A Philosophical Structuralism

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Abstract*: In philosophy, a version of structuralism was developed by logical positivists, independently of linguistic structuralism. It shares enough features with the linguistic structuralism originating from de Saussure, however, to deserve the designation. Although this philosophical structuralism has a different point of departure, it is shaped by some of the same intellectual forces that produced structuralism within linguistics. First, logical positivist philosophy of science was focused on structure rather than content. Second, the structure in question was linguistic. Third, logical positivist philosophy of science was synchronic rather than diachronic, being studiously ahistorical. These points suggest a deep motivation shared by both kinds of structuralism, viz. their commitment to an ideal of science modelled upon the most abstract parts of natural science, where theories are defined by their purely formal-mathematical features. These methodological commitments, moreover, were also useful in neutralizing some ideological tensions within logical positivism itself. Harking from its early, Vienne Circle days, the movement was split between a physicalist, materialist (and socialist) and an idealist (and liberal) wing. In his monumental early work, Der logische Aufbau der Welt, Rudolf Carnap tried to defuze this conflict by insisting that the systematic "constitution" of the total body of scientific knowledge out of simpler elements is purely a matter of relations (= structure), not of the nature of the relata.*

Keywords: Philosophical structuralism, logical positivism, Rudolf Carnap, constitution of scientific knowledge

1. Introduction

Structuralism, as a style of theory formation originating in linguistics, has gained ground in certain sectors of philosophy – although ironically, especially in the form of a *post-structuralism* that overcomes structuralism in the same moment as holding on to some of

its key tenets. Michel Foucault (1926–1984) and Jacques Derrida (1930–2004) are the best-known representatives of this trend.

Within philosophy, an indigenous structuralism was developed by logical positivists, independently of linguistic structuralism. It shares enough features with the linguistic structuralism originating from de Saussure, however, to deserve the designation. Moreover, although this philosophical structuralism has a different point of departure, it is shaped by some of the same intellectual forces that produced structuralism within linguistics, in addition to some concerns of its own. Hence, an examination of philosophical structuralism will throw some light upon the roots of linguistic structuralism.

Here are some of the features shared by the two species of structuralism. In the first place, logical positivist philosophy of science was focused on structure rather than content. Second, the structure in question was linguistic. Third, logical positivist philosophy of science was synchronic rather than diachronic, in the sense of being studiously ahistorical. These points suggest a deep motivation shared by both kinds of structuralism, *viz*. their commitment to an ideal of science modelled upon the most abstract parts of natural science, in particular theoretical physics. Theoretical physics aims to articulate laws of universal scope, which is typically taken to mean laws with no temporal or spatial restrictions. From this point of view, the fact of temporal development and history becomes an embarrassment, with no grounding in natural laws in themselves but just an effect of the accidental constellation of objects on which the laws operate (the "initial conditions" of deductive-nomological explanation, in logical positivist lingo). Moreover, to uncover such general truths, it is necessary to neglect the richness and diversity of immediate human experience. The scientific understanding of a phenomenon must necessarily break away from immediate human experience and the everyday conception of the world; that which Husserl would call the "lifeworld". Fourthly, since natural science accords a key role to mathematics and precise logico-formal articulation, mathematics and logic were viewed by both schools as key intellectual tools.

The history of science is largely a story about how the scientific picture of the world would gradually diverge ever farther from the

way it presents itself within the human lifeworld. Quantum Mechanics and Relativity Theory teach us that even space and time are quite other than the way they appear in human experience. In abandoning the phenomenal realm, science achieves greater objectivity, testability, and generality. This has been the formula for success in the natural sciences, and structuralism takes these sciences as its model.

However, logical positivism combined this adoration for natural science with a firm commitment to the experiential basis of science. This went beyond the obligation of science, definitory of the very enterprise, to investigate reality by means of observation and experiment: It was a concern to free science of the deadweight of metaphysical impurities left over from past historical modes of thinking. This agenda represents a continuation of classical British empiricism and its project to get rid of meaningless verbiage and commit any text containing it to the flames (cf. Hume 1748, sect 12, pt 3). Meaningfulness could only be preserved by grounding talk securely in human experience.

It would be tempting to see the split personality of this philosophical school to be reflected in the dual names under which it is known, "logical positivism" and "logical empiricism". However, the history of this double appellation is complex and does not allow such simple explanation. But by any name, logical positivism/empiricism combined what might be termed "scientism" with an epistemology and semantic theory that accorded a key function to elementary sensory experience. The scientist and empiricist aspects represent two somewhat different agendas that could proceed in tandem at the start, but which were soon forced apart by developments within logical positivism/empiricism itself.

