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Carnap's Logical Structure of the World

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Abstract

This article aims to give an overview of Carnap's 1928 book *Logical Structure of the World* or *Aufbau* and the most influential interpretations of its significance. After giving an outline of the book in Section 2, I turn to the first sustained interpretations of the book offered by Goodman and Quine in Section 3. Section 4 explains how this empirical reductionist interpretation was largely displaced by its main competitor. This is the line of interpretation offered by Friedman and Richardson which focuses on issues of objectivity. In Section 5, I turn to two more recent interpretations that can be thought of as emphasizing Carnap's concern with rational reconstruction. Finally, the article concludes by noting some current work by Leitgeb that aims to develop and update some aspects of the *Aufbau* project for contemporary epistemology.

1. Introduction

Rudolf Carnap (1891–1970) is a central figure in the development of analytic philosophy, with influences ranging from the foundations of logic and mathematics through the philosophy of science and the philosophy of language. His first book *Der logische Aufbau der Welt* was published in 1928, but translated into English as *The Logical Structure of the World* only in 1967. Despite this delay, it is fair to say that the *Aufbau*, as the book is typically called, is one of the most important books for the history of analytic philosophy. The exact nature of the *Aufbau*'s significance remains a subject of intense debate largely because different interpreters have drawn attention to different aspects of the work at the expense of other aspects. These disagreements, along with the fairly technical details of certain parts of Carnap's discussion, make the book somewhat daunting for first-time readers. The main aim of this article is to help the non-specialist approach the *Aufbau* and begin to appreciate why so many philosophers have spent so much time trying to understand it.

2. An Overview of Constitution Theory

Carnap's primary goal in the *Aufbau* is to introduce a novel discipline that he refers to as 'constitution theory'.[1] This theory aims to develop and investigate several constitution systems using the results of the various sciences along with the formal logical resources developed by Frege, Russell and Whitehead, among others. In the preface of the book Carnap signals the 'inner kinship' between this work and the broader cultural movements 'which strive for meaningful forms of personal and collective life' (xviii). As we will see, constitution theory itself requires the collaboration of scientists and philosophers of a certain kind, and Carnap seems to have hoped that the *Aufbau* would revolutionize the practice of philosophy.

The book itself is divided into five parts. The first part sets out the main objectives of constitution theory. Carnap begins with Russell's maxim that 'Wherever possible, logical

constructions are to be substituted for inferred entities' and states his aim to be to provide a constitution system in which all scientific objects are constituted out of a few in a fully rigorous logical way. A central thesis is that there are such constitution systems that build on a single domain. This shows, for Carnap, the unity of our scientific knowledge that is hidden underneath the divisions between the sciences as they are typically practiced. In the only extended example that Carnap gives of a constitution system a single relation is shown to be sufficient for the constitution. The remaining objects are constituted on this slender basis using definitions that employ only the basic relation and logical symbols. Another priority in the first part is Carnap's view that scientific knowledge is objective despite its origins in subjective experiences.

The second part of the *Aufbau* presents a preliminary survey of the form of scientific statements and the different stages of the constitution system. Carnap insists that the ultimate form of scientific statements must be given in purely logical or structural terms. This is because each object studied by science can be constituted or defined using a definite description that picks out the object using just its formal relations to other scientific objects. Using the example of the railway stations of Eurasia, Carnap explains how a purely structural definite description of each station is possible in terms of the network of connections between the stations. This presentation of scientific knowledge is motivated by the concern about objectivity: 'science wants to speak about what is objective, and whatever does not belong to the structure but to the material … is, in the final analysis, subjective' (§ 16). Physics is presented as already almost completely structural based on its reliance on mathematics.

