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Carnap and the compulsions of interpretation: Reining in the liberalization of empiricism

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Abstract Carnap's work was instrumental to the liberalization of empiricism in the 1930s that transformed the logical positivism of the Vienna Circle to what came to be known as logical empiricism. A central feature of this liberalization was the deployment of the Principle of Tolerance, originally introduced in logic, but now invoked in an epistemological context in "Testability and Meaning" (Carnap 1936a, 1937b). Immediately afterwards, starting with *Foundations of Logic and Mathematics*, Carnap (1939) embraced semantics and turned to interpretation to guide the choice of a theoretical language for science. The first thesis of this paper is that recourse to an intended interpretation led to a partial retrenchment of the conventionalism implied by the Principle of Tolerance. It required that the choice of a language be based on abstraction from a (typically empirical) context; this procedure later became a component of the process of explication that was distinctive to Carnap's mature views. The (typically empirical) interpretive origin of formal systems also ensured their likely syntactic consistency, an issue on which Carnap was strongly criticized by figures such as Beth and Gödel. The second thesis of this paper is that this reliance on an intended interpretation enabled constructed formal systems to be relevant to the development of empirical science.

Keywords Carnap · Confirmability · Convention · Empiricism · Interpretation · Logical empiricism · Logical positivism · Principle of Tolerance · Testability · Verifiability

1 Introduction

Central to Carnap's (1934/1937a) *Logical Syntax of Language* was a Principle of Tolerance which was stated, oddly enough, in a more strident and imperious tone than any other claim in the book: "*It is not our business to set up prohibitions*, *but to arrive*

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at conventions. . . . *In logic*, *there are no morals*. Everyone is at liberty to build up his own logic, i.e., his own form of language, as he wishes. All that is required of him is that, if he wishes to discuss it, he must state his method clearly, and give syntactic rules instead of philosophical arguments."[1] The conventionalism incorporated in the Principle of Tolerance has been subjected to repeated—and divergent—analyses over the last two decades[2] as historical attention has begun, finally, to focus on the logical empiricists and their contributions to the philosophy of science after decades of rejection and not-so-benign neglect.[3] The first historical claim of this paper is that Carnap's conventionalism, in a form that is, at least in one respect, even stronger than that incorporated in the Principle of Tolerance, was central to the so-called liberalization of empiricism[4] that transformed logical *positivism* during this period and, on some accounts, replaced it with a gentler, kinder logical *empiricism*.[5] This assessment is based on a close reading of a major work from this period, "Testability and Meaning" (1936a, 1937b), which has only occasionally received recent commentary in spite of containing several innovations that were central to the development of both logical empiricism and Carnap's thinking on the problems of empiricism during this critical period.[6]

"Testability and Meaning" was the last major work from Carnap's syntactic phase, that is, the period during which he was yet to accept the legitimacy of formal semantics in his published work and deploy it in the analysis of what he called the language of science. By 1942, when he published *Introduction to Semantics*, Carnap had developed his version of

[1] Carnap (1937a), p. 52; italics in the original. Ben-Menahem (2006, p. 178) has also observed that the Principle of Tolerance "is emotionally charged and has pronounced moral undertones" though Carnap's stridency was explicitly limited only to epistemic issues.

[2] See, *e.g.*, Sarkar (1992), Goldfarb (1995), and Ben-Menahem (2006); the last of these provides a particularly useful entry into this literature. The Principle of Tolerance is also a major theme in various contributions to Wagner (2009).

[3] For once-popular dismissive attitudes to logical empiricism, see, for example, the contributions in Suppe (1977b).

[4] The locution "liberalization of empiricism" is due to Carnap (1963a, §9) and it referred to the developments initiated in "Testability and Meaning." The sense in which *TM* went even beyond the Principle of Tolerance was in the suggestion that empiricism itself was to be taken as a proposal—see Section 4, below.

[5] Whether logical empiricism should—or can—be usefully distinguished from logical positivism is itself a matter of controversy; if the two programs can be usefully distinguished, how this should be done is a matter of even further controversy. For instance, Creath (2011) and Uebel (2011) deny that there is any distinction of relevance. For Leitgeb (2011), the distinction is that which marked the Vienna Circle's transition from empiricism to the philosophy of science—this is consistent with the central role for "Testability and Meaning" that is being urged in this paper. On Salmon's (1999) construal, Reichenbach's (1938) *Experience and Prediction*, which treated the same subjects as Carnap (1936a, 1937) though from Reichenbach's very different probabilistic perspective, was the first major work of logical empiricism. While the origin of the term "logical empiricism" remains uncertain (see below), in the sense that is relevant to the discussions of this paper it goes back at least to Neurath (1931, 1935) who advocated physicalism over phenomenalism and the liberalized perspective towards empiricism. The First Congress for the Unity of Science in Paris, 1935 began with a session "Philosophie scientifique et empiricisme logique," presumably because of Neurath's role in its organization (Stadler 2001, p. 366). See, also, Kaila (1936) who was at times a peripheral member of the Vienna Circle. Meanwhile, Reichenbach (1936) introduced the awkward "logistic empiricism." Uebel (2013) discusses earlier uses of "logical empiricism" in somewhat different, though not entirely unrelated, senses—for instance, by Kaila in 1926 and Dewey as early as 1907. In any case, the question whether logical empiricism should be distinguished from logical positivism is marginal to the issues that are central to this paper which are (i) the conventionalist implications of the Principle of Tolerance for empiricism, (ii) the partial retreat from a radical empiricism through the acceptance of formal semantics, and (iii) the role of interpretation in Carnap's account of formal systems.

[6] For interesting recent commentary, see Demopoulos (2007); Friedman (2011) provides a response to some of the issues raised there. Earlier attention to this work include Creath (1992) and Psillos (1999).

semantics which in many ways remained distinct from Tarski's approach for the rest of his career (Carnap 1963a, p. 62). The second historical claim that this paper argues for—and this claim is perhaps more novel than the first—is that Carnap's embrace of semantics was not only complete by 1939 (which has been recognized [Carnap 1963a, p. 61]), but presented with a rich philosophical discussion when he published yet another work that has often been neglected by recent commentators, namely, *Foundations of Logic and Mathematics*, which was one of Carnap's contributions to the newly launched *International Encyclopedia of Unified Science*. This account of semantics amounted to a retreat (or at least a restriction) of the Principle of Tolerance as deployed in "Testability and Meaning," resulting in a less liberal, and more plausible, version of empiricism. Finally, and this is the third and perhaps most important historical claim of this paper, this turn to semantics relied on a philosophically loaded conception of interpretation which subsequently became central to Carnap's views. Indeed, this conception of interpretation is precisely what is supposed to allow Carnap to evade several otherwise telling criticisms of those views that were prepared for publication in the Schilpp (1963) volume on Carnap including those of Beth (1963a) which was published as planned and Gödel (1995) which was not published until, eventually, as part of his *Nachlass*.