Contrary to a popular misconception of logical positivism, the loser in this battle would be the scientistic agenda. Logical positivism is often incorrectly held to express natural scientists' "spontaneous philosophy of science", but the aim of logical positivism was never to reflect scientific practice but rather to reform it. Developments within the school during its heyday moved it ever farther away from the ways of thought of natural scientists, and its suggestions for the regimentation of scientific theorizing were never

seriously considered by working scientists. This increasing distance left a large space into which Thomas Kuhn would later move with his historico-sociological account of scientific practice, later to be followed by an entire movement committed to a strictly empirical investigation of science, under such names as Sociology of Scientific Knowledge or Science and Technology Studies.

2. Rudolf Carnap and the dual agenda of logical positivism

Logical positivism/empiricism is a highly multifarious philosophical tradition, and it is high time that I make a crucial clarification concerning the subject of this article: The above remarks were made with one particular logical positivist in mind, namely Rudolf Carnap (1891–1970), and apply in full only to him. Still there is a point in extending this characterization to logical positivism in general, since Carnap is rightly regarded as the quintessential logical positivist. This is so for several reasons. He was a philosopher of considerable stature who exerted a lasting influence upon the discipline through his pupils, a factor strengthened by the long span of his active career, as compared with other key figures of logical positivism such as Moritz Schlick (1882–1936), Otto Neurath (1882–1945) and Hans Reichenbach (1891–1953). Thus, he came to define logical positivism for future generations. Moreover, although Schlick, Neurath and Reichenbach each differed from Carnap on important points, Carnap may be seen as the universal logical positivist in his constant effort to mediate and overcome these differences. He did so through his celebrated *neutralism*, of which structuralism is a main element. Carnap's work constitutes a microcosm of logical positivism, and a suitable object of the investigation I will conduct in the following. The purely technical disagreements among the leading logical positivists were exacerbated by an intermixture with the political schism between liberals and materialist Marxists within the Vienna Circle. Moritz Schlick, the founder of the Circle, would represent the former, while Otto Neurath would be the most prominent exponent of the latter position. These are the special features that give logical positivist structuralism its particular flavour.

As Carnap himself indicates in the programmatic piece "Überwindung der Metaphysik durch logische Analyse der Sprache" (Carnap 1932),[1] logical positivism pursues a negative and a positive project. The negative project is the eradication of metaphysics, to be achieved by strict adherence to the empiricist maxim that all statements about the empirical world must be grounded in experience, and experience only. The positive project is to lay bare, and refine, the structure of (natural) science.

This tidy dual picture is a simplification, however, as the two programmes were inextricably intertwined. A substantial part of the positive programme consisted in eliminating metaphysical aspects of science itself, i.e. elements that did not conform to empiricist strictures upon meaning. Beyond this on the positive side, Carnap made important contributions to the analysis of probabilistic reasoning in science, but this would happen largely in the later phase of his career, after his migration to the USA.

It has become customary in recent literature on logical positivism, and especially on Carnap's contribution, to downplay its continuity with classical empiricism. The trend was initiated by Michael Friedman in an important series of articles, later collected in a volume entitled *Reconsidering Logical Positivism* (Friedman 1999). The supposed connection with classical empiricism is dismissed as largely an artefact of Ayer's rather superficial depiction of logical positivism in his widely read book *Language, Truth and Logic* (Ayer 1936). Instead, it is argued, Carnap's thought was rooted in neo-Kantianism, the main concern of which was the objectivity of scientific knowledge. Now, it is indeed true that Carnap received his academic training in the neo-Kantian intellectual environment dominant in Germany in his youth, and his philosophy may be construed as a meta-logical solution to the neo-Kantian search for objective structures in scientific knowledge. But it is equally true, as also documented in the recent literature,[2] that Carnap fought

1. In the following, I quote from the English translation of the article published in Ayer, ed., Logical Positivism. Glencoe, Ill.: The Free Press, 60–81, where it is entitled "Elimination of Metaphysics through Logical Analysis of Language".

2. Friedman (1996).

vigorously against metaphysical speculation in a way that is intellectually continuous with the efforts of classical empiricism. His critique of Heidegger's "existential phenomenology" is a famous (to some philosophers, infamous) and paradigmatic example. This constituted the negative aspect of the logical positivist agenda, and it is undeniable that Carnap was aware of its affinity with the anti-metaphysical efforts of British empiricism, especially Hume. Carnap mentions the "empiricists of the 19th century" in the opening paragraph of the "Wiederlegung" as a previous instalment of the same anti-metaphysical effort, although one lacking the logical instruments needed to succeed. The anti-metaphysical argument reappears in most of Carnap's major works, including those subsequent to the "Wiederlegung", although it is now an aspect of the "positive" project of devising suitable languages for the conduct of science.[3] In more general terms, to deny a link between British empiricism and the group of German and Austrian philosophers under discussion here would be to suggest that the name "logical empiricism" was adopted by them in a state of absentmindedness, and its implications never reflected upon. There is no reason to treat the neo-Kantian and empiricist elements of Carnap's thought as mutually exclusive.

The neglect of the neo-Kantian background to Carnap's philosophy was not a peculiarity of Ayer's presentation and was not generated by it. Neo-Kantianism, and even Kant himself for all the admired depth of his thought, were regarded by British philosophers of the early and mid-20th century as a retrograde epicycle in the history of modern philosophy, a misguided attempt to salvage something from the bankruptcy of rationalist a priorism. Instead, the progressive line of modern philosophy was held, with considerable Anglocentrism, to be running from Hume (1711–1776) via Mill (1806–1873) to Russell(1872–1970). Carnap was seen as continuing Russell's project, a reading made all the more natural by the fact that Carnap had picked a sentence from Russell's article "The Re-

3. For a thorough documentation of this point, see Popper's "Demarcation between Science and Metaphysics" in Popper (1963). For an account of the same development in a less polemical tone of voice, see Carl G. Hempel (1964).

lation of Sense-Data to Physics" (Russell 1914) as the motto for the *Aufbau*. This interpretation of Carnap's agenda is further supported by Carnap's "Intellectual Autobiography", which forms the introductory chapter to the volume on Carnap in the *Library on Living Philosophers* (Carnap 1963). Here, Carnap states that "the men who had the strongest effect on my philosophical thinking were Frege and Russell", adding on the next page that "in my philosophical thinking in general I learned most from Bertrand Russell" (*Op. cit.,* 12–13). Incidentally, in the article cited in the previous footnote, Popper writes that "[Russell's] influence upon Carnap and upon us all was greater than anybody else's"). From this perspective, the powerful position of neo-Kantianism in German philosophy at the time would appear as rather irrelevant. Ayer's presentation is an expression of this interpretation of Carnap's work, not its instigator. Incidentally, the influence of logical positivism in Britain would soon be undermined by two arrivals from the continent, Karl Popper (1902–1994) and Ludwig Wittgenstein (1889–1951). Popper's falsificationism would offer a powerful alternative to logical positivist theory of science, regardless of how its philosophical ancestry is understood, while Wittgenstein laid out a totally different and revolutionary perspective upon language.

3. Carnap's negative agenda

Let us first have a look at Carnap's negative agenda, the campaign against metaphysics as presented in "Elimination of Metaphysics through Logical Analysis of Language". It offers a particularly stringent version of empiricism, as it declares non-empirical issues to be strictly meaningless, not merely futile. The difference between earlier critiques of metaphysics and the logical positivist one is that the latter is armed with the sharp teeth of formal logic. Logical analysis shows that the vague, "phenomenological" notion of meaning of a sentence is correctly rendered as a question of what other sentences are deducible from that sentence, and what sentences it is deducible from (*op. cit*., 62). Eventually, in the case of meaningful sentences about empirical matters, such deductive strings will terminate in sentences recording immediate experience. (In formal disciplines

such as logic and mathematics, the deductions – i.e. proofs – terminate in the axioms of the particular formal system adopted.) The totality of observation sentences exhausts the meaning of the original sentence.

4. The positive agenda and structuralism

Next, the positive agenda, the rational reconstruction of science, in which structuralism came to the forefront. The structuralist stance was announced in *Der logische Aufbau der Welt*, which was Carnap's first major work. (In the following, I quote from the English translation, *The Logical Structure of the World* published in 1967, which contains a bonus in the form of a new preface from Carnap).

Before I proceed to document the structuralist stance in the *Aufbau*, and analyse the purposes it serves, let me remark briefly upon its historical sources. One is formalist mathematics as developed by David Hilbert, which makes mathematics out to be purely (syntactic) form without content. Another is Frege and Russell's logicism, which aims to derive arithmetic from formal logic and indeed depicts the former as an extension of the latter. The point was given a philosophical underpinning in Wittgenstein's *Tractatus*, a key thesis of which is the purely formal and structural character of logic and mathematics. The two disciplines have no subject matter of their own but simply reflect the formal framework in which human thought must be articulated. There are copious and generous references to the writings of Frege, Russell and Wittgenstein in the *Aufbau*.

Let me start with a few quotations from the *Aufbau* expressing the structuralist stance. Science is essentially a public, intersubjective mode of knowledge; hence a special strategy is required to make room for it within the framework of a subjectivist epistemology. The solution is structuralism:

> The series of experiences is different for each subject. If we want to achieve, in spite of this, agreement in the names for the entities which are constructed on the basis of these experiences, then this cannot be done by reference to the completely divergent content, but only through

> the formal description of the structure of these entities. However, it is still a problem how, through the application of uniform formal construction rules, entities result which have a structure which is the same for all subjects even though they are based on such immensely different series of experiences. This is the problem of intersubjective reality. We shall return to it later. Let it suffice for the moment to say that, *for science it is possible and at the same time necessary to restrict itself to structure statements* (p. 29, Italics in original).