Part three surveys in more detail what Carnap calls the 'formal problems' for his constitution system: the ascension forms, the system form, the basis, the object forms and the form of representing a constitution system. It is only with this discussion of the ascension form that Carnap's sparse conception of constitution becomes evident. For he insists that each scientific object be defined in a narrow sense of 'definition' that implies that all statements about that object be translatable into statements that are just about the basic objects of the system. Two sorts of definitions are allowed. In an *explicit definition* each sign for the object being defined is replaced by signs for objects that have already been defined. A more flexible notion of definition is *definition in use*. This focuses only on entire sentences and requires that any sentence containing a sign for the object can be transformed into a sentence that uses only signs for previously defined objects. Carnap presents either kind of definition as sufficient not only to constitute the new objects out of the old objects, but also to reduce the new objects to the old objects (§ 35).

Carnap repeatedly emphasizes that no further conclusions should be drawn about the status of an object based on its reducibility or on the existence of a constitutive definition. Manifestations of this attitude are Carnap's insistence that there is no significant distinction between scientific concepts and scientific objects (§ 5) and that an acceptable definition need only preserve the logical value or extension of the sign being defined (§ 51). Any additional associations with a scientific statement are deemed irrelevant. This conception of translation makes definitions easier to achieve and highlights a difference between Carnap's claims about reduction and some other more ambitious philosophical projects.

Carnap explains the details of his constitution systems using the logical vocabulary of Russell and Whitehead's *Principia Mathematica*. At the bottom of their logic, Russell and Whitehead place individuals. Then come classes of these individuals, followed by classes of classes of these individuals, and so on. Each level corresponds to a different type of object and Carnap uses this notion of type to make sense of the differences among

scientific objects. In particular, he emphasizes that explicit definitions are adequate to constitute an object from other objects in that type, whereas definitions in use constitute an object of higher type from objects of lower type (§§ 38–39). From a logical perspective, though, we can see all the objects of the constitution system as classes whose elements ultimately terminate in objects of the lowest type.

Part three also contains Carnap's explanation for his particular choice of constitution system. He requires that the definitions of this system respect the order of epistemic primacy. This order reflects how an individual can come to know something about the object. Carnap introduces a notion of indicator to make this more precise: 'We shall use the term ''indicator'' only for such conditions as are ordinarily used to identify the state of affairs' that is a basic kind of occurrence for that kind of object (§ 49). He assumes that each scientific object has 'an infallible and at the same time always present indicator' (§ 49) so that adequate definitions are in principle available for every object. The resulting constitution system begins with the elementary experiences of a single individual, and so is called 'autopsychological' to distinguish it from other heteropsychological systems that begin with the experiences of other individuals (§ 58). Carnap's basis is specified using a single basic relation Rs of recollected similarity. The elementary experiences are thought of as total momentary experiences that include as aspects inputs from all the different sense modalities including the will and the emotions. 'x Rs y' obtains when a memory of x is compared with a present experience y and some similarity is found in some respect (§ 78).

A final crucial contribution from part three is Carnap's introduction of four languages that he will use to present his constitution system. The basic language is the language of logic because it is the most precise and least likely to suggest improper interpretations. Additional languages are used for clarification and motivation. They are an ordinary 'word' language, a realist language and a language of fictional construction. Each definition can be given using these alternative languages and Carnap does this for some of the definitions of his constitution system. But he is quite clear that the logical language is the only one that he takes seriously and that any additional realistic or idealistic connotations of the other languages should be rejected.

In part four Carnap presents his outline of the autopsychological constitution system. It is divided into three stages. In the first stage, the autopsychological domain is constituted using the basic relation Rs. Here many of the definitions are presented in full detail and Carnap seems to think the constitutions are more or less complete. In the second stage, Carnap extends the system to the physical world. Here the definitions are not given in any detail and Carnap concedes in at least one place that 'our kind of constitution of physical points and of the physical space is by no means a fully satisfactory solution' (§ 124). Finally, in the third stage, the experiences of others along with an intersubjective world are given. Again, the definitions are merely sketched. Carnap alludes to two final levels where he locates cultural objects and values.

Carnap deploys a novel logical procedure called 'quasi-analysis' when he constitutes the autopsychological domain. The definitions operate on the pairs of elementary experiences satisfied by the Rs relation and deliver classes or relations between such experiences or higher-level entities like a class of relations between classes of experiences. These higher-level entities are used to define objects called quality classes, which are described in the realistic language as classes of elementary experiences that have a particular quality, like a color at a point in the visual field or a smell, in common (§ 112). But given that the elementary experiences are treated as units, this is not a genuine decomposition into

parts, so it is called 'quasi-analysis'. Quality classes, in turn, are used to define the sensations and the visual field is picked out by some of its characteristic features.

A different approach is used to constitute the physical things that make up the physical world. Carnap begins by setting up a four-dimensional manifold of real numbers with an ordinary Euclidean metric. This purely mathematical object is constituted at the earliest stages of the constitution system (§ 107). The first coordinate is thought of as the time coordinate, whereas the other three are the usual spatial coordinates. Carnap then presents 12 policies for assigning colors from the visual field to the 'world points' of this 'space-time world' (§ 126). Using this assignment, Carnap proceeds to constitute the visual things, including one labeled 'my body'. This step, in turn, allows a further identification of the other sensory modalities such as touch, and sensations from these senses are then applied to the world points as well. The end result of this fleshing out of the visual world is the perceptual world populated by perceptual things. It is only at this point that Carnap constitutes the physical world and the physical objects. They are obtained by coordinating the sensory qualities of the perceptual world with the numerical state magnitudes of the physical world. A key requirement, though, is that the resulting physical world be governed by deterministic laws. Carnap allows that there are several ways to do this, but counsels that principles of simplicity can be used to settle on a particular system of state magnitudes and laws (§ 136).

The last stage of the constitution system begins with the identification of other humans and the constitution of their sensory experiences based on their actions and statements (§ 140). Carnap then argues that there will be a kind of correspondence between the experiences that we wind up attributing to others and what we have constituted for ourselves. The resulting common overlap is called 'intersubjective coordination' (§ 146) and is used to constitute an 'intersubjective world' (§ 148) upon which all agents can agree. In line with Carnap's earlier discussion of subjectivity and objectivity, the intersubjective world is the subject matter of genuine scientific investigation and all claims about it are communicable to all agents (§ 149).

Finally, part five of the *Aufbau* discusses some of the implications of constitution theory for traditional philosophical problems such as the relation between mind and body and the decision between realism and idealism. Carnap takes the objects in his constitution system to exhaust what is properly the concern of scientific knowledge. Although other attitudes or approaches to life are allowed, all genuinely factual issues must be resolved in terms amenable to his sort of constitution. This means, in particular, that any further questions about the 'essence' or 'nature' of the mind, the body or their relation are not well-formed questions. Similarly, the traditional debate between realists and idealists about the existence of physical objects independently of minds is dismissed. This does not stop Carnap from articulating a distinction between empirically real objects and illusions. But this distinction is given in terms of the levels of his constitution system, e.g. is a given perceptual object coordinated with a physical object that is located in the physical world (§ 170)? Of course, this system-specific sense of 'real' is a far cry from the traditional philosophical debate, but this is precisely the sort of overcoming of traditional philosophy, especially metaphysics, that Carnap hoped for.

3. Empiricist Reduction

Goodman offered the first sustained discussion of Carnap's *Aufbau* and his objections to it remain some of the most influential. Goodman approaches the *Aufbau* as a 'constructional' system that starts with particulars and aims to construct universals like qualities.

Goodman argues that a condition of adequacy for such a system is that its definitions do not depend on 'doubtful extrasystematic assumptions' (*Structure* 134). This shows that Goodman has a prior standard that he uses to judge the adequacy of Carnap's definitions. The failure of Carnap's approach is used to motivate Goodman's own preference for a system that begins with sensory qualities and seeks to construct particular experiences.

Goodman's objections focus entirely on Carnap's constitution of the autopsychological domain. The basic point is that Carnap's transition from the elementary experiences to the points of the visual field and its colors will capture their intended domain only if the elementary experiences are related in a very special way by the Rs relation. Carnap's first step is to define the classes of part similar (Ps) experiences as the union of pairs of experiences that stand in the Rs relation in either order. The similarity circles are obtained from the classes of Ps experiences by taking the largest class of experiences such that every member of the class is part similar to every member of the class. Carnap assumes that these similarity circles will overlap, and so must introduce some complexities to isolate the circles that are meant to represent particular qualities, e.g. a given color at a given place in the visual field. Goodman's two main objections of 'companionship' and 'imperfect community' can arise at several stages, but we will put them in terms of the adequacy of the similarity circles. Companionship applies when the pattern of Rs relations makes Carnap's procedure miss subclasses of the similarity circles that are genuinely similar in some respect, whereas imperfect community comes into play when the procedure generates similarity circles over and above those that are genuinely present. Suppose we find {1, 2, 3} to be a similarity circle. The former difficulty would occur if the quality *a* occurred only in experiences 1, 2 and 3 while *b* occurred only in 2 and 3. Then Carnap's procedure would have no similarity circle {2, 3} because the maximization rule requires that we also add in 1 to this set. So, even though these two experiences are similar in an important respect, they have no separate similarity circle. The latter imperfect community problem arises in a simple way when 1 and 2 have quality *a*, 2 and 3 have quality *b* and 3 and 1 have quality *c*. Each member here stands in the Rs relation to every member and so {1, 2, 3} could wind up as a similarity circle. Carnap's definitions, then, would suggest that {1, 2, 3} is a genuine similarity circle even though there is no actual similarity shared among these three experiences.

Carnap shows some awareness of Goodman's concerns in the *Aufbau* itself (§ 81). Carnap's remarks suggest that does not think that 'extrasystematic' assumptions are needed to rule out Goodman's difficulties. Instead, Carnap claims that if an agent found herself in one of these unfavorable situations, she would not be in a position to realize the deficiency of the definitions. As the system aims to reconstruct the agent's knowledge, this can be understood as a failing of the agent's knowledge, not the system itself. To evaluate this response we would have to decide the extent to which Carnap aims merely at some kind of rational reconstruction or at the justification of our knowledge.

Quine focuses on a different stage in the constitution, namely the constitution of perceptual things, but as with Goodman, Quine uses the alleged failures of Carnap's project to motivate an alternative project. In line with Carnap's remarks about translation, Quine assumes Carnap is a radical reductionist: 'Radical reductionism … set itself the task of specifying a sense-datum language and showing how to translate the rest of significant discourse, statement by statement into it' ('Two Dogmas' 39). The project fails when Carnap tries to assign perceptual qualities to space-time points as he constitutes the perceptual world. The rules counsel us to maximize certain features of our overall assignment, and so 'it provides no indication … of how a statement of the form ''Quality q is

at x;y;z;t'' could ever be translated into Carnap's initial language of sense data. The connective ''is at'' remains an added undefined connective' ('Two Dogmas' 40). In 'Epistemology Naturalized' Quine makes clear why radical reductionism was desirable and what the implications of its failure are. If all scientific objects could be defined in sensory terms, then this 'could be expected to elicit and clarify the sensory evidence for science' as well as 'deepen our understanding of our discourse about the world' ('Epistemology' 74–5). The failure to define 'is at' shows Quine that such aspirations should be given up and that we should settle for his own descriptive approach to epistemology that sees questions of epistemology as part of psychology.

As we saw, Carnap recognized the limitations of his transition to the physical world (§ 124), but it remains unclear if he was worried about the sorts of problems that Quine mentioned. On Carnap's behalf we can note that, as more recent interpreters argue, it is not clear that Carnap's main concern was empiricist reduction. At the very least, we can note Carnap's remark from a 1935 paper that the '*theory of knowledge* is in its previous form *an unclear mixture of psychological and logical elements*. That holds as well for the work of our circle, not excluding my own earlier work' (quoted by Ricketts 258). This suggests that Carnap gave a different diagnosis of the failures of the *Aufbau* project than Quine. Carnap's own reactions to the criticisms of Goodman and Quine are given in his 'Intellectual Autobiography' and his 'Replies' in Schilpp (ed.). Curiously, these later remarks seem to grant the validity of Goodman's and Quine's objections. Whether this indicates a change in Carnap's views or is simply an attempt to respond kindly to criticisms remains a topic of scholarly debate.

4. Objectivity

Michael Friedman is responsible for much of the contemporary interest in the *Aufbau* based on two papers: 'Carnap's *Aufbau* Reconsidered' (1987) and 'Epistemology in the *Aufbau*' (1992), reprinted with a postscript and additional footnotes in *Reconsidering Logical Positivism* (1999). He objected to Goodman's and Quine's interpretations based on the near-absence of traditional empiricist motivations for reduction of scientific objects to experience in Carnap's text. Friedman instead emphasizes Carnap's many remarks about the need to make the experiences of individuals objective through purely structural definite descriptions. This preoccupation is linked with the Kantian demand for an explanation of how objective knowledge is possible. Here Friedman notes striking similarities with the neo-Kantian philosophers that Carnap cites in the *Aufbau* such as Rickert and Bauch, from the so-called Southwest school, and Natorp and Cassirer, from the so-called Marburg school. Friedman argues that the new logic of Frege and Russell allows Carnap to transform the extant accounts of objectivity so that 'a radically new conception of objectivity' (Friedman 95) emerges. In particular, the strength of the formal logic that Carnap employs lets him aspire to a kind of philosophical neutrality that is absent in the various neo-Kantian approaches.

Friedman uses his interpretation to explain Carnap's detailed constitution of the autopsychological domain which many empiricists would take for granted. An additional benefit of the focus on objectivity is that it allows an understanding of Carnap's peculiar attempt to define his basic relation Rs using a purely structural definite description in §§ 153–155. The idea behind this definition is that only the intended Rs relation will give rise to a chosen 'empirical theorem'. This is a theorem that is not a logical consequence of the constitutive definitions, e.g. that the color solid has three dimensions (§ 155). But Carnap realizes that a purely structural definition will fail to be unique here because the

domain of experiences can be permuted to yield any number of unintended relations with the same structure. The somewhat lame attempt to solve this problem is to posit a special kind of 'founded' relation based on its natural or experiential features. For Friedman, this deprives the definition of Rs of its purely structural character and so 'the difficulty is extremely fundamental' (103).

In later discussions, Friedman has admitted that this difficulty is not as fundamental as he earlier thought (105 fn. 24, noting 43 fn. 29). His stated reason for this shift is that he now believes that Carnap has no need to ground his constitution system in some domain of objects that is independent of the constitution system. Instead, the objectivity of the various scientific objects is achieved using only the resources available from within the constitution system. So there is a notion of objectivity that is internal to the constitution system. Although Friedman does not put it this way, we can emphasize the existence within the constitution system of the intersubjective objects of the intersubjective world. At the time of writing the *Aufbau*, it may be that this sort of system-specific intersubjectivity was all the objectivity that Carnap needed. This does not undermine Friedman's basic point that Carnap's neo-Kantian context is important for his development or that it influenced his structural conception of objectivity.

Still, Friedman continues to worry that 'serious technical problems' (160) undermine the *Aufbau*. He is concerned about the same aspect of the system that Quine focused his objections on. Friedman's objection is that the defined objects here are not assigned a particular level in the hierarchy of classes. The problem is not Quine's problem that the open-ended character of the rules blocks a translation of a statement into a statement about experiences. It is rather the fact that later stages of the constitution system, such as the reports of others, are used to adjust the earlier stages of the constitution system. This creates a kind of circularity so that 'Carnap's construction of the physical world … is continually revised to infinity' (161).

On this interpretation, what is missing is a stable standpoint outside of a given constitution system that can be used to effectively carry out the required constitutions. In his book *Carnap's Construction of the World* (1998), Alan Richardson arrives at a similar conclusion based on a different understanding of the connection between Carnap's *Aufbau* and its neo-Kantian context. Richardson draws on Carnap's work prior to 1928 to discern two conceptions of objectivity in the *Aufbau*. The first is the quest for purely structural definite descriptions based on the given structure of the Rs relation noted by Friedman. But Richardson notes a second conception of objectivity based on the mathematically specified structures of physics. This second approach emphasizes the need for new structures to be brought into coordination with experience if the originally subjective experiences are to be made objective and suitable for scientific study, e.g. as in psychology. The existence of two notions of objectivity creates serious tensions within Carnap's project. One problem that Richardson emphasizes is the difficulty of locating the second conception of objectivity within the constitution system that Carnap gives in the *Aufbau*, or indeed anywhere in his constitution theory. Carnap's distinction between subjective and objective

> must find a place either within the realm of empirical concepts of the objective sciences or within the formal concepts of logic. It is precisely the inability of the objective-subjective divide to be captured comfortably in either realm that lends it its problematic status here (184).

Taking the empirical realm first, it might seem acceptable for Carnap to cash out his conception of objectivity using only resources internal to his constitution system as it is this system that is meant to clarify the scientific knowledge of an agent. Richardson objects

to this route because he argues that scientific knowledge deals only with objective matters and so it has no access to the crucial epistemological distinction between the subjective and the objective: 'it is manifestly not a distinction within any empirical science, since these are recognizable as such simply because they deal with the objective only' (189). Locating the objective–subjective divide using formal logic is no better. Here, Carnap does have the notion of a purely structural definite description at his disposal, but taking this too seriously undermines his constitution of the physical world and also leads to the failed attempt to eliminate the basic Rs relation. Richardson sees the latter as a sign of how attempting a formal, logical characterization of objectivity leads to the erasure of 'the distinction between logic and empirical science' (194). The diagnosis is clear: 'The way out … would have to consist in the adoption of a genuine metalogical perspective' (197). Richardson thus links the failures of Carnap's *Aufbau* project to his later *Logical Syntax* project where Carnap will struggle to articulate a metalanguage that he can use to discuss the various object languages of the sciences.

5. Rational Reconstruction

Pincock's 'Reserved Reading of Carnap's *Aufbau*' (2005) can be seen as responding to some of these concerns by casting constitution theory as an empirical scientific discipline:

> The standards and assumptions of traditional science take the place of any substantial philosophical motivations or presuppositions … neutrality is achieved by construction theory because it is one more scientific discipline (Pincock 522–3).

Seizing on Carnap's remark that 'Science as a whole … needs both an experiential and a materialistic derivation of all concepts' (§ 59), Pincock ties the autopsychological constitution system to a special purpose: its 'focus is on the rational reconstruction of our actual cognitive processes, smoothed out and appropriately clarified' (526). In contrast, a physical constitution's order 'is an order of physical dependence' (532). On this interpretation, the structural conception of objectivity is, contra Richardson, 'not imposed from the outside as a criterion of adequacy on the cognitive construction system, but is rather something that must be reconstructed within it, along with all other relevant features of our cognition' (530). This limited concern with objectivity is reinforced, for Pincock, by his suggestion that there is no analogous need to constitute an intersubjective world in the physical constitution system because its basis starts off as already objective.

In his recent book *Carnap and Twentieth-Century Thought* (2007), Carus also emphasizes the importance of rational reconstruction of existing scientific knowledge for an understanding of the *Aufbau* project. Unlike Pincock, though, Carus traces the development of Carnap's autopsychological system in some detail, noting a number of important shifts in Carnap's thinking between his 1921 dissertation *Space* and the 1928 *Aufbau*. For example, Carus sees the shift in § 126 from definitions to assignment policies as a holdover from the 1922 manuscript 'From Chaos to Reality' (169–70). A crucial source of the tensions in the *Aufbau* is Wittgenstein's conception of logic as 'artefacts of representation' (185) and his sparse conception of what sorts of propositions are possible. On Carus' interpretation, Carnap grafted this conception of logic onto his prior constitutive project. But Carnap failed to reconcile this picture of logic, and the strictures it imposed, with his earlier rational reconstruction project. As a result, 'At no point in this period [1922–1930] did Carnap reach an equilibrium, an overall position that solved all the outstanding problems' (203). Carus views Carnap's later work, starting with *Logical Syntax* and the

principle of tolerance, as the transformation of the project of rational reconstruction of prior knowledge into a more radical explication project. In the explication project, existing scientific practices can be discarded if they fail to contribute to a more pragmatically effective unified science.

6. Contemporary Significance

As we have seen, Carnap's *Aufbau* is of ongoing interest to anyone who shares the concerns about empiricism, objectivity or rational reconstruction that interpreters have found in the *Aufbau*. The book has seemed especially important to formally inclined philosophers interested in making sense of scientific knowledge. A noteworthy recent example of this is Leitgeb's paper, 'New Life for Carnap's *Aufbau*?'. Leitgeb presents a more modest version of Carnap's project in terms of the preservation of empirical content: 'Every scientific sentence can be translated into an *empirically* equivalent one which consists solely of logico-*mathematical* signs and terms that refer to a subject's *experience*' (4). To achieve this goal, and avoid worries analogous to Goodman's and Quine's, Leitgeb draws on newly chosen basic relations and some results of set theory and contemporary mathematics. The new basis is presented as a set of 'experiential tropes' (19) or concrete property instances such as the red of a particular pencil. The tropes are ordered by one basic relation '<' when they fail to overlap temporally and are further grouped together into sets by the other basic relation 'Ov' when each member of the set has 'a common qualitative overlap' (20). This shift allows Leitgeb to precisely describe which conditions must obtain for the definitions of the autopsychological domain to be successful. Leitgeb argues that he can then overcome Goodman's concerns about companionship and imperfect community. An important further contribution is that Leitgeb offers definitions of dimension that are consistent with only finitely many basic elements. This responds to another problem with Carnap's original approach first noted by Goodman, but also endorsed by later commentators such as Friedman.

When it comes to the transition to the perceptual and physical worlds Leitgeb argues that the problem with Carnap's original approach arise because 'is at' is a theoretical term whose features are pinned down but not defined by the 12 rules that Carnap offers in § 126. This inspires Leitgeb to solve the problem by deploying techniques from later discussions of theoretical terms, e.g. the Ramsey-style translation of any sentence B[t] involving the problematic term 't' with finitely axiomatized theory A[t] into the sentence $\exists x$ (A[x] & B[x]) (For more on Ramsey sentences, see Demopoulos). To evaluate this proposal more would have to be said about Leitgeb's understanding of 'empirical content' and how he aims to respond to the traditional objections against this sort of definition. Whatever we make of the viability of Leitgeb's approach, it is a clear sign of the continuing importance of Carnap's *Aufbau* project for philosophy.

An exciting recent development for Carnap scholarship is the appearance of the first volume of the *Collected Works of Rudolf Carnap* (Carus et al.). The first translation into English of Carnap's early papers and the scholarly apparatus of this edition of Carnap's works, along with the companion series *Full Circle: Publications of the Archives of Scientific Philosophy*, will surely encourage a new generation of *Aufbau* scholars.

7. A Note on Translation

I have followed more recent scholarship in translating Carnap's 'Konstitutionstheorie' as 'constitution theory', unlike George's choice of 'construction theory'. A reason for this is

Carnap's special use of the word 'Konstruktion', as with the title of § 100: 'Die Konstitution als rationale Nachkonstruktion'. Carnap seems to mainly use 'Konstruktion' in connection with the language of fictional construction or 'die Sprache einer fiktiven Konstruktion', which George awkwardly translates as the 'language of fictitious constructive operations' (§ 95; Friedman 137, fn. 38).

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Short Biography

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Notes

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[1] See 'A Note on Translation' at the end of this article for this choice of terminology.

Works Cited

Carnap, Rudolf. *The Logical Structure of the World*. Trans. R. George. Chicago: Open Court Classics, 2003.

Carus, A. W. *Carnap and Twentieth-Century Thought. Explication as Enlightenment*. Cambridge: Cambridge University Press, 2007.

——, Michael Friedman, Wolfgang Kienzer and Sven Schlotter, eds. *Collected Works of Rudolf Carnap. Volume I: Early Writings*. Chicago: Open Court, 2009.

Demopoulos, William. 'Carnap on the Rational Reconstruction of Scientific Theories.' In Freidman and Creath, eds. 248–72.

Friedman, Michael. *Reconsidering Logical Positivism*. Cambridge: Cambridge University Press, 1999.

—— and Richard Creath, eds. *The Cambridge Companion to Carnap*. Cambridge: Cambridge University Press, 2007.

Goodman, Nelson. *The Structure of Appearance*. 3rd ed. Dordrecht: Reidel, 1977.

Leitgeb, Hannes. 'New Life for Carnap's *Aufbau*?' *Synthese* doi 10-1007/s11229-009-9605-x (forthcoming).

Pincock, Christopher. 'A Reserved Reading of Carnap's *Aufbau*.' *Pacific Philosophical Quarterly* 86 (2005): 518–43.

Quine, W. v. O. 'Epistemology Naturalized.' Reprinted in *Ontological Relativity and Other Essays*. New York: Columbia University Press, 1977. 69–91.

——. 'Two Dogmas of Empiricism.' Reprinted in *From a Logical Point of View*. 2nd ed. Cambridge: Harvard University Press, 1980. 20–46.

Richardson, Alan. *Carnap's Construction of the World: The Aufbau and the Emergence of Logical Empiricism*. Cambridge: Cambridge University Press, 1998.

Ricketts, Thomas. 'Languages and Calculi.' *Logical Empiricism in North America*. Eds. G. Hardcastle and A. Richardson. Minneapolis: University of Minnesota Press, 2003. 257–80.

Schilpp, P. A., ed. *The Philosophy of Rudolf Carnap*. La Salle: Open Court, 1963.

Further Reading on the Aufbau

Coffa, J. Alberto. *The Semantic Tradition from Kant to Carnap: To the Vienna Station*. Cambridge: Cambridge University Press, 1991.
Cohnitz, Daniel and Marcus Rossberg. *Nelson Goodman*. Montreal: McGill-Queen's University Press, 2006.
Creath, Richard, ed. *Dear Carnap, Dear Van: The Quine-Carnap Correspondence and Related Work*. Berkeley, CA: University of California Press, 1990.
Hylton, Peter. *Quine*. New York: Routledge, 2007.
Lewis, David. 'Policing the *Aufbau*.' *Philosophical Studies* 20 (1969): 13–7.
Mormann, Thomas. *Rudolf Carnap*. Munich: Beck, 2007.
Moulines, C. 'Making Sense of Carnap's *Aufbau*.' *Erkenntnis* 35 (1991): 263–86.
Richardson, Alan and Thomas Uebel, eds. *The Cambridge Companion to Logical Empiricism*. Cambridge: Cambridge University Press, 2007.
Rungggaldier, E. *Carnap's Early Conventionalism: An Inquiry into the Historical Background of the Vienna Circle*. Amsterