (2008: 189), or Sneed (1983).

- Stegmüller's monograph *Der Phänomenalismus und seine Schwierigkeiten* (1958) and Moulines' *La estructura del mundo sensible* (1973) are both works especially dedicated to an analysis of the *Aufbau*.

- It is clear that at no point, structuralism refers explicitly to Carnap's *Aufbau* as their primary source of information and motivation. The direct motivation for the methodological tools for structuralism can rather be found in Suppes' (1957) method of defining set-theoretic predicates.

- Notwithstanding, there are many indices to suppose an "indirect" connection between the early Carnap and the structuralist program.

- Although Carnap's logical method of expressing our knowledge in purely structural terms is strictly speaking not equivalent to what in structuralism is usually taken to be the right logical tool for analyzing empirical theories, in both approaches, there is a primary focus on structures.

- Carnap aims to describe our knowledge of the world in purely relational terms. Structuralism describes our knowledge of scientific theories in structural terms.

4. Summary

- In the *Aufbau*, the main aim is to provide a logical method for the reconstruction of our knowledge of the world.
- Such a description is provided by purely structural (relational) descriptions.
- Sneed-Stegmüller structuralism aims to describe the logical structure and the dynamics of scientific theories. As scientific theories are taken to be our most sophisticated, elaborated and systematized descriptions of our knowledge of the world, it is, as in Carnap's, an intent of reconstructing our knowledge of the world. It just starts from the reconstruction of our empirical theories and is in this sense, not a direct, but an indirect description.

- Kuhn's ideas about revolutionary theory change are reformulated in a logically precise sense in structuralism.

- Within the framework of structuralism, it is formally visible how theories actually change through time and how these are interrelated in every single case. The dynamics of scientific theories are modeled logically, not only metaphorically, as in Kuhn.

- Stegmüller alludes to a relative a-priori, which he associates with the structuralist conception of what a scientific theory is.

- The whole structuralist program is addressing a wider range of questions than modeling theoretical change. But one core part of Stegmüller's contribution to the development of structuralism is his analysis of Kuhn's ideas on theory change and also his application of a structural view of our knowledge about empirical theories.

Thank you!

This work is funded by

Alexander von Humboldt
Stiftung/Foundation