All three claims, but especially the first two, support the first thesis that this paper urges, that recourse to an intended interpretation led to a retrenchment of the conventionalism implied by the Principle of Tolerance in Carnap's subsequent work. The third historical claim is germane to the second—and perhaps less controversial—thesis, that reliance on an intended interpretation enabled constructed formal systems to be relevant to the development of empirical science. These arguments also suggest that both "Testability and Meaning" (hereafter *TM*) and *Foundations of Logic and Mathematics* (hereafter *FLM*) should receive much more critical attention than they have in historical and philosophical recent work on Carnap or logical empiricism.[7]

2 Contexts[8]

The relevant period for this paper is from 1936 to 1940. As background, Carnap had moved to Vienna in 1926 where he was welcomed into the group surrounding Schlick that came to be known as the Vienna Circle. While there, he published *Der Logische Aufbau der Welt* (Carnap 1928), his first major work according to most later assessments (Sarkar 2001). This was the period when the views of the members of the Vienna Circle—in spite of the sizeable differences between them—came to be known as logical positivism in the Anglophone world.[9] For Carnap's philosophical development, the crucial event during those years was Gödel's proof of the incompleteness of arithmetic in 1931 as well as his method of the arithmeticization of syntax in a metalanguage (or "syntax language" in

[7] As noted earlier, at least some recent work does treat *TM*—see, *e.g.*, Creath (1992), Psillos (1999), and Demopoulos (2007) but it deserves more attention than that. Interestingly, *TM* did receive attention in earlier work in philosophy of science, even those that reject rather than develop logical empiricism, *e.g.*, Suppe (1977a). In contrast *FLM* appears to have been relatively ignored; Beth (1963), which will briefly be discussed in the text below (Section 6), is perhaps the most notable early exception. Koellner (2009) provides a brief but important treatment which will also be considered later in this paper.

[8] Throughout this paper, biographical details are from Carnap (1963a) and Mormann (2000).

[9] The term "logical positivism" was apparently introduced by Blumberg and Feigl (1931).

Carnap's terminology) for that proof. In 1931 Carnap moved from Vienna to Prague where he held the Chair in Natural Philosophy at the German University until December 1935 when, under the shadow of Hitler, he emigrated to the United States, settling down permanently at the University of Chicago in 1936 after spending time at Harvard. He remained at Chicago until 1954 before succeeding Reichenbach at the University of California at Los Angeles (after the latter's death in 1953).

Logical Syntax of Language, Carnap's response to Gödel's results, was composed during Carnap's tenure at Prague. It was originally published in German in 1934 though some parts were excised because of a shortage of paper in Germany at the time.[10] A complete English translation was published in 1937. Gödel's influence was felt in two ways: (i) the book was designed to incorporate the incompleteness results into a new account of the foundations of mathematics; and (ii), at the level of technique, following Gödel, it relied on the arithmeticization of syntax in a metalanguage to study the syntactic properties of the language itself. The time spent at Prague, devoted mainly to this project, marked the height of the syntactic phase of Carnap's philosophical career which continued into and ended with *TM*.

The last mentioned work, *TM*, was mainly composed after Carnap's move to the United States, in 1935 and, perhaps, early 1936 though Carnap (1963a, §9) mentioned that he had already begun work on the problems treated in it while still in Prague.[11] As will be discussed in detail below, it marked the end of Carnap's syntactic phase. *FLM*, published in May 1939, was the first important work from Carnap's long and fecund period at Chicago during which his views matured into their final form, while the major doctrines associated with logical empiricism were fully developed by him and others including Reichenbach, Nagel, Hempel, and Feigl.

3 The principle of tolerance

Though *Logical Syntax of Language* is often regarded as one of Carnap's most important works—and sometimes even as a classic of analytic philosophy[12]—commentators have diverged on why it is supposed to be of such signal importance. For some, the importance of the book lies in technical developments in logic, *viz*., the fixed point lemma, a proof of the indefinability of truth distinct from Tarski's better known result, the development of a transfinitary logic, *etc*.[13] For others, it is the radical view of philosophy as syntax alone or, more accurately, the thesis that philosophy is to be replaced by the syntax of the language of science.[14] To see the import of this claim it may help to ponder on what it implies: all

[10] Details throughout this section are from Sarkar (1992).

[11] It was published in two parts in 1936 and 1937 (Carnap 1936a, 1937b). The date of composition is partly based on which works Carnap (1937b) identified as having been written after the composition of *TM*. These included Neurath (1935) and Ayer (1936). Some of the ideas, especially the critical move to reduction sentences, go back to one of Carnap's contribution to the 1935 Paris First Congress for the Unity of Science (Carnap 1936b)—see, also, Uebel (2007). Thanks are due to Uebel for help with the relevant history.

[12] See, for example, Wagner (2009).

[13] Perhaps the most sustained development of this assessment is Sarkar (1992). See, also, Koellner (2009).

[14] This was a view often expressed by Burton Dreben (personal communication) who regarded *Logical Syntax of Language* as Carnap's most important work. A very positive contemporary assessment is to be found in Quine's 1934 lectures on the book which were eventually published by Creath (1990).

that matters, philosophically, about any subject is its structure and not content. Syntacticism, and the term is aptly awkward, relegates all matters of content to pragmatic considerations unfit for the kind of theoretical reasoning that, according to Carnap, was constitutive of philosophy. (Note that, at this point, Carnap did not admit the possibility of a formal semantics.) For most commentators, though, what makes *Logical Syntax of Language* important is the Principle of Tolerance with which this paper began[15]: Carnap's remarkable advocacy of complete epistemic discretion in the choice of a logic.

Conventionalism, though, was hardly an entirely new theme in Carnap's work. In *Logische Aufbau der Welt* (Carnap 1928) he had already suggested that the choice of an epistemological basis for the construction of the world, whether it should be autopsychological (roughly, solipsistic) or physical, could be regarded as a matter of choice even though the former had epistemic privilege. Nevertheless, to extend epistemic discretion to logic itself—the very basis for inference—was a radical move and has been duly recognized as such in the recent assessments mentioned earlier.[16] The choice of a logic was to be determined on pragmatic grounds, the practical use of the system. There was no question of correctness; there was no theoretical issue involved. (Following Carnap [*e.g.*, 1937a, b, 1939] a "theoretical" claim is one that has a truth-value.) This move had significant philosophical consequences only two of which will be relevant to the discussion below.

First, to Carnap's obvious delight, the Principle of Tolerance apparently defused the controversy over the foundations of mathematics between intuitionists, formalists, and logicists. To satisfy intuitionist strictures, Carnap constructed a restrictive finitary Language I with bounded quantification. However, most of classical mathematics was beyond the scope of Language I. Consequently, much of the reasoning in the theoretical sciences (especially physics) could not be accommodated within that language. But this was no reason for undue concern. Given the Principle of Tolerance, Carnap was at liberty to construct richer languages—these included his Language II which admitted all of classical mathematics. Thus, the controversy between intuitionists on one side, and formalists and logicists on the other, was defused in the sense that it came down to a conventional choice of language guided by the intended use of the logical system.

But, what of the dispute between formalists and logicists? Here, Carnap moved into new territory. In the spirit of Frege and Russell, as late as 1931, Carnap (1931) had characterized logicism as consisting of two claims: (i) "The concepts of mathematics can be derived from logical concepts through explicit definitions"; and (ii) "The theorems of mathematics can be derived from logical axioms through logical deduction" (Carnap [1983], p. 41). There was no ambiguity here about what logic was supposed to mean.[17] The Principle of Tolerance made this formulation irrelevant

[15] See, for instance, Creath (1992), Sarkar (1992), Ben-Menahem (2006). Sarkar (1992) discusses the role of other figures in the introduction of the Principle, especially that of Menger.

[16] Note, though, that contemporary reviewers in the 1930s, particularly logicians and mathematicians, did not find the move particularly surprising or interesting—see the discussion of these reviews in Sarkar (1992): entrenchment of a single system (or even a small set of systems) as "logic," as later happened in much of analytic philosophy, is notably absent.

[17] What Carnap had in mind was the system of *Principia Mathematica* but that makes the second claim problematic. At the conference at which Carnap made that claim (in a symposium in which Heyting and von Neumann presented the intuitionist and formalist positions, respectively), Gödel announced his first incompleteness result as part of the ensuing discussion (Sarkar 1992). But even without that, the Axioms of Infinity and Reducibility (which were part of the system of the *Principia*) were problematic insofar as it was far from clear that they counted as legitimate logical axioms.

since it was a matter of choice as to what system could be adopted as a logic, including those such as Language II which embraced all of mathematics.

For Carnap, after adoption of the Principle of Tolerance, the difference between formalism and logicism simply amounted to this: beyond the formalist, the logicist required that "the meaning of the symbols must be determined" (Carnap [1937b], p. 326). An argument he had already used in 1931 now became central to the logicist position: "the sentence 'In this room there are now two people present'" he argued, "cannot be derived from the sentence 'Charles and Peter are in this room and no one else' with the help of the logico-mathematical calculus alone, as it is usually constructed by the formalists" (p. 326). The critical difference-maker was Frege's definition of number which allowed the two claims to be appropriately connected.[18] Formalism was not incorrect; it was merely incomplete if one made the pragmatic choice of requiring that the selected logical system could be deployed while doing empirical science. In retrospect, what was implicit here is the importance of having an interpreted formalism, the issue that moved to central stage in *FLM* and ever afterwards.

Second, besides Language I and II, *Logical Syntax of Language* included a discussion of "General Syntax," the syntactical properties of any language whatsoever. In particular, the syntax of any language required the specification of formation rules to define admissible formulae, and transformation rules, namely, rules of derivation to obtain new formulae. Carnap accepted the possibility of incorporating empirical sentences into a language, both general laws of nature and singular facts. Here the syntacticism led to an interesting move: even the laws of nature could be formalized as transformation rules on par with logico-mathematical rules of derivation. The striking contrast here is with the customary method of introducing them as axioms with empirical content (which Carnap also allowed).

The crucial point about the Principle of Tolerance was that there was no correct logic. In fact, if this view is accepted and taken seriously, all that is explicitly stated in *Logical Syntax of Language*, including what, critically, is *not* stated, there is a potentially serious problem: Carnap did not even require a language to be consistent. Moreover, as Gödel had also shown, for any language rich enough to permit science, there could be no proof of the consistency of that language using only the (logical) resources available within it. This was the issue that came to trouble Carnap's later critics, especially Beth (Carnap 1963a) and Gödel (1995). Both thought that the only way out was by some appeal to intuition to ensure consistency, an appeal that was anathema to Carnap throughout his career (Creath 1992). But Carnap had a way out, through an appeal to interpretation (see §6 below) consistency could be presumed, as he correctly pointed out in his reply to Beth (Carnap 1963b)—but that is a development that began with *FLM* (and will be discussed in detail below). Meanwhile it is worth analyzing what the Principle of Tolerance required when, returning from this excursus into the foundations of mathematics, Carnap broached epistemological problems within the philosophy of science that were more central to the logical positivism of the Vienna Circle (and to much of his own earlier work).

[18] For the earlier use of this argument in 1931, see Dawson (1984). At that point, given the characterization of logicism (in the text above), this argument for logicism was only of subsidiary importance. With the Principle of Tolerance, it became central to any defense of logicism over formalism (Sarkar 1992).

4 The proposal of empiricism

By the time Carnap began work on *TM*, conversations with Tarski and Gödel had begun to convince him of the possibility of a theoretical, that is to say, a formal semantics. However, this change of position had very little explicit influence on *TM* beyond two relatively minor points. First, in a footnote, Carnap (1937b, p. 1) referred to Tarski (1935) and semantics, and observed that much of what he was doing would fall under the scope of what Tarski called semantics; however, this point was not developed and played no further role in the subsequent discussion in *TM*.[19] Second, given that the present paper argues that the acceptance of semantics based on interpretation restricted the scope of the Principle of Tolerance starting with *FLM*, it should be noted that the Principle is also never explicitly invoked in *TM*. However, as will be seen below, the Principle was repeatedly used in the arguments of *TM*; in fact, it was not invoked only in name.

The historical significance of *TM* lies in its liberalization of empiricism and, in that sense, creating a logical "empiricism" rather than "positivism."[20] The liberalization began with the explicit rejection of all versions of the principle of verifiability for the meaningfulness (of terms) that had once been central to many in the Vienna Circle (Carnap 1936a, pp. 421–424).[21] This rejection was based on the objections raised by several empiricists including Nagel, Popper, and Reichenbach.[22] The term "verifiable" was to be replaced by "testable" and "confirmable" each of which, as a criterion of meaning, received a weaker and stronger formulation (depending on whether only observability or also realizability was required—see below for further explanation); all versions of these requirements were weaker than verifiability (Carnap 1937b, pp. 33–35).[23] Which of these should be used is a matter of choice, that is, of convention—this is the type of conventionalism that pervades *TM*.[24] These new formulations required the construction of an infinite hierarchy of languages of increasing complexity (which Carnap [1937b, p. 24] calls a "scale of languages"). This was syntactically specified and was essentially a version of what has come to be called the arithmetical hierarchy. At the lowest level, L_0, were (molecular) sentences with no quantifiers. At the next, there were only universal quantifiers (L_1). At the next (L_2), these universal quantifiers were preceded by existential quantifiers. This process of introducing new quantifiers was iterated indefinitely with each type of quantifier being alternately introduced at successive levels of the hierarchy. Thus the hierarchy embraced sentences of arbitrary complexity,

[19] Tarski (1935) is listed as one of the works that was published only after *TM* was composed which may explain why its methods were not deployed at this stage (compared to *FLM*).

[20] However, Carnap does not use the term "logical empiricism," preferring "scientific empiricism" instead (Carnap 1937b, p. 38).

[21] Indeed, this is what Carnap (1963a, §9) primarily had in mind in referring to these developments as the liberalization of empiricism.

[22] For a full discussion see Carnap (1936a), pp. 422–424.

[23] Additionally, as part of the ongoing liberalization of empiricism, Carnap no longer prioritized the methodological solipsism of *Logische Aufbau der Welt* which had found much but not complete support within the Vienna Circle; this avoidance was motivated by the situation that "in spite of all explanations and warnings [methodological solipsism] . . . was often misunderstood" (Carnap 1936a, p. 424). The same point also pertains to the use of an autopsychological basis for the construction of the world in that work.

[24] Note that Carnap repeatedly appeals to conventions explicitly in *TM* (*e.g.*, Carnap [Carnap 1936a], pp. 426, 430; Carnap [Carnap 1937a], pp. 20, 24).

the level being determined by the number of changes of quantifier-type (from universal to existential or *vice versa*) in the sequence of quantifiers in it.

As noted earlier, both confirmability and testability were supposed to be weaker than verifiability. Moreover, confirmability was itself supposed to be a weaker requirement than testability: "a sentence may be confirmable without being testable; e.g. if we know that our observations of such and such a course of events would confirm the sentence, and such and such a different course would confirm its negation without knowing how to set up this or that observation" (Carnap 1936a, pp. 421–422). The relevant lack of ability was due to technological (or other practical) constraints. In Carnap's (pp. 455–456) terminology, confirmability required reducibility (which will be explained below) to an observable basis; testability required reducibility to a realizable basis. Here, an observable basis consists of atomic sentences with observable predicates: for a sentence formed using such a predicate, its correctness could be determined with a certain degree of confidence by an individual "under suitable circumstances . . . with the help of few observations" (p. 455). In the case of a realizable basis, the relevant assessment of correctness must be "full" (p. 456) in the sense of not invoking a certain degree of confidence. (Since "observable" and "realizable" were supposed to be "basic terms," these characterizations were not intended as definitions; rather they were "rough explanations" [p. 454].) Both bases were, by *choice*, restricted to predicates in a "thing-language," that, is where each predicate referred to everyday physical things (see below).

The central concept on which the definitions of confirmability and testability were based was that of reducibility, initially introduced to formalize disposition concepts such as "*x* is soluble." The problem with such concepts was that they could not be adequately explicitly defined (using traditional biconditionals) from an observable or realizable basis (that is, using predicates corresponding to directly observable or realizable properties). For instance, suppose that "*x* is soluble" was defined by:

x is soluble if and only if, for all times, *t*, if *x* is put into water at *t*, then *x* dissolves at *t*.

Now, suppose that *x* is a piece of wood and *x* was somehow destroyed before *t* without ever having been put in water. Presumably one would still want to say that "*x* is soluble" is not true, that is, *x* is not soluble. Now, in the biconditional given above, consider the second component which is itself a conditional. Since the antecedent is false, the conditional must be true. Consequently, this definition would make *x* soluble (Carnap 1936a, p. 440). Thus, Carnap concluded, this definitional strategy would not work. Instead, all that could be done was to lay down conditions that had to be fulfilled for such concepts to be reducible to observable or realizable ones—once again, empiricism had to be liberalized.[25] Very roughly, formalization of disposition concepts was to be achieved through the introduction of statements with two conditionals (or one conditional and one biconditional) (pp. 440–441):

[25] Demopoulos (2007) takes this aspect of the liberalization of empiricism to be central to *TM* and concludes that *TM* "is the clearest anticipation of the mature view [on rational reconstruction of theories that Carnap] developed in the 1950s and 1960s" (p. 249). In contrast, the present paper views *TM* as constituting the final stage of Carnap's syntacticism and sees more continuity between it and previous works such as *Logical Syntax of Language*, than between it and works that accept semantics and emphasize interpretation, starting with *FLM*. Nevertheless, the point that explicit definitions may not be possible for all theoretical concepts in science is an important development in Carnap's epistemological views during this period.

If x is put in water at time t, then, if x is soluble then x dissolves at time t.

The embedded conditional (that is, the one which comprises the consequent of the full conditional) could potentially be replaced by a biconditional in these reduction sentences. This method of "reduction sentences" was then generalized to permit the introduction of the concepts of confirmable and testable as noted earlier. Additionally, chains of reduction sentences were to be used to connect concepts far removed from observation to those concepts that were directly reducible to sentences in the observable or realizable bases (both of which consisted of sentences that were formulated in a "thing language). Some of these technical developments were quite interesting—and, indeed, ingenious for the time—but are not germane to the considerations of this paper.

What is at stake in this paper is the role of the Principle of Tolerance and the associated conventionalism and the discussion above has already emphasized the choices that were available. As noted earlier, the Principle is not invoked by name, but remained central to *TM*. What Carnap stated in that work is conceptually indistinguishable from the formulation of the Principle of Tolerance in *Logical Syntax of Language* with which this paper started. Here is the formulation in *TM*: "We may construct a [a language] L in whatever way we wish. There is no question of right or wrong, but only a practical question of convenience or inconvenience of a system form, i.e. its suitability for certain purposes" (Carnap 1937b, p. 4). In the same spirit, with respect to confirmability and testability, Carnap noted: "Different requirements are discussed, corresponding to different restrictions on language; the choice between them is a matter of practical decision" (Carnap 1936a, p. 421). The differences between him and Schlick on verifiability concerned "not a theoretical question of truth but a practical question of decision concerning the form of a language-system, and especially the formation rules" (Carnap 1936a, p. 424). The same point is made repeatedly—there should be no question that the Principle of Tolerance is central to *TM*.

Moreover, in yet more epistemic discretion, the choice of a particular criterion of confirmability or testability (that is, between them and between each of the two criteria for them, as defined by Carnap) also required a choice of one of the languages in the hierarchy described earlier. For instance, Carnap argued, Popper's (1935) criterion of falsifiability amounted to a restriction of scientific theories to a language with sentences containing only universal quantifier, that is, L_1. (Carnap 1937b, p. 26). However, Popper admitted that physics required universally quantified sentences where these quantifiers ranged over an existentially quantified sentence (*i.e.*, sentences of the form $(\forall.)(\exists.)$ …)—for Carnap, this was the choice of another language higher in the hierarchy, namely, L_2 (Carnap Carnap 1937a, p. 27). However, nothing precluded the choice of languages at higher levels of the hierarchy.