So, at this initial step of the constructionist programme, structuralism serves as the key to making room for an intersubjective reality in the first place. This is a requirement not only for science but also for everyday knowledge. Next, we move to science proper:

> In the following, we shall maintain and seek to establish the thesis that *science deals only with the description of structural properties of objects* (p. 19).
>
> … *each scientific statement can in principle be so transformed that it is nothing but a structure statement.* (p. 29).

We are reminded of the importance of this in the face of the empiricist semantics:

> But this transformation is not only possible, it is imperative. For science aims at expressing what is objective, and whatever does not belong to the structure but to the material (i.e. anything that can be pointed out in a concrete ostensive definition) is, in the final analysis, subjective (*Ibid.*).

Most observational terms would suffer from being "material" in the sense of the Carnap quote above, i.e. being something that can be pointed to. Such sensory terms as "red" and other colour terms can only be defined by ostensive definition, i.e. by pointing to one of their instances. And this would make them incurably subjective. Thus, they have to be replaced or superseded by structural terms.

Carnap goes on to specify the concept of structure, which adds a further layer of abstraction to the concept of relations:

> In a structure description, only the structure of the relation is indicated, i.e., the totality of its formal properties. ... By formal properties of a relation, we mean those that can be formulated without reference to the meaning of the relation of the type of objects between which it holds. They are the subject of the theory of relations. The formal properties of relations can be defined exclusively with the aid of logical symbols, i.e., ultimately with the aid of the few fundamental symbols which form the basis of logistics (symbolic logic) (p. 21).

It is not for nothing that the title of the book refers to the *logical* structure of the world!

With these steps, the requirements of scientific objectivity (intersubjectivity) have been taken care of: Human experience exhibits robust structural features, which are intersubjectively communicable and hence constitute a shared, intersubjectively verifiable aspect of reality. Hence, they are also open to investigation through the systematic efforts of science. The scientific effort results in theories the concepts of which capture these fundamental structural features of intersubjective reality.

5. Structuralism and political ideology

This step, however, does nothing to ease the ideological tensions within logical positivism between idealists and materialists: Are these structures fundamentally structures of an ideational nature, or are they material? Are they structures in the pool of collective human experience, or in a material reality?

This is the point where Carnap launches his neutralism: His short answer is, *both*, but which of the two is salient depends on the individual scientist's concerns. This is the third point at which structuralism comes to the rescue. The overall constructional system of scientific concepts is structural in a sense that elevates it above the level of its component's concepts (as captured in the previous point). Each node in the system may be filled with different contents, while the overall structural relationships between nodes remain fixed. The main contenders as fillers are, respectively, concepts defined in experiential, observational terms, and concepts couched

in materialistic terms. The formal requirement imposed upon the fillers is *extensional equivalence*, which means that sentences featuring one filler must retain its truth value (true or false) if replaced with one of the alternatives.

Carnap mentions psycho-physical duality as an example of such equivalence (*Op. cit.* 92). At the time, establishing psycho-physical identities was just an optimistic dream, way beyond the reach of the observational techniques of the day, and without any basis in existing theories about the brain's workings, so Carnap provides no concrete examples. During the later revival of psycho-physical identity theory in the 1960s, however, one example gained prominence, viz. the identity between pain and the firing of so-called C-fibres in the brain.[4] This example would have served Carnap well: The relevant slot in the overall construction scheme might be filled alternatively with the phenomenal term "pain" and the materialist, physiological term "firing of C-fibres".

We may clarify Carnap's notion of construction by assimilating it to the more familiar and closely related concept of *reduction*. The empiricist aspect of construction corresponds to the reduction of complex terms to simpler ones by definition, and we may refer to this as *definitional* reduction (or construction). The scientistic aspect of construction corresponds to the reduction of observational terms, or at least terms from the "lifeworld", to the theoretical terms of science. A familiar example would be the reduction of water to H_2O. We may refer to this as *explanatory* reduction (or construction), since it depends on the possibility of explaining the "lifeworld" phenomenon in terms of its theoretical twin, e.g. explaining the observable properties of water in terms of nuclear chemistry.

Intuitively, the two kinds of construction proceed in opposite directions, which we may term "downwards" and "upwards", respectively. Definitional construction moves *upwards* from simple terms and concepts towards complex ones. To satisfy the empiricist strictures of the constructivist programme, such construction must start out from the level of simple observational concepts. This follows from the verifiability criterion, which requires meaningful

4. See for instance Smart (1959).

theoretical terms to be translatable into observational terms. *Downwards* construction is the explanation of observational phenomena in terms of their counterparts within higher-level theories. This is the derivation of the observable properties of "water" from its theoretical sibling "H_2O", in combination with chemical theory, and of the observational property "colour" from its theoretical counterpart, "light of such-and-such wavelengths". This is the scientistic aspect of the programme.

In terms of Carnap's philosophical project in the *Aufbau*, however, this difference in direction is irrelevant. At each level of the constructed conceptual hierarchy, whether traversed in the upwards or downwards direction, the experiential and the materialist descriptions of its occupant will be extensionally equivalent. A sentence referring to one occupant will retain its truth value (true or false) if a reference to an appropriately selected alternative occupant is substituted.

Thus, the constructional system, which organizes the entire body of scientific concepts, is a structure of nodes, or slots, that allow alternative fillings. Different types of filling serve different projects within the overall scientific enterprise. What is philosophically important is the system of nodes, not the actual fillings. This is the key point of Carnap's structuralism, which, to him, serves the important additional purpose of reconciling the two factions of the neo-positivist movement.

But is there still not an additional issue to be pondered, i.e. what reality is like in itself, independently of any particular scientific investigational aim? In particular, it might appear that definitional construction in experiential terms would imply an idealist ontology, whereas explanatory construction would indicate a physicalist or at least materialist ontology. Don't we have to choose between them? Carnap's answer is an emphatic *no*. Any such verdict would be metaphysical, in the strict logical sense of being beyond possible verification and hence being meaningless. Carnap impresses this point upon his reader in the final section of the *Aufbau*.

In the meantime, Carnap had worked out the position in detail in the article "Empiricism, Semantics and Ontology" from 1950. Here, he introduced a distinction between internal and external

questions that may be raised with respect to any scientific theory. Truth is an *internal* property of a theory, which means that the truth value of any sentence articulated within it is decided in terms of the specific methods of the theory, and the resulting truths are couched in the vocabulary of the theory. Questions as to whether a true theory "corresponds" to reality are external, as they cannot be answered within the framework of the theory itself. Nor can they be answered by any other scientific theory, which means that they are metaphysical and hence strictly empirically meaningless.

6. Definitional construction runs into trouble

Now back to the *Aufbau*. So far, we have dealt mainly with the methodological preamble to the book, and with its concluding anti-metaphysical section. In the bulk of the book, Carnap focused upon what I called "definitional" construction. Still, what was launched in the *Aufbau* was just a programme, and in the process of unfolding this programme over the following years, the tensions inherent in logical positivism from the start would gradually surface.

Let us examine how this programme slowly ran into trouble. A problem inherent in its very foundations came to a head in the article "Testability and Meaning" from 1936–37. Here, Carnap introduced a relaxation of the definitional link between scientific terms and their empirical basis. This move was forced upon him as a side-effect of his commitment to a purely extensional analysis of language. The difficulty manifested itself even with such simple terms as "soluble in water". Intuitively, this could be translated as

x is soluble in water = x will dissolve if placed in water

If we read the right-hand side of this equation extensionally i.e. as the material implication

a is placed in water ⇒ a dissolves

it is formally equivalent to the disjunction

a is not placed in water ∨ a dissolves.

This sentence is true for any x that is not placed in water, which means that the definition makes anything that is not placed in water soluble, including sticks, stones, cars and mountains. This is of course unacceptable.

To get around this problem, Carnap introduced the technical device of "reduction sentences". This is a sentential structure consisting of a bi-conditional specifying the observational criterion for the defined property, embedded in a material conditional, the antecedent of which specifies the experimental setting for the test, thus:

$$x \text{ is placed in water} \Rightarrow (x \text{ is water soluble} \Leftrightarrow x \text{ dissolves}).$$

Thereby, the test criterion is restricted to items that are placed in water, thus avoiding making everything not so placed soluble. This comes at the price, however, of failing to tell us what it means for a thing not placed in water to be water soluble. Hence, the logical positivists' "operational" definition of dispositional terms could only be partial.

This problem stemmed solely from the meaning-theoretical strictures of logical positivism. Soon, other problems would crop up that reflected genuine features of the subject matter under investigation, i.e. the nature of theoretical concepts. Carnap would grapple with these problems in a sequence of publications stretching from the late 1930s to the mid-1960s. The ultimate formulation of his position is given in *Philosophical Foundations of Physics* from 1966, which is a transcript of lectures Carnap held in the late 1950s, subsequently edited and published by Martin Gardner with extensive collaboration from Carnap.

One problem addressed in this sequence of texts is that theoretical concepts have multiple operational criteria. This is a consequence of the fact that theoretical concepts integrate a plurality of different phenomena under one conceptual heading, each of which conversely serves as evidence of the theoretical construct. For instance, there are many different tests for establishing that an object is electrically charged. For each of these, a separate reduction sentence must be provided, stating the specific test conditions in its antecedent. Hence, each reduction sentence delivers only part

of a fuller definition of a theoretical term into observational ones. The partial definition issue represented a technical challenge to the formalization of scientific theories but hardly worried Carnap as a substantial problem in the philosophy of science, as extant definitions could be supplemented with additional clauses whenever new kinds of evidence emerged. The problem would eventually vanish with the articulation of a complete and all-encompassing *Einheitswissenschaft*.

7. The interdefinition of theoretical terms

Carnap would gradually come to realize that there is an even deeper source of the need for partial definition of theoretical terms in science. When it comes to the most abstract terms at the core of physics and other advanced scientific theories, they are not individually translatable into observation terms, but only collectively. No observational implications follow if only one theoretical parameter is tied down, values must also be assigned to the other key parameters of the theory. The cluster of terms at the core of a physical theory are tied together by a network of logical implications. These constitute *implicit definitions* of those terms, which are then collectively tied to observational test conditions by what Carnap called "correspondence rules".

An example – not Carnap's own – might be Darwinian evolutionary theory. We may conveniently start with the familiar slogan of the theory, "survival of the fittest". This is often suspected of being a tautology, since the *fittest* must be defined as those who *survive*. This is correct so far as it goes, but it is not the full story, since Darwinian theory requires that the superior fit of the surviving individual can be traced back to an anatomical or behavioural *feature* that sets it apart from the *co-specific individuals* who did less well in the *competition* for survival. If this feature is *inheritable*, it will be passed on to the offspring of the successful specimen, who will thus inherit the *evolutionary advantage* enjoyed by their ancestor, and the superior gene will eventually come to dominate the *gene pool*. In time, this will lead to the formation of an entirely new *species*, construed as a population of *interbreeding animals*.

The above text specifies the content of Darwinian evolutionary theory, with the interdefined theoretical terms indicated in italics. Notice that this definitional feature does not make the theory true by definition: There is the stage where you define your terms, and the stage where you take your terms and definitions out into the field and check whether anything out there corresponds to them. This applies to the intricately interdefined terms of a scientific theory as much as it applies to the simple definitional truth of "unicorn = horse-like creature with a long spiralled horn on the front of its head". This definitional truth notoriously does not guarantee the existence of unicorns.

In the context of scientific practice, the formal-semantic points made above mean that until the theoretical work is completed, we do not really know what we are talking about when using the theoretical terms of the theory, such as "atom", "quark" or "spin". They refer to something-we-do-not-fully-know-what, but which we get to know ever better through our efforts of theoretical elaboration and experimental testing.

This may be compared to the way police, during their investigation of a particular horrendous string of murders, may refer to the killer as "Jack the Ripper". That term is really shorthand for "The person, whoever that may be, who did this to victim 1, that thing to victim 2, yet another thing to victim 3 … all the way down to victim n". There is an assumption made in this that goes beyond the naked evidence, i.e. that all of this was the work of one person. To put it in logical terms, this is really an existentially quantified sentence saying "There is one and only one person who did this to victim 1, that thing to victim 2 etc."

8. Carnap adopts Ramsey sentences

In the case of science, what we are looking for is not a "thing" or entity, however, but a structure. Structures, as we learn from Carnap, are abstractions from systems of relations, and the pure structure shines forth when we remove all substantial fillings from its nodes (as we are obliged to do by Carnap's ontological "neutralism"). We can bring out the point in terms of our little toy example above,

since it is already relational: The murderer's gruesome molestations of his victims are, logically speaking, just as many relations between murderer and victims. We can "neutralize" the London Police's conjecture about the identity of the culprit by replacing all relations and all individual references with variables, all within the scope of nested existential quantifiers. The result is along the lines of "There is an x and a y and a z … and relations R and S and T… such that xRy and xSz … etc".

When completely and correctly formalized in predicate logic and the logic of relations, the result is a so-called "Ramsey sentence", named after the British philosopher Frank Ramsey (1903–1930). Ramsey suggested this format in an analysis of some earlier similar work by Bertrand Russell, and Carnap adopted it, with some technical modifications that are not relevant here.

Carnap's espousal of a Ramsey-style articulation of scientific theories highlights the formalistic, language-oriented nature of his approach. When talking about structure, Carnap does not have in mind the kind of spatial structures that would once be referred to a "primary qualities" of things, to be contrasted with the "secondary qualities" which are only bestowed upon them by our human senses. To the extent that reality possesses spatial properties (which is probably the case), they figure in the theory as fillers (arguments) in the slots in the Ramsey sentence that articulates it. The fundamental structure of the world is linguistic, and the language in question is that of the logical calculi, including the logic of relations. This point is indeed already foreshadowed in the Introduction to *Aufbau*, where Carnap declares that the aim of the project may equally be described as the construction of *concepts* as of *things*. Talking about the structure of the word and talking about the logico-linguistic structures in which we capture it basically comes to the same thing. Carnap's understanding of scientific theories has rightly been described as *syntactic*, where the syntax in question is that of formal logic.

Hence care should be taken when translating the Ramsey sentence into ordinary language. The standard reading of the existential quantification would go along the lines of "There exists something that has the following structure …" This would invite speculation as to what this something is – is it e.g. a material thing, or an ide-

ational manifold? But this would mean falling into the metaphysical trap. Instead, the Ramsey sentence merely asserts the existence of a certain structure, which, innocuously, may be thought of simply as the structure of the sentence itself, as displayed in any concrete token of it.

9. Philosophical and linguistic structuralism

Let us now take stock, summarizing the points on which logical positivist philosophy of science (as developed by Carnap) resembles structuralism within linguistics. In the first place, it deals with structures. Secondly, it is strongly focused on language: The structures articulated by science are fundamentally logico-linguistic, rather than, say, spatio-temporal. Third, there is great emphasis upon structural interdefinition of terms. Fourthly, logical positivist philosophy of science is synchronic, with no regard for the history of science or for the social process though which a particular theory emerges victorious. True, Carnap would grant that we are not yet in possession of a finished *Einheitswissenschaft*, which means that partial definition must play a large role in our analysis of the scientific edifice. But this shortcoming will disappear in the fullness of time. Fifthly, the entire enterprise is inspired by an (idealized) conception of natural science and in particular theoretical physics.

As we wait for the final unifying "theory of everything", there are no rational steps we can take to speed up the progress of research beyond cleansing extant science of metaphysical residue. Logical positivists labelled the dynamic aspect of science as the "context of discovery" and put it aside as basically a-rational and hence outside the scope of philosophical analysis. The Carnapian analysis of science may thus fairly be called retrospective, since it basically limits the scientific enterprise to the regimentation of experiential data already garnered. Every other aspect is a-rational and hence really a-scientific. The context of discovery is a part of the *praxis* of science, which in general resists rational analysis. It is so to speak the *parole* of science, to be kept strictly apart from its *langue*, which alone permits rational reconstruction.

10. Late logical positivism and the Kuhnian revolution

Gradually, however, second-generation logical positivists would begin to strain against the shackles of this narrow analysis. It was felt by such figures as Ernest Nagel (1901–1985) and Carl G. Hempel (1905–1997) that something could be said, philosophically, even about the dynamic aspect of science. Theoretical concepts have a function beyond organizing what we already know, as they also serve to guide us towards further possible discoveries. In brief, theories have a *heuristic* role. Moreover, Hempel and Nagel would begin to recognize the function of theoretical *models* at this point. As scientists themselves would report, they do not grasp theories only in terms of an abstract linguistic formulation (and certainly not in terms of the abstract Ramsey formula), but typically also in terms of an analogical model. This model captures what is known so far but possesses additional traits that point towards further aspects of reality, to be explored through subsequent development of the theory and testing in future experiments. Models support a type of *analogical reasoning* that serves an important heuristic function in science. These ideas would emerge in the writings of Hempel and Nagel in the late 1950s and early 60s.[5]

The final phase of logical positivist theory of science of the early 1960s, in which these changes took place, is richly deserving of examination in its own right, but I have to bypass it here for lack of space. Instead, I will shift focus towards a celebrated figure in 20th century philosophy of science who radicalized and fused many of the novel ideas emerging within late logical positivist theory of science, and in so doing finally eclipsed the latter. That figure is Thomas S. Kuhn (1922–1996).

Let me swiftly run through Kuhn's celebrated paradigm theory to indicate where it contradicted logical positivist orthodoxy. First, logical positivism's a-historical, synchronic approach: Kuhn made a "historical turn", introduced in the very opening paragraph of the book:

5. Cf. Hempel (1958), Nagel (1961).

> History, if viewed as more than a repository for anecdote or chronology, could produce a decisive transformation in the image of science by which we are now possessed. That image has previously been drawn, even by scientists themselves, mainly from the study of finished scientific achievements as these are recorded in the classics and, more recently, in the textbooks from which each new scientific generation learns to practice its trade. … This essay attempts to show that we have been misled by them in fundamental ways. Its aim is a sketch of the quite different concept of science that can emerge from the historical record of the research activity itself.

We may rightly see what is announced here as the reverse of the movement by which Saussurean structuralist linguistics broke away from its historically oriented forebears.

Another key point on which Kuhn reversed logical positivist orthodoxy concerns the programme of "construction" of theoretical concepts in terms of observational ones. According to Kuhn, it is rather the other way around: Observational terms are heavily saturated with theoretical assumptions, hence cannot be used for neutral construction of theoretical terms.

Finally, Kuhn made room for scientific *praxis* within the compass of the philosophy of science, reversing the exclusive focus of logical positivism upon the abstract final product of scientific activity, the linguistic articulations of scientific theories. This was Kuhn's celebrated analysis of "normal science" as inevitably producing a growing number of "anomalies", leading first to "extraordinary science" and eventually to a scientific revolution and a paradigm shift. By this broadening of scope, the "parole" of science was made a legitimate part of the philosophy of science alongside its "langue".

Thus, the opening paragraphs of Kuhn's text may fairly be called a declaration of war on the logical positivist picture of science. Logical positivism is not mentioned in these paragraphs, however, nor anywhere else in the treatise. The reason probably is that Kuhn did not have a very precise picture of logical positivism, but only what he would later call "an everyday image" of it, and it was against this he rebelled (Cf. Andersen 2001, 11f.). In the Introduction to *Structure*, Kuhn states that the picture of science which he hopes to

overturn has been presented "even by scientists themselves". This hints that this picture mainly originated among people who were not scientists or at least had no practical experience with scientific research, and that it is surprising that scientists would adopt it. But Kuhn does not reveal who these other people are.

It is a well-known fact that Kuhn's tract was originally published in the *Foundations of the Unity of Science*, the series instituted by Carnap and other leading positivists to serve as an outlet for their publications on the unification of science. Kuhn would later confess that he was not really familiar with Carnap's writings, in which case he would no doubt have recognized an anticipation of his views about truth in scientific theories in Carnap's "Empiricism, Semantics, and Ontology" (Cf. Andersen 2001, 12). Like Carnap, Kuhn rejected as meaningless the question whether or not our theories, even the best among them, are *true* of reality:

> A scientific theory is usually felt to be better than its predecessors not only in the sense that it is a better instrument for discovering and solving puzzles but also because it is somehow a better representation of what nature is really like. One often hears that successive theories grow ever closer to, or approximate more and more closely to, the truth. Apparently generalizations like that refer not to the puzzle-solutions and the concrete predictions derived from a theory but rather to its ontology, to the match, that is, between the entities with which the theory postulates nature and what is "really there".
>
> Perhaps there is some other way of salvaging the notion of "truth" for application to whole theories, but this one will not do. There is, I think, no theory-independent way to reconstruct the notion of 'really there'; the notion of a match between the ontology of a theory and its "real" counterpart in nature now seems to me illusive in principle (Kuhn 1962/1970, 206).

This reads like a page straight out of Carnap's 1950 article, which does not, however, diminish the magnitude of Kuhn's divergence from logical positivist doctrine on the points previously mentioned. Moreover, unlike Carnap, Kuhn did not arrive at his conclusions through the logical analysis of the constraints on semantic meaningfulness, but instead through reflection on the

history of science, "viewed as more than a repository for anecdote or chronology".

In the view of most modern philosophers of science, Carnap's long detour through logico-linguistic ("syntactic") considerations was a distraction and a waste of intellectual resources better employed elsewhere. This had been Karl Popper's main complaint about the programme all along, going back to his discussions with Carnap in the earliest days of the Vienna Circle. The point is accepted even by those who do not subscribe to Popper's scientific realism, but share Carnap's anti-realist or a-realist conception of science. I will end with a quote from a prominent modern philosopher of science, Bas van Fraassen (1941-), whose "constructive empiricism" shows considerable points of similarity with Carnap's view:

> Perhaps the worst consequence of the syntactic approach was the way it focussed attention on philosophically irrelevant technical questions. It is hard not to conclude that those discussions of axiomatizability in restricted vocabularies, 'theoretical terms', Craig's theorem, 'reduction sentences', 'empirical languages', Ramsey and Carnap sentences, were one and all off the mark–solutions to purely self-generated problems, and philosophically irrelevant. (1980, 56)

This assessment of the merits of Carnap's structuralist-syntactic approach to the philosophy of science is probably correct. To do justice to Carnap's place in 20th century philosophy, however, we have to keep in mind that to him, the analysis of science was part of a grander project, i.e. the promotion of a "Wissenschafliche Weltauffassung" to serve as an antidote to the intellectual obscurantism and political radicalization he witnessed in Austria and his native Germany. To assist him in the cause, he had joined a circle of like-minded people, the *Wiener Kreis*, and he was instrumental in expanding it into an international movement under the name of "logical positivism". Apart from their shared commitment to a mode of political rationality inspired by the standards of natural science, the members of this movement had rather divergent political and intellectual convictions. Carnap's neutralist, syntactic and structuralist analysis of science must also be viewed as an attempt

to overcome these internal differences, thereby keeping together a group of brilliant academics in their good fight against the dark political forces that were gaining strength in Europe. This is an effort for which one cannot fail to feel deep sympathy.

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