

## Rudolf Carnap (1891–1970)

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Rudolf Carnap, pre-eminent member of the Vienna Circle, was one of the most influential figures of twentieth-century analytic philosophy. The Vienna Circle was responsible for promulgating a set of doctrines (initially in the 1920s) which came to be known as logical positivism or logical empiricism. This set of doctrines provides the point of departure for most subsequent developments in the philosophy of science. Consequently Carnap must be regarded as one of the most important philosophers of science of this century. Nevertheless, his most lasting positive contributions were in the philosophy of logic and mathematics and the philosophy of language. Meanwhile, his systematic but ultimately unsuccessful attempt to construct an inductive logic has been equally influential since its failure has convinced most philosophers that such a project must fail.

Carnap was born in 1891 in Ronsdorf, near Bremen, and now incorporated into the city of Wuppertal, in Germany.<sup>1</sup> In early childhood he was educated at home by his mother, Anna Carnap (née Dörpfeld), who had been a schoolteacher. From 1898, he attended the Gymnasium at Barmen, where the family moved after his father's death that year. In school, Carnap's chief interests were in mathematics and Latin. From 1910 to 1914 Carnap studied at the universities of Jena and Freiburg, concentrating first on philosophy and mathematics and, later, on philosophy and physics. Among his teachers in Jena were Bruno Bauch, a prominent neo-Kantian, and Gottlob Frege, a founder of the modern theory of quantification in logic. Bauch impressed upon him the power of Kant's conception that the geometrical structure of space was determined by the form of pure intuition. Though Carnap was impressed by Frege's ongoing philosophical projects, his real (and lasting) influence only came later through a study of his writings (see FREGE). Carnap's formal intellectual work was interrupted between 1914 and 1918 while he did military service during World War I. His political views had already been of a mildly socialist/pacifist nature. The horrors of the war served to make them more explicit and more conscious, and to codify them somewhat more rigorously.

### Space

After the war, Carnap returned to Jena to begin research. His contacts with Hans Reichenbach and others pursuing philosophy informed by current science began

during this period. In 1919 he read Whitehead and Russell's *Principia Mathematica* and was deeply influenced by the clarity of thought that could apparently be achieved through symbolization. He began the construction of a putative axiom system for a physical theory of space-time. The physicists – represented by Max Wien, head of the Institute of Physics at the University of Jena – were convinced that the project did not belong in physics. Meanwhile, Bauch was equally certain that it did not belong in philosophy. This incident was instrumental in convincing Carnap of the institutional difficulties faced in Germany of doing interdisciplinary work that bridged the chasm between philosophy and the natural sciences. It also probably helped generate the attitude that later led the logical empiricists to dismiss much of traditional philosophy, especially metaphysics. By this point in his intellectual development (the early 1920s) Carnap was already a committed empiricist who, nevertheless, accepted both the analyticity of logic and mathematics and the Frege–Russell thesis of logicism which required that mathematics be formally constructed and derived from logic.

Faced with this lack of enthusiasm for his original project in Jena, Carnap abandoned it to write a dissertation on the philosophical foundations of geometry, which was subsequently published as *Der Raum* (1922). A fundamentally neo-Kantian work, it included a discussion of “intuitive space,” determined by pure intuition, independent of all contingent experience, and distinct from both mathematical (or abstract) space and physical space. However, in contrast to Kant, Carnap restricted what could be grasped by pure intuition to some topological properties of space; metric properties and even the dimensionality of space were regarded as empirical matters. In agreement with Helmholtz and Moritz Schlick (a physicist-turned-philosopher, and founder of the Vienna Circle – see below), the geometry of physical space was also regarded as an empirical matter. Carnap included a discussion of the role of non-Euclidean geometry in Einstein's General Relativity Theory. By distinguishing between intuitive, mathematical, and physical spaces, Carnap attempted to resolve the apparent differences between philosophers, mathematicians, and physicists by assigning the disputing camps to different discursive domains. In retrospect, this move heralded what later became the most salient features of Carnap's philosophical work: tolerance for diverse points of view (so long as they met stringent criteria of clarity and rigor) and an assignment of these viewpoints to different realms, the choice between which is to be resolved not by philosophically substantive (for instance, epistemological) criteria but by pragmatic ones.

## The constructionist phase

During the winter of 1921, Carnap read Russell's *Our Knowledge of the External World* (1914). According to Carnap's intellectual autobiography (1963a), this work led him, between 1922 and 1925, to begin the analysis that culminated in *Der logische Aufbau der Welt* (1967), which is usually regarded as Carnap's first major work. The purpose of the *Aufbau* was to construct the everyday world from a phenomenalist basis. This is an epistemological choice (§§54, 58).<sup>2</sup> Carnap distinguished between four domains of objects: autopsychological, physical, heteropsychological, and cultural (§58). The first of these consists of objects of an individual's own psychology; the second of physical entities (Carnap does not distinguish between everyday material objects and the

abstract entities of theoretical physics); the third consists of the objects of some other individual's psychology; and the fourth of cultural objects (*geistige Gegenstände*), which include historical and sociological phenomena.