Thus, not only had the requirement for meaningfulness (one of the central concerns of the Vienna Circle's logical positivism), been replaced by syntactical criteria (rules of formation for the admissible sentences of a language), the Principle of Tolerance had led to the admissibility of different criteria with the differences to be adjudicated entirely on practical grounds of convenience. Further, and this is a critical point, when the liberalization of empiricism in *TM* went beyond mere weakening of the traditional requirement of verifiability, that is, when it led to the admission of more than one possibility for a criterion of empirical meaningfulness, the liberalization was being driven by the Principle of Tolerance. Finally, a variety of languages

(from the hierarchy described earlier) were available and the one to be used was to be selected on pragmatic grounds. It should, therefore, hardly be surprising that the final languages (and note the plural) that Carnap endorsed depended on a sequence of explicitly discussed decisions: thus, what is exhibited here, and extended, is the type of conventionalism that had begun to be promoted in *Logical Syntax of Language*. Also consistent with the earlier work, as far as the observable or realizable bases were concerned, one could choose a "positivist" phenomenological language, a "thing" language referring to everyday things, or a physicalist language that supplemented the thing language with the terminological repertoire of physics (Carnap 1936a, pp. 436–437): the choice between them was a matter of convention though, for most of the discussion, Carnap had a decided preference for the thing language (as was also the case in *Logical Syntax of Language*).

How far could this conventionalism be taken? So far that, by the end of *TM*, the liberalization of empiricism had, arguably, gone beyond what was merely suggested by the Principle of Tolerance though Carnap seems to have regarded it as a natural development from that principle. Empiricism itself became a proposal:

> "It seems to me that it is preferable to formulate the principle of empiricism not in the form of an assertion—'all knowledge is empirical' or 'all synthetic sentences that we can know are based on (or connected with) experiences' or the like—but rather in the form of a proposal or requirement. As empiricists, we require the language of science to be restricted in a certain way; we require that descriptive predicates and hence synthetic sentences are not to be admitted unless they have some connections with possible observations, a connection that has to be characterized in a suitable way. By such a formulation, it seems to me, greater clarity will be gained both for carrying out the discussion between empiricists and anti-empiricists as well as for reflections of empiricists" (Carnap Carnap 1937a, p. 33).

Thus, there were different criteria of meaningfulness and each could also be relativized to a particular language in the hierarchy. One could take each of these to specify what it means to be an empiricist but, taking Carnap at face value, one could also refuse to play the game altogether—this liberalism now presumably even tolerated metaphysics in the sense that the requirement that descriptive sentences be connected to observations is only part of a proposal. A metaphysician (in the logical empiricists' sense) would simply not accept this proposal. Science, as customarily understood may become impractical (or, at least, extremely difficult) but the metaphysician would not committed a theoretical error. Such a metaphysician would simply have a non-empiricist attitude towards science. Luckily for empiricism, and for the philosophy of science, there was a retrenchment of this conventionalism once Carnap endorsed semantics and, more importantly, began to insist on the availability of a contextual interpretation of linguistic terms, starting with *FLM* in 1939.

5 Recourse to interpretation

Perhaps the most striking aspect of *FLM* is that much of it (the largest of the three chapters) was devoted to empirical science, in spite of the book supposedly being about logic and mathematics which, being analytic, are epistemically distinct from the

synthetic realm of empirical science. This feature underscores a recurrent theme in Carnap's work throughout his career, *viz*., that logic and mathematics were mainly interesting insofar as they could be used in the empirical sciences. From this perspective, *Logical Syntax of Language* was somewhat of a digression or, perhaps, a derailment from the main lines of development of logical empiricism that was induced by the sheer unexpectedness of Gödel's incompleteness results and their deflationary implications for the ongoing debates on the foundations of mathematics. That admitted, with *TM*, Carnap returned to the central concerns of the Vienna Circle but the Principle of Tolerance remained in the foreground (as pointed out in Section 4). However, in the context of empirical science, Gödel's (and other metamathematical) results have little, if any, relevance. It should come as no surprise, therefore, that these concerns disappeared almost entirely from Carnap's subsequent work.[26]

In this context, *FLM* can be regarded as establishing a new beginning: reformulating the foundations of logic and mathematics in a new way and in a fashion designed to ensure their straightforward applicability to empirical science. The crucial innovation, of course, was the acceptance of semantics (Koellner 2009). In subsequent decades when Carnap returned repeatedly to the concerns of *TM*, to confirmation and cognitive significance, the methodology was radically different—not only were the formulations not purely syntactic, as would be expected after the turn to semantics but, more importantly, the profligacy of definitions and languages was gone, or at least severely constrained. What follows will show why.

Carnap's purpose in *FLM* was "to make clear the role of logic and mathematics *as applied in empirical science*" (*FLM*, § 1, p. 2; emphasis added).[27] He began with an analysis of language which he divided into three parts (note the order): pragmatics, semantics, and syntax. Two processes of abstraction connect the three parts: the first, which will be called abstraction$_1$ here, enables the transition from pragmatics to semantics; the second, which will be called abstraction$_2$, here, enables that from semantics to syntax.

Pragmatics must take into account "the action, state, and environment of a man who speaks or hears [some linguistic entity]" (*FLM*, § 2, p. 4). Carnap observed: "In this way we slowly learn the designata and mode of use of all the words and expressions . . .; we find out both the cause and the effects of their utterance" (*FLM*, § 3, p. 6). What is found out constrains what semantical system is an admissible interpretation of the syntactic system that was to be introduced. As Carnap emphasized: "Pragmatical observations are the basis of all linguistic research" (*FLM*, § 3, p. 6). The way in which these observations ground the system will be the way in which empirical facts ground scientific theories.

Semantics, which came next, was explained in more detail. Consider a language, **B**. In semantics:

> "We study the relations between the expressions of **B** and their designata. On the basis of those facts we are going to lay down a system or rules establishing

[26] This is why Sarkar (1992) argued that *Logical Syntax of Language* should be judged on the basis of what it contributed to technical logic and the foundations of mathematics rather than it advocacy of particular philosophical positions.

[27] There were many editions of *FLM*, identical in content, but with different pagination because the piece was both issued independently and as part of volumes of the different editions of the *International Encyclopedia of Unified Science*. Citations, therefore, include section numbers which were cumulative even though the work was divided into three chapters; page numbers are to the Carnap (1939) edition.

> those relations. We call them *semantical rules*. These rules are not unambiguously determined by facts.[28] . . . The facts do not determine if the use of a certain expression is right or wrong but only how often it occurs and how often it leads to the effect intended, and the like. A question of right or wrong must always refer to a system of rules. Strictly speaking, the rules which we shall lay down are not the rules of the factually given language B; they constitute a language system corresponding to **B** which we will call the *semantical system **B**-S*" (*FLM*, § 4, pp. 6–7).

For Carnap, the semantical rules included the formation rules of a language besides rules establishing the designata and truth conditions. In retrospect, this seems somewhat awkward in the sense that formation rules had to be introduced again as part of syntax and these were then constrained to be isomorphic to their semantic counterparts: that was the price that had to be paid if semantics was to be epistemically privileged over syntax (which is what was implied by Carnap's views in *FLM*).

More important in this context, Carnap repeatedly referred to the process of obtaining semantic rules from a given empirical language as "abstraction" (*e.g.*, *FLM*, § 6, p. 11, § 8, p. 16; this is abstraction$_1$ in what follows). It is because of abstraction$_1$ that choice is available in the formulation of the semantical rules as mentioned in the last paragraph.[29] During abstraction$_1$, "some properties drop out of consideration and hence some distinctions disappear. Because of the semantical synonymity [*sic*] of . . . names . . ., the sentences 'titisee ist kalt' and 'rumber ist kalt'[30] are also semantically synonymous. These two sentences have the same truth conditions, although different conditions of application" (*FLM*, § 6, p. 11). Abstraction$_1$ thus involves making usage precise in the context of formal semantics so that semantical rules can be used for the purpose of the designation of truth and meaning and establishing relations such as equivalence and implication (what Carnap called "L-equivalence" and "L-implication"; *FLM*, § 7). It is important to note what abstraction$_1$ does not allow: for example, it does not allow all sentences of **B** considered to be true by users to turn out to be false. In fact, if most such sentences turn out to be false, that is a sign of poor construction of **B**-*S*.

A different process, also called abstraction by Carnap (*FLM*, § 8, p. 16; this is abstraction$_2$ in what follows), this time from the semantical rules, provided the rules of syntax of the language which was "the formal theory of an object-language, formulated in the metalanguage" (*FLM*, § 8, p. 16). Besides formation rules (see above), syntax included the usual transformation rules, that is, the rules of inference. As in the case of abstraction$_1$ in the transition from pragmatics to semantics, the abstraction$_2$ involved in the transition from semantics to syntax left room for choice: "There are an infinite number of . . . possible choices of primitive sentences and rules

[28] Carnap gave an example: "Suppose that we have found that the word 'mond' of **B** was used in 98 % of the cases for the moon and 2 % for a certain lantern. Now it is a matter of our decision whether we construct the rules in such a way that both the moon and the lantern are designata of 'mond' or only the moon. If we choose the first, the use of 'mond' in those 2 % of cases was right—with respect to our rules; if we choose the second, it was wrong" (*FLM*, § 4, p. 6).

[29] Koellner (2009) emphasizes this role of choice. However, in contrast to the arguments being presented here, he ignores the issues of abstraction and interpretation which results thereby in his also ignoring the role of empirical science in Carnap's project.

[30] "Titisee" is supposed to be the name of a lake in a fictitious country; on certain holidays the lake happens to be called "rumber" (*FLM*, § 3, p. 5).

of inference which would lead to the same result" (*FLM*, § 9, p. 19). Nevertheless, this freedom is not unconstrained: the syntactic rules must maintain proper concordance with the semantical ones. Trivially, the syntactically well-formed structures must also be semantically well-formed (because semantic rules of formation were introduced first, as noted earlier). However, the constraints on the rules of transformation are more important: each such rule must correspond correctly to its semantic counterpart in the sense of giving concordant classifications of sentences with respect to their logical properties (*FLM*, § 9, p. 18). For instance, syntactic implication ("C-implication"; *FLM*, § 9, p. 19) must correspond to semantic implication ("L-implication"). Now, because, abstraction$_1$ was constrained by the intended application to the given pragmatic context, abstraction$_2$ is indirectly so constrained. What emerges is a syntactic system (formal calculus) and its intended interpretation, namely the semantical rules.

Finally, when it came to empirical languages including laws of nature, these were only introduced as axioms rather than also as potential transformation rules (unlike the situation in *Logical Syntax of Language* or *TM*). This was preferable because semantics allowed sentences to have precise content, in this case that of the relevant laws of nature. With laws as axioms, Carnap provided an account of scientific explanation which is identical to what Hempel and Oppenheim (1948) popularized much later as the deductive-nomological model of explanation (*FLM*, § 15, p. 36).[31]

Conventional choices were still relevant in the construction of a system—when abstraction$_1$ was involved in the transition from pragmatics to semantics and abstraction$_2$ in the transition from the latter to syntax. Nevertheless, there are two ways in which these choices were far more constrained than in *Logical Syntax of Language* and *TM*. The first conceptually follows from the fact that the acceptance of semantics reduces the scope of the epistemic discretion that was available. That is to say, if the semantic features of a language (questions of truth and meaning) were also a matter of pragmatics and, therefore, did not at all constrain the syntax of the language (as was the case in *Logical Syntax of Language*), there was even more room for choice (epistemic discretion) than in the situation in which the rules of semantics constrained the syntactical rules that were admissible. The second way in which conventional choices become more constrained is more interesting—through interpretation. It shows how the Principle of Tolerance must itself be severely curtailed. That will be the topic of the next section.

6 Consequences of contextual interpretation

The procedure for constructing a language that was outlined in Section 5 was not the only one that Carnap considered in *FLM*. For expository ease, the procedure outlined in Section 5 will be referred to as the contextual procedure because it relies (at the level of pragmatics) on the context for the construction and adoption of a language. Carnap also admitted a procedure in which the syntactical rules were chosen first, with no constraint

[31] Strangely, Hempel and Oppenheim (1948) do not refer to *FLM* though they refer to several of Carnap's later works. Even Salmon (1989) ignores the priority of *FLM* in what is supposed to be a comprehensive history of discussions of scientific explanation during the post-1940 period.

on them, followed by the formulation of a set of semantic rules to provide an interpretation. In contrast to the contextual procedure, this method will be called "formal" (see, also, Koellner 2009). It is similar to the process of language construction in *Logical Syntax of Language* with an added stage of formulating semantic rules to interpret the formal system. As far as the choice of the syntactic rules was concerned, the Principle of Tolerance ruled though, pointedly, Carnap made no explicit mention of it.

Instead, Carnap summarized the situation as follows:

> "The result of our discussion is the following: logic or the rules of deduction . . . can be chosen arbitrarily and hence are conventional if they are taken as the basis of the construction of the system and if the interpretation of the system is later superimposed. On the other hand, a system of logic is not a matter of choice, *but either right or wrong*, *if an interpretation of the logical signs is given in advance*" (*FLM*, § 12, p. 26; emphasis added).

This was not intended to suggest that there is no conventional element at all in the contextual procedure (that is, the second procedure mentioned in the quotation). There still was, as noted earlier, during the processes of abstraction$_1$ and abstraction$_2$, but, nevertheless, the available epistemic discretion was curtailed.[32] In the contextual procedure there was no Principle of Tolerance as formulated in *Logical Syntax of Language*: one was never "at liberty to build up his own logic . . . as he wishes." The interpretation came first: logic was built subsequently through sequential abstraction$_1$ and abstraction$_2$ to semantic and, finally, syntactic rules. If logic and mathematics were to be applied to empirical science, which Carnap repeatedly emphasized, the contextual procedure was clearly preferable to the formal one. However, this privilege was not based on theoretical considerations—it remained a pragmatic decision. While the conventionalism of *Logical Syntax of Language* and *TM* was severely curtailed, conventions still remained central to Carnap's thinking as it did throughout the rest of his career.

Starting with an interpretation has important consequences, a point that has far too often been missed by Carnap's critics and commentators. Carnap repeatedly emphasized (*e.g.*, Carnap [1963b]) that an interpretation required more than simply providing a model for a (syntactically formulated) theory, and that this interpretation was epistemically privileged (in the sense that it came first). By "model" Carnap meant what was (and is) usually meant: the specification of any formal structure into which syntactic forms could be translated so as to assign truth-related properties to these structures (*e.g.*, making some sentences true and others false). For Carnap, an interpretation required more: besides the model, which is a purely formal structure, there must be an assignment of meaning in a pragmatically fixed context. In fact, this assignment is what is important—the intermediate stage of a formal model is dispensable.[33] Moreover, the same formal model can

[32] However, this is not a return to Carnap (1931) where he says: "Logicism proposed to construct the logical-mathematical system in such a way that . . . that the axioms are chosen with an interpretation of the primitive symbols in mind" which left virtually no discretion at all.

[33] This is how Carnap (1963b, p. 902, italics as in the original) puts it: "To give an *interpretation* for a language (or for an axiom system) is to assign meanings to the signs and sentences, either formally by explicit semantical rules or informally by non-technical indications of any form. An interpretation should not be identified with a model, as is sometimes done. It is true that an interpretation can sometimes be given by the specification of a model. But there is no one-to-one correspondence between interpretations and models; two different (i.e., not logically equivalent) descriptions of the *same* model represent two *different* interpretations."

belong to more than one interpretation corresponding to different meaning assignments. If the requisite meaning assignments came first, that is, the pragmatic context was specified first, as in what is here being called the contextual procedure, there is an intended interpretation with the context specifying the intent.

Nevertheless, Beth (1963) deployed the existence of non-standard models of a language as an argument against Carnap's views on the importance of constructed systems for philosophical analysis. Though Beth (1963) claimed to have addressed Carnap's requirement of needing an interpretation by providing models for a syntactical system, this interpretation was obtained by following the formal procedure of *FLM* insofar as providing an interpretation (through the model) came *after*, rather than *before*, the formulation of the syntactical system. It was not what Carnap accepted as an interpretation. In response, Carnap (1963b), perhaps understandably, brushed Beth's criticism aside and, less understandably, ignored Beth's (interesting) formal arguments altogether.[34] For Carnap, not all models had the same epistemological status: the model with the intended interpretation was epistemologically privileged. This was the model obtained by an abstraction$_1$ from the given (typically empirical) context. Hintikka (1992) takes Carnap to task for not adopting a fully model-theoretic perspective. The claim that Carnap does not do so is correct but irrelevant; the point is that the role of interpretation is precisely to privilege some models over others because of their contextual (and, typically, empirical) relevance.

Finally, though this is a matter of conjecture, and Carnap did not make such an argument explicitly in *FLM* or elsewhere, contextual interpretation provides good reason to expect no inconsistency in a formal system. The argument is as follows: assuming that the process of abstraction$_1$ by and large preserves truth, at least of the abstracted claims when they are interpreted in their original context, the syntactic forms obtained should be consistent. This assumes that any realizable context does not consist of "inconsistent facts" (and it is unclear what inconsistent facts could even mean at least in an empirical context where these facts consist of observation reports after they have been scrutinized and simultaneously accepted). While this does not constitute a formal demonstration of the consistency of the resulting system (and, indeed, Gödel's results show that such a formal demonstration cannot be expected), nevertheless, the argument as stated is compelling enough to believe that no inconsistency would arise once the language is deployed in practice, that is, for the further investigation of the context from which the language was abstracted. It was perhaps the best that Carnap could do against the skepticism of Gödel and Beth.[35]

This is not to suggest that the interpretive turn does not introduce its own problems but a detailed discussion of that issue that will be left for another occasion—the most serious problems have to do with the coherence of Carnap's notion of explication (see Section 8 below). Suffice it here to note one problem that occurred within *FLM*, one which Carnap did not resolve successfully. The context was that of geometry. Compared to other mathematical calculi, Carnap claimed: "Geometry must be dealt with separately. . . . [T]he customary interpretations of geometrical calculi are descriptive, while those of the mathematical calculi are logical" (*FLM*, § 21, p. 51). Yet, when

[34] Friedman (2009) suggests that Carnap conceded Beth's formal arguments. However, Carnap (1963a) did not address them at all—certainly, there is no explicit acceptance.

[35] For a different analysis of Carnap's response, see Awodey and Carus (2007).

Carnap analyzed the geometrical situation carefully the result was (unsurprisingly) that (i) formal/mathematical geometry was like any other mathematical calculus whereas (ii) physical geometry was an empirical theory (like any other part of physics). In other words, the distinctive feature of the preliminary interpretation with which the analysis of formal/mathematical geometry began, *viz*., the descriptive nature of geometry, gets lost during the abstraction$_1$. That feature only reappears in physical geometry. This means that, if geometry is to be regarded as a part of mathematics rather than physics (which is what is typically assumed), the preliminary spatially based interpretations of geometry were in some sense incorrect. There is a tension here that Carnap could not resolve: in fact, within his account there seems to be no scope for resolution and the problem was left hanging in *FLM* with no further analysis.

7 Aftermath

Carnap extensively developed semantics in *Introduction to Semantics* (Carnap 1942), carefully cataloging the departures from *Logical Syntax of Language* (Sarkar 1992). Once again, interpretation came first. Formal semantics was next formulated and included formation rules (besides rules of designation and truth). The syntactical system was introduced later with the formation rules constrained by the semantical ones but not necessarily isomorphic to them (to allow construction of more complex systems than those treated in *FLM*). However, in contrast to *FLM*, there was little concern for empirical science presumably because the explicit task of this work was to correct the treatment of logic in *Logical Syntax of Language*. In *Introduction to Semantics*, Carnap also promised a series of planned "Studies in Semantics." *Formalization of Logic* (Carnap 1943) came next—it also departed from the general trend of focusing on empirical applicability insofar as it included discussions of non-standard models ("non-normal interpretations") of propositional logic. For once, the formal procedure for language construction was given almost as much attention as the contextual one, but only because the topic of this book was formalization itself. *Formalization of Logic* promised a third volume of semantics on modalities—this was the influential *Meaning and Necessity* (Carnap 1947).

In his later work, though also starting in the 1940s, Carnap returned to the epistemological problems that had occupied *TM*. For him, the problem of confirmation became that of finding an appropriate interpretation of probability, *viz*., logical probability, followed by a quantitative measure for it (that is, for confirmation), a project on which he began working in 1941. Initial results were presented in a set of papers from the mid-1940s and then, comprehensively, in *Logical Foundations of Probability* (Carnap 1950). The main contrast with *TM* lies in the fact that the earlier work did not accept the concept of probability to have been sufficiently clarified (by Reichenbach or others) to be useful in addressing epistemological concerns. The problem of characterizing empirical meaningfulness eventually became that of finding an adequate criterion of cognitive significance. Carnap's final efforts in that direction were reported in Carnap (1956) which also attempted to provide a systematic account of the distinction between observational and theoretical terms in an empirical science.

For the purposes of this paper, both with respect to confirmation and cognitive significance, the relevant point is that the radical conventionalism of *TM* was long gone.

Contextual interpretation limited admissible proposals to a select few, a far cry from the profligate promises of the Principle of Tolerance. Carnap's ultimate goal was to find a single measure of confirmation though that turned out to be much more difficult than he had even anticipated or, perhaps, ever realized (Shimony 1992). Similarly, the later Carnap (1956) was searching for a single criterion of (empirical) meaning or cognitive significance, unlike the case of *TM* where an array of possibilities was presented. Conventionalism remained, but only in a mitigated form—especially in the choice of a framework or language.

8 Concluding remarks

In the context of Carnap's later work, the fundamental move in *FLM* was to anchor a formal system to an interpretation but, even more critically, to anchor that interpretation on the context in which the philosophical analysis was initiated. Equally crucial, for both Carnap and for the subsequent development of logical empiricism, was that the most important such context was the empirical one of scientific research as attested by the extensive discussion of physical theory in *FLM*. Here, there was continuity between *FLM* and *TM*, in contrast to *Logical Syntax of Language* and, more strangely, with *Introduction to Semantics* and *Formalization of Logic*. This is not to suggest that *Logical Syntax of Language* was entirely devoid of empirical concerns—far from it: as noted earlier (in Section 3), its discussion of general syntax even included the possibility of transformation rules that constituted laws of nature. Nevertheless, empirical issues get short shrift in that work. The startling consequences of Gödel's results had derailed the empiricist program of logical positivism into a searching examination of the foundations of mathematics. *Introduction to Semantics* and *Formalization of Logic* consisted of a translation of the insights of *Logical Syntax of Language* into a new logical context that included formal semantics, regarding it as epistemologically privileged (compared to syntax) which empirical concerns temporarily bracketed.

However, in the late 1930s, Carnap returned to that empiricist program of the Vienna Circle in *TM* but continued to embrace the somewhat radical conventionalism embodied in the Principle of Tolerance. The requirement of contextual interpretation in *FLM* removed much of the epistemic discretion that was provided by that Principle. But not all epistemic discretion was irretrievably lost. As pointed out earlier, semantical rules were obtained for a given context through a process of abstraction (*viz*., abstraction$_1$). By the late 1940s the process of abstraction$_1$ became codified as part of what became the distinctive feature of Carnap's later views[36]: *explication*, a concept that was elaborated in detail in Chapter 1 of *Logical Foundations of Probability* (1950). "The task of explication is of very general importance in the construction of concepts," Carnap there argues (Carnap 1950, p. 2). "It consists in transforming a given more or less inexact concept into an exact one or, rather, in replacing the first with the second (Carnap 1950, p. 3)." Explication required the elimination of ambiguity (recall the discussion of

[36] Note that explication is the abstraction$_1$ to the semantic rules from the pragmatic context; it is not the abstraction$_2$ of the syntactic rules from the semantic ones which is also part of the contextual procedure or language construction in *FLM*.

Section 5). However, not only did some distinctions disappear (as in abstraction$_1$), sometimes, the same informal concept could lead to more than one explicated concept: for instance, informal classical probability led to two different ones, the first appropriate for a logic of confirmation and the second appropriate for physical contexts. Thus, explication was more elaborate than abstraction$_1$ but the latter remained a component of the former.

The success of an explication was to be judged using four criteria: (1) similarity of the *explicatum* to the *explicandum*; (2) exactness; (3) fruitfulness; and (4) simplicity, with the fourth having lesser importance than the other three. Carnap's discussion of the similarity criterion was quite detailed: in particular, there may be a tradeoff between similarity and fruitfulness. For instance, if an attempt was made to maximize the similarity between the *explicatum* and *explicandum* (for instance, by retaining for the former as many of the uses of the latter as was possible under the constraint of exactness), the result may not have allowed as many scientifically interesting laws to be stated for the *explicatum* as would have been possible had some of the uses of the *explicandum* been sacrificed. These pragmatic considerations may remain informal; nevertheless, they make no appeal to intuition. As argued earlier, this is the point that Beth (1963) and others missed—unless one takes the view that all nonformal discussion necessarily involves some appeal to intuition.

Carnap explicitly addressed the issue of interpretation in this context.[37] At first sight he seems to have reneged on the contextual procedure of system construction from *FLM*. He characterized explication as requiring two distinct processes of formalization and interpretation with the former to precede the latter, as if in accordance with the formal procedure of *FLM*. Perhaps this was a recognition of the fact that the contextual procedure (recall Section 5) included the awkward requirement that formation rules were initially part of the semantical system. Nevertheless, it seems to hearken back to the syntacticism of the earlier period. Luckily Carnap added:

> "We are not speaking here of a formal system in the strict sense, sometimes called a calculus (in the strict sense) or a syntactical system; in a system of this kind all rules are purely syntactical and all signs occurring are left entirely uninterpreted. . . . On the other hand, we are not speaking of axiom systems of the traditional kind, which are entirely interpreted. In the discussions of this book we are rather thinking of those semiformal, semi-interpreted systems which are constructed by contemporary authors, especially mathematicians, under the title of axiom systems (or postulate systems) (1950, p. 15)."

There was thus no return to the earlier syntacticism: interpretation remained inextricably tied to formalization. Arguably, this is what made Carnap's methodology relevant to the practice of science, with philosophy, through explication, playing an essential clarificatory role. This appears to be the best defense of that methodology that can be offered even today. The beginnings are in *FLM*; hence, the import of that work (and the relevance of the historical reconstruction offered in this paper).

[37] See § 6, "Formalization and Interpretation," of Chapter 1 of Carnap (1950).

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