From Carnap's point of view, "[a]n object . . . is called *epistemically primary* relative to another one . . . if the second one is recognized through the mediation of the first and thus presupposes, for its recognition, the recognition of the first" (§54). Autopsychological objects are epistemically primary relative to the others in this sense. Moreover, physical objects are epistemically primary to heteropsychological ones because the latter can only be recognized through the mediation of the former: an expression on a face, a reading in an instrument, etc. Finally, heteropsychological objects are epistemically primary relative to cultural ones for the same reason.

The main task of the *Aufbau* is construction, which Carnap conceives of as the converse of what he regarded as reduction (which is far from what was then – or is now – conceived of as "reduction" in Anglophone philosophy):

*an object is 'reducible' to others . . . if all statements about it can be translated into statements which speak only about these other objects. . . . By constructing a concept from other concepts, we shall mean the indication of its "constructional definition" on the basis of other concepts. By a constructional definition of the concept *a* on the basis of the concepts *b* and *c*, we mean a rule of translation which gives a general indication how any propositional function in which *a* occurs may be transformed into a coextensive propositional function in which *a* no longer occurs, but only *b* and *c*. If a concept is reducible to others, then it must indeed be possible to construct it from them. (§35)*

However, construction and reduction present different formal problems because, except in some degenerate cases (such as explicit definition), the transformations in the two directions may not have any simple explicit relation to each other. The question of reducibility/constructibility is distinct from that of epistemic primacy. In an important innovation in an empiricist context, Carnap argues that both the autopsychological and physical domains can be reduced to each other (in his sense). Thus, at the formal level, either could serve as the basis of the construction. It is epistemic primacy that dictates the choice of the former.

Carnap's task, ultimately, is to set up a constructional system that will allow the construction of the cultural domain from the autopsychological through the two intermediate domains. In the *Aufbau*, there are only informal discussions of how the last two stages of such a construction are to be executed. Only the construction of the physical from the autopsychological is fully treated formally. As the basic units of the constructional system Carnap chose what he calls "elementary experiences" (*Elementarerlebnisse*) (*elx*).<sup>3</sup> These are supposed to be instantaneous cross-sections of the stream of experience – or at least bits of that stream in the smallest perceivable unit of time – that are incapable of further analysis. The only primitive relation that Carnap introduces is "recollection of similarity" (*Rs*). (In the formal development of the system, *Rs* is introduced first and the *elx* are defined as the field of *Rs*.) The asymmetry of *Rs* is eventually exploited by Carnap to introduce temporal ordering.

Since the *elx* are elementary, they cannot be further analyzed to define what would be regarded as constituent qualities of them, such as partial sensations or intensity

components of a sensation. Had the *elox* not been elementary, Carnap could have used “proper analysis” to define such qualities by isolating the individuals into classes on the basis of having a certain (symmetric) relationship with each other. Carnap defines the process of “quasi-analysis” to be formally analogous to proper analysis but only defining “quasi-characteristics” or “quasi-constituents” because the *elox* are unanalyzable.<sup>4</sup> Quasi-analysis based on the relation “part similarity” (*Ps*), itself defined from *Rs*, is the central technique of the *Aufbau*. It is used eventually to define sense classes and, then, the visual sense, visual field places, the spatial order of the visual field, the order of colors and, eventually, sensations. Thus the physical domain is constructed out of the autopsychological. Carnap’s accounts of the construction between the other two domains remain promissory sketches.

Carnap was aware that there were unresolved technical problems with his construction of the physical from the autopsychological, though he probably underestimated the seriousness of these problems. The systematic problems are that when a quality is defined as a class selected by quasi-analysis on the basis of a relation: (1) two (different) qualities that happen always to occur together (say, red and hot) will never be separated; and (2) quality classes may emerge in which any two members bear some required relation to each other but there may yet be no relation that holds between all members of the class. Carnap’s response to these problems was extra-systematic: in the complicated construction of our world from our *elox*, he hoped that such examples would never or only very rarely arise.<sup>5</sup> Nevertheless, because of these problems, and because the other constructions are not carried out, the attitude of the *Aufbau* is tentative and exploratory: the constructional system is presented as essentially unfinished.<sup>6</sup>

By this point of his intellectual development, Carnap had not only fully endorsed the logicism of the *Principia*, but also the form that Whitehead and Russell had given to logic (that is, the ramified theory of types including the axioms of infinity and reducibility) in that work. However, Poincaré also emerges as a major influence during this period. Carnap did considerable work on the conceptual foundations of physics in the 1920s and some of this work – in particular, his analysis of the relationship between causal determination and the structure of space – shows strong conventionalist attitudes (Carnap 1924; see also Carnap 1923 and 1926).

## Viennese positivism

In 1926, at Schlick’s invitation, Carnap moved to Vienna to become a *Privatdozent* (instructor) in philosophy at the University of Vienna for the next five years. An early version of the *Aufbau* served as his *Habilitationsschrift*. He was welcomed into the Vienna Circle, a scientific philosophy discussion group organized by (and centered around) Schlick, who had occupied the Chair for Philosophy of the Inductive Sciences since 1922. In the meetings of the Vienna Circle the typescript of the *Aufbau* was read and discussed. What Carnap seems to have found most congenial in the Circle – besides its members’ concern for science and competence in modern logic – was their rejection of traditional metaphysics. Over the years, besides Carnap and Schlick, the Circle included Herbert Feigl, Kurt Gödel, Hans Hahn, Karl Menger, Otto Neurath, and Friedrich Waismann, though Gödel would later claim that he had little sympathy for the

anti-metaphysical position of the other members. The meetings of the Circle were characterized by open, intensely critical, discussion with no tolerance for ambiguity of formulation or lack of rigor in demonstration. The members of the Circle believed that philosophy was a collective enterprise in which progress could be made.

These attitudes, even more than any canonical set of positions, characterized the philosophical movement, initially known as logical positivism and, later, as logical empiricism, that emerged from the work of the members of the Circle and a few others, especially Reichenbach. However, besides rejecting traditional metaphysics, most members of the Circle accepted logicism and a sharp distinction between analytic and synthetic truths. The analytic was identified with the a priori; the synthetic with the a posteriori. A. J. Ayer, who attended some meetings of the Circle in 1933 (after Carnap had left – see below) returned to London and published *Language, Truth and Logic* in 1936 (see AYER). This short book did much to popularize the views of the Vienna Circle among Anglophone philosophers though it lacks the sophistication that is found in the writings of the members of the Circle, particularly Carnap.

Under Neurath's influence, during his Vienna years, Carnap abandoned the phenomenalist language he had preferred in the *Aufbau* and came to accept physicalism. The epistemically privileged language is one in which sentences reporting empirical knowledge of the world ("protocol sentences") employ terms referring to material bodies and their observable properties. From Carnap's point of view, the chief advantage of a physicalist language is its intersubjectivity. Physicalism, moreover, came hand-in-hand with the thesis of the "unity of science," that is, that the different empirical sciences (including the social sciences) were merely different branches of a single unified science. To defend this thesis, it had to be demonstrated that psychology could be based on a physicalist language. In an important paper only published somewhat later, Carnap (1934b) attempted that demonstration. Carnap's adoption of physicalism was final; he never went back to a phenomenalist language. However, what he meant by "physicalism" underwent radical transformations over the years. By the end of his life, it meant no more than the adoption of a non-solipsistic language, that is, one in which intersubjective communication is possible (Carnap 1963b).

In the Vienna Circle, Wittgenstein's *Tractatus* was discussed in detail. Carnap found Wittgenstein's rejection of metaphysics concordant with the views he had developed independently. Partly because of Wittgenstein's influence on some members of the Circle (though not Carnap), the rejection of metaphysics took the form of an assertion that the sentences of metaphysics are meaningless in the sense of being devoid of cognitive content. Moreover, the decision whether a sentence is meaningful was to be made on the basis of the principle of verifiability, which claims that the meaning of a sentence is given by the conditions of its (potential) verification. Observation terms are directly meaningful on this account. Theoretical terms only acquire meaning through explicit definition from observation terms. Carnap's major innovation in these discussions within the Circle was to suggest that even the thesis of realism – asserting the "reality" of the external world – is also meaningless, a position not shared by Schlick, Neurath, or Reichenbach. Problems generated by meaningless questions became the celebrated "pseudo-problems" of philosophy (Carnap 1967).

Wittgenstein's principle of verifiability posed fairly obvious problems in any scientific context. No universal generalization can ever be verified. Perhaps independently,

Karl Popper perceived the same problem (see POPPER). This led him to replace the requirement of verifiability with that of falsifiability, though only as a criterion to demarcate science from metaphysics, and not as one also to be used to demarcate meaningful from meaningless claims. It is also unclear what the status of the principle itself is, that is, whether it is meaningful by its own criterion of meaningfulness. Carnap, as well as other members of the Vienna Circle including Hahn and Neurath, realized that a weaker criterion of meaningfulness was necessary. Thus began the program of the “liberalization of empiricism.” There was no unanimity within the Vienna Circle on this point. The differences between the members are sometimes described as those between a conservative “right” wing, led by Schlick and Waismann, which rejected the liberalization of empiricism, and the epistemological anti-foundationalism that is involved in the move to physicalism; and a radical “left” wing, led by Neurath and Carnap, which endorsed the opposite views. The “left” wing also emphasized fallibilism and pragmatics; Carnap went far enough along this line to suggest that empiricism itself was a proposal to be accepted on pragmatic grounds. This difference also reflected political attitudes insofar as Neurath, and to a lesser extent, Carnap viewed science as a tool for social reform.

The precise formulation of what came to be called the criterion of cognitive significance took three decades. (See Hempel 1950 and Carnap 1956 and 1961.) In an important pair of papers, “Testability and Meaning,” Carnap (1936, 1937a) replaced the requirement of verification with that of confirmation; at this stage, he made no attempt to quantify the latter. Individual terms replace sentences as the units of meaning. Universal generalizations are no longer problematic; though they cannot be conclusively verified, they can yet be confirmed. Moreover, in “Testability and Meaning,” theoretical terms no longer require explicit definition from observational ones in order to acquire meaning; the connection between the two may be indirect through a system of implicit definitions. Carnap also provides an important pioneering discussion of disposition predicates.

## **The syntactic phase**

Meanwhile, in 1931, Carnap had moved to Prague, where he held the Chair for Natural Philosophy at the German University until 1935 when, under the shadow of Hitler, he emigrated to the United States. Towards the end of his Vienna years, a subtle but important shift in Carnap’s philosophical interests had taken place. This shift was from a predominant concern for the foundations of physics to that for the foundations of mathematics and logic, even though he remained emphatic that the latter were important only insofar as they were used in the empirical sciences, especially physics.

In Vienna and before, following Frege and Russell, Carnap espoused logicism in its conventional sense, that is, as the doctrine that held that the concepts of mathematics were definable from those of logic and the theorems of mathematics were derivable from the principles of logic. In the aftermath of Gödel’s (1931) incompleteness theorems (see TARSKI, CHURCH, GÖDEL), however, Carnap abandoned this type of logicism and opted, instead, for the requirement that the concepts of mathematics and logic always have their customary, that is, everyday interpretation in all contexts. He also began to advocate a strong conventionalism regarding what constituted “logic.”

Besides the philosophical significance of Gödel's results, what impressed Carnap most about that work was Gödel's arithmetization of syntax. Downplaying the distinction between an object language and its metalanguage, Carnap interpreted this procedure as enabling the representation of the syntax of a language within the language itself. At this point Carnap had not yet accepted the possibility of semantics even though he was aware of some of Tarski's work and had had some contact with the Polish school of logic. In this context, the representation of the syntax of a language within itself suggested to Carnap that all properties of a language could be studied within itself through a study of syntax.

These positions were codified in Carnap's major work from this period, *The Logical Syntax of Language* (Carnap 1937b). The English translation includes material that had to be omitted from the German original owing to a shortage of paper; the omitted material was separately published in German as papers (Carnap 1934a, 1935). Conventionalism about logic was incorporated into the well-known Principle of Tolerance:

*It is not our business to set up prohibitions but to arrive at conventions [about what constitutes a logic]. . . . In logic, there are no morals. Every one is at liberty to build up his own logic, i.e., his own form of language, as he wishes. All that is required is that, if he wishes to discuss it, he must state his method clearly, and give syntactic rules instead of philosophical arguments. (1937b: 51–2; emphasis in the original)*

Logic, therefore, is nothing but the syntax of language.

In *Syntax*, the Principle of Tolerance allows Carnap to navigate the ongoing disputes between logicism, formalism, and intuitionism/constructivism in the foundations of mathematics without abandoning any insight of interest from these schools. Carnap begins with a detailed study of the construction of two languages, I and II. The last few sections of *Syntax* also present a few results regarding the syntax of any language and also discuss the philosophical ramifications of the syntactic point of view.<sup>7</sup>

Language I, which Carnap calls "definite," is intended as a neutral core of all logically interesting languages, neutral enough to satisfy the strictures of almost any intuitionist or constructivist. It permits the definition of primitive recursive arithmetic and has bounded quantification (for all  $x$  up to some upper bound) but not much more. Its syntax is fully constructed formally. Language II, which is "indefinite" for Carnap, is richer. It includes Language I and has sufficient resources for the formulation of all of classical mathematics and is, therefore, non-constructive. Moreover, Carnap permits descriptive predicates in each language. Thus, the resources of Language II are strong enough to permit, in principle, the formulation of classical physics. The important point is that, because of the Principle of Tolerance, the choice between Languages I and II or, for that matter, any other syntactically specified language, is not based on factual considerations. If one wants to use mathematics to study physics in the customary way, Language II is preferable since, as yet, non-constructive mathematics remains necessary for physics. But the adoption of Language II, dictated by the pragmatic concern for doing physics, does not make Language I incorrect. This was Carnap's response to the foundational disputes of mathematics: by tolerance they are defined out of existence.

The price paid if one adopts the Principle of Tolerance is a radical conventionalism about what constitutes logic. Conventionalism, already apparent in Carnap's admission of both a phenomenalist and a physicalist possible basis for construction in the *Aufbau*, and strongly present in the works on the foundations of physics in the 1920s, had now been extended in *Syntax* to logic. As a consequence, what might be considered to be the most important question in any mathematical or empirical context – the choice of language – became pragmatic. This trend of relegating troublesome questions to the realm of pragmatics almost by fiat, thereby excusing them from systematic philosophical exploration, became increasingly prevalent in Carnap's views as the years went on.

*Syntax* contained four technical innovations in logic that are of significance: (1) a definition of analyticity that, as was later shown by S. C. Kleene, mimicked Tarski's definition of truth for a formalized language; (2) Carnap constructed a proof, independently of Tarski, that truth cannot be defined as a syntactic predicate in any consistent formalized language; (3) a rule for infinite induction (in Language I) that later came to be called the omega rule; and (4), most important, a generalization of Gödel's first incompleteness theorem that has come to be called the fixed-point lemma. With respect to (4), what Carnap proved is that, in a language strong enough to permit arithmetization, for any syntactic predicate, one can construct a sentence that would be interpreted as saying that it satisfies that predicate. If the chosen predicate is unprovability, one gets Gödel's result.

Besides the Principle of Tolerance, the main philosophical contribution of *Syntax* was the thesis that philosophy consisted of the study of logical syntax. Giving a new twist to the Vienna Circle's claim that metaphysical claims were meaningless, Carnap argues and tries to show by example that sentences making metaphysical claims are all syntactically ill-formed. Moreover, since the arithmetization procedure shows that all the syntactic rules of a language can be formulated within the language, even the rules that determine what sentences are meaningless can be constructed within the language. All that is left for philosophy is a study of the logic of science. But, as Carnap puts it: "The *logic of science* (logical methodology) is nothing else than the *syntax of the language of science*. . . . To share this view is to *substitute logical syntax for philosophy*" (1937b: 7–8). The claims of *Syntax* are far more grandiose – and more flamboyant – than anything in the *Aufbau*.

## Semantics

In the late 1930s Carnap abandoned the narrow syntacticism of *Syntax* and, under the influence of Tarski and the Polish school of logic, came to accept semantics. With this move, Carnap's work enters its final mature phase. For the first time, he accepted that the concept of truth can be given more than pragmatic content. Thereupon, he turned to the systematization of semantics with characteristic vigor, especially after his immigration to the US where he taught at the University of Chicago from 1936 to 1952. In his contribution to the *International Encyclopedia of Unified Science*, in 1939, on the foundations of logic and mathematics, the distinctions between syntactic, semantic, and pragmatic considerations regarding any language are first presented in their mature form.



*Introduction to Semantics*, which followed in 1942, develops semantics systematically. In *Syntax* Carnap had distinguished between two types of transformations on sentences: those involving “the method of derivation” or “*d*-method”; and those involving the “method of consequence” or “*c*-method.” Both of these were supposed to be syntactic but there is a critical distinction between them. The former allows only a finite number of elementary steps. The latter places no such restriction and is, therefore, more “indefinite.” Terms defined using the *d*-method (“*d*-terms”) include “derivable,” “demonstrable,” “refutable,” “resoluble,” and “irresoluble”; the corresponding “*c*-terms” are “consequence,” “analytic,” “contradictory,” “*L*-determinate,” and “synthetic.” After the conversion to semantics Carnap proposed that the *c*-method essentially captured what semantics allowed; the *c*-terms referred to semantic concepts.

Thus semantics involves a kind of formalization, though one that is dependent on stronger inference rules than the syntactical ones. In this sense, as Church (1956: 65) has perceptively pointed out, Carnap (and Tarski) reduce semantics to formal rules, that is, syntax. Thus emerges the interpretation of deductive logic that has since become the textbook version, so commonly accepted that it has become unnecessary to refer to Carnap when one uses it. For Carnap, the semantic move had an important philosophical consequence: philosophy was no longer to be replaced just by the syntax of the language of science; rather, it was to be replaced by the syntax and the semantics of the language of science.

Carnap’s most original – and influential – work in semantics is *Meaning and Necessity* (1947), where the basis for an intensional semantics was laid down. Largely following Frege, intensional concepts are distinguished from extensional ones. Semantical rules are introduced and the analytic/synthetic distinction is clarified by requiring that any definition of analyticity must satisfy the (meta-)criterion that analytic sentences follow from the semantical rules alone. By now Carnap had fully accepted that semantic concepts and methods are more fundamental than syntactic ones: the retreat from the flamboyance of *Syntax* was complete. The most important contribution of *Meaning and Necessity* was the reintroduction into logic, in the new intensional framework, of modal concepts that had been ignored since the pioneering work of Lewis (1918). In the concluding chapter of his book Carnap introduced an operator for necessity, gave semantic rules for its use, and showed how other modal concepts such as possibility, impossibility, necessary implication, and necessary equivalence can be defined from this basis.

By this point, Carnap had begun to restrict his analyses to exactly constructed languages, implicitly abandoning even a distant hope that they would have any direct bearing on natural languages. The problem with the latter is that their ambiguities made them unsuited for the analysis of science which, ultimately, remained the motivation of all of Carnap’s work. Nevertheless, Carnap’s distinction between the analytic and the synthetic came under considerable criticism from many, including Quine (1951), primarily on the basis of considerations about natural languages. Though philosophical fashion has largely followed Quine on this point, at least until recently, Carnap was never overly impressed by this criticism (Stein 1992). The analytic/synthetic distinction continued to be fundamental to his views and, in a rejoinder to Quine, Carnap argued that nothing prevented empirical linguistics from exploring intensions and thereby discovering cases of synonymy and analyticity (Carnap 1955).

Carnap's most systematic exposition of his final views on ontology is also from this period (1950a). A clear distinction is maintained between questions that are internal to a linguistic framework and questions that are external to it. The choice of a linguistic framework is to be based not on cognitive but on pragmatic considerations. The external question of "realism," which ostensibly refers to the "reality" of entities of a framework in some sense independent of it, rather than to their "reality" within it after the framework has been accepted, is rejected as non-cognitive. This appears to be an anti-"realist" position but is not in the sense that, within a framework, Carnap is tolerant of the abstract entities that bother nominalists. The interesting question becomes the pragmatic one, that is, what frameworks are fruitful in which contexts, and Carnap's attitude towards the investigation of various alternative frameworks remains characteristically and consistently tolerant.

Carnap continued to explore questions about the nature of theoretical concepts and to search for a criterion of cognitive significance, preoccupations of the logical empiricists that date back to the Vienna Circle. In 1956 he published a detailed exposition of his final views regarding the relation between the theoretical and observational parts of a scientific language (Carnap 1956). This paper emphasizes the methodological and pragmatic aspects of theoretical concepts.

It also contains his most subtle, though not his last, attempt to explicate the notion of the cognitive significance of a term and thus establish clearly the boundary between scientific and nonscientific discourse. However, the criterion he formulates makes theoretical terms significant only with respect to a class of terms, a theoretical language, an observation language, correspondence rules between them, and a theory. Relativization to a theory is critical to avoiding the problems that beset earlier attempts to find such a criterion. Carnap proves several theorems that are designed to show that the criterion does capture the distinction between scientific and nonscientific discourse. This criterion was criticized by Roozeboom (1960) and Kaplan (1975) but these criticisms depend on modifying Carnap's original proposal in important ways. According to Kaplan, Carnap accepted his criticism though there is apparently no independent confirmation of that fact. However, Carnap (1961) did turn to a different formalism (Hilbert's  $\epsilon$ -operator) in his last attempt to formulate such a criterion and this may indicate dissatisfaction with the 1956 attempt. If so, it remains unclear why: that attempt did manage to avoid the technical problems associated with the earlier attempts of the logical empiricists.

## **Inductive logic**

From 1941 onwards Carnap also began a systematic attempt to analyze the concepts of probability and to formulate an adequate inductive logic (a logic of confirmation), a project that would occupy him for the rest of his life. Carnap viewed this work as an extension of the semantical methods that he had been developing for the last decade. This underscores an interesting pattern in Carnap's intellectual development. Until the late 1930s Carnap only viewed syntactic categories as non-pragmatically specifiable; questions of truth and confirmation were viewed as pragmatic. His conversion to semantics saw the recovery of truth from the pragmatic to the semantic realm. Now, confirmation followed truth down the same pathway.

In *Logical Foundations of Probability* (1950b), his first systematic analysis of probability, Carnap distinguished between two concepts of probability: “statistical probability,” which was the relevant concept to be used in empirical contexts and generally estimated from the relative frequencies of events, and “logical probability,” which was to be used in contexts such as the confirmation of scientific hypotheses by empirical data. Though the latter concept, usually called the “logical interpretation” of probability went back to Keynes (1921), Carnap provides its first systematic explication.

Logical probability is explicated from three different points of view (1950b: 164–8): (1) as a conditional probability  $c(h,e)$  which measures the degree of confirmation of a hypothesis  $h$  on the basis of evidence  $e$  (if  $c(h,e) = r$ , then  $r$  is determined by logical relations between  $h$  and  $e$ ); (2) as a rational degree of belief or fair betting quotient (if  $c(h,e) = r$ , then  $r$  is a fair bet on  $h$  if  $e$  correctly describes the total knowledge available to a bettor); and (3) as the limit of relative frequencies in some cases. According to Carnap, the first of these, which specifies a confirmation function (“ $c$ -function”), is the concept that is most relevant to the problem of induction. In the formal development of the theory, probabilities are associated with sentences of a formalized language.

In *Foundations*, Carnap believed that a unique measure  $c(h,e)$  of the degree of confirmation can be found and he even proposed one (namely, Laplace’s rule of succession) though he could not prove its uniqueness satisfactorily. His general strategy was to augment the standard axioms of the probability calculus by a set of “conventions on adequacy” (1950b: 285), which turned out to be equivalent to assumptions about the rationality of degrees of belief that had independently been proposed by both Ramsey and de Finetti (Shimony 1992). In a later work, *The Continuum of Inductive Methods* (1952), using the conventions on adequacy and some plausible symmetry principles, Carnap managed to show that all acceptable  $c$ -functions could be parameterized by a single parameter, a real number,  $\lambda \in [0, \infty]$ . The trouble remained that there is no intuitively appealing a priori strategy to restrict  $\lambda$  to some preferably very small subset of  $[0, \infty]$ . At one point, Carnap even speculated that it would have to be fixed empirically. Unfortunately, some higher-order induction would then be required to justify the procedure for its estimation and, potentially, this leads to infinite regress.

Carnap spent 1952–4 at the Institute for Advanced Study at Princeton where he continued to work on inductive logic, often in collaboration with John Kemeny. He also returned to the foundations of physics, apparently motivated by a desire to trace and explicate the relations between the physical concept of entropy and an abstract concept of entropy appropriate for inductive logic. His discussion with physicists proved to be disappointing and he did not publish his results.<sup>8</sup>

In 1954 Carnap moved to the University of California at Los Angeles to assume the chair that had become vacant with Reichenbach’s death in 1953. There he continued to work primarily on inductive logic, often with several collaborators, over the next decade. There were significant modifications of his earlier attempts to formulate a systematic inductive logic.<sup>9</sup> Obviously impressed by the earlier work of Ramsey and de Finetti, Carnap (1971b) returned to the second of his three 1950 explications of logical probability and emphasized the use of inductive logic in decision problems.

More importantly, Carnap, in “A Basic System of Inductive Logic” (1971a, 1980) finally recognized that attributing probabilities to sentences was too restrictive. If a

conceptual system uses real numbers and real-valued functions, no language can express all possible cases using only sentences or classes of sentences. Because of this, he now began to attribute probabilities to events or propositions (which are taken to be synonymous). This finally brought some concordance between his formal methods and those of mathematical statisticians interested in epistemological questions. Propositions are identified with sets of models; however, the fields of the sets are defined using the atomic propositions of a formalized language. Thus, though probabilities are defined as measures of sets, they still remain relativized to a particular formalized language. Because of this, and because the languages considered remain relatively simple (mostly monadic predicate languages) much of this work remains similar to the earlier attempts.

By this point Carnap had abandoned the hope of finding a unique *c*-function. Instead, he distinguished between subjective and objective approaches in inductive logic. The former emphasizes individual freedom in the choice of necessary conventions; the latter emphasizes the existence of limitations. Though Carnap characteristically claimed to keep an open mind about these two approaches, his emphasis was on finding rational a priori principles which would systematically limit the choice of *c*-functions. Carnap was still working on this project when he died on 14 September 1970. He had not finished revising the last sections of the second part of the “Basic System,” both parts of which were only published posthumously.

Towards the end of his life, Carnap’s concern for political and social justice had led him to become an active supporter of an African-American civil rights organization in Los Angeles. According to Stegmüller (1972: lxvi), the “last photograph we have of Carnap shows him in the office of this organization, in conversation with various members. He was the only white in the discussion group.”

## The legacy

Some decades after Carnap’s death it is easier to assess Carnap’s legacy, and that of logical empiricism, than it was in the 1960s and 1970s when a new generation of analytic philosophers and philosophers of science apparently felt that they had to reject that work altogether in order to be able to define their own philosophical agendas. This reaction can itself be taken as evidence of Carnap’s seminal influence but, nevertheless, it is fair to say that Carnap and logical empiricism fell into a period of neglect in the 1970s from which it only began to emerge in the late 1980s and early 1990s. Meanwhile it became commonplace among philosophers to assume that Carnap’s projects had failed.

Diagnoses of this failure have varied. For some it was a result of the logical empiricists’ alleged inability to produce a technically acceptable criterion for cognitive significance. For others, it was because of Quine’s dicta against the concept of analyticity and the analytic/synthetic distinction. Some took Popper’s work to have superseded that of Carnap and the logical empiricists. Many viewed Kuhn’s seminal work on scientific change to have shown that the project of inductive logic was misplaced (see KUHN); they, and others, generally regarded Carnap’s attempt to explicate inductive logic to have been a failure. Finally, a new school of “scientific realists” attempted to escape Carnap’s arguments against external realism.

There can be little doubt that Carnap's project of founding inductive logic has faltered. He never claimed that he had gone beyond preliminary explorations of possibilities and though there has been some work since, by and large, epistemologists of science have abandoned that project in favor of less restrictive formalisms, for instance, those associated with Bayesian or Fisherian statistics. But, with respect to every other case mentioned in the last paragraph, the situation is far less clear. It has already been noted that Carnap's final criterion for cognitive significance does not suffer from any technical difficulty no matter what its other demerits may be. Quine's dicta against analyticity no longer appear as persuasive as they once did (Stein 1992); Quine's preference for using natural – rather than formalized – language in the analysis of science has proved to be counterproductive; and his program of naturalizing epistemology is yet to live up to any initial promise that it ever might have had. Putnam's "internal realism" is based on and revives Carnap's views on ontology and Kuhn is perhaps now better regarded as having contributed significantly to the sociology rather than the epistemology of science.

However, to note that some of the traditionally fashionable objections to Carnap and logical empiricism cannot be sustained does not show that that work deserves a positive assessment on its own. We are still left with the question: what, exactly, did Carnap contribute? The answer turns out to be surprisingly straightforward: the textbook picture of deductive logic that we have today is the one that Carnap produced in the early 1940s after he came to acknowledge the possibility of semantics. The fixed-point lemma has turned out to be an important minor contribution to logic. The reintroduction of modal logic into philosophy opened up new vistas for Kripke and others in the 1950s and 1960s (see KRIPKE). Carnap's views on ontology continue to influence philosophers today. Moreover, even though the project of inductive logic seems unsalvageable to most philosophers it is hard to deny that Carnap managed to clarify significantly the ways in which concepts of probability must be deployed in the empirical sciences and why the problem of inductive logic is so difficult. But, most of all, Carnap took philosophy to a new level of rigor and clarity, accompanied by an open-mindedness (codified in the Principle of Tolerance) that, unfortunately, has not been widely shared in analytic philosophy.<sup>10</sup>

## Notes

- 1 Biographical details are from Carnap 1963a.
- 2 References to the *Aufbau* are to sections; this permits the simultaneous use of the German and English editions.
- 3 An excellent discussion of Carnap's construction is to be found in Goodman 1951, ch. 5.
- 4 Thus, if an *elox* is both *c* in color and *t* in temperature, *c* or *t* can be defined as classes of every *elox* having *c* or *t* respectively. However, to say that *c* or *t* is a quality would imply that an *elox* is analyzable into simpler constituents. Quasi-analysis proceeds formally in this way (as if it is proper analysis) but only defines quasi-characteristics thus leaving each *elox* unanalyzable.
- 5 Goodman (1951) also provides a very lucid discussion of these problems.
- 6 Some recent scholarship has questioned whether Carnap had any traditional epistemological concerns in the *Aufbau*. In particular, Friedman (e.g. 1992) has championed the view that Carnap's concerns in that work are purely ontological: the *Aufbau* is not concerned with the

question of the source or status of our knowledge of the external world; rather, it investigates the bases on which such a world may be constructed. (See, also, Richardson 1998. Both Friedman and Richardson – as well as Sauer (1985) and Haack (1977) long before them – emphasize the Kantian roots of the *Aufbau*.) If this reinterpretation is correct, then what exactly the *Aufbau* owes to Russell (and traditional empiricism) becomes uncertain. However, as Putnam (private communication) has pointed out, this reinterpretation goes too far: though the project of the *Aufbau* is not identical to that of Russell's external world program (for reasons including those that Friedman gives), there is sufficient congruence between the two projects for Carnap to have correctly believed that he was carrying out Russell's program. In particular, the formal constructions of the *Aufbau* are a necessary prerequisite for the development of the epistemology that Russell had in mind: one must be able to construct the world formally from a phenomenalist basis before one can suggest that this construction shows that the phenomena are the source of our knowledge of the world. Moreover, this reinterpretation ignores the epistemological remarks scattered throughout the *Aufbau* itself, including Carnap's concern for the epistemic primacy of the basis he begins with.

- 7 Sarkar (1992) attempts a comprehensible reconstruction of the notoriously difficult formalism of *Syntax*.
- 8 These were edited and published by Abner Shimony (as *Two Essays on Entropy*, 1977) after Carnap's death.
- 9 See Carnap and Jeffrey 1971 and Jeffrey 1980. An excellent introduction to this part of Carnap's work on inductive logic is Hilpinen 1975.
- 10 For comments on earlier versions of this essay thanks are due to Justin Garson, Cory Juhl, Al Martinich, and Itai Sher.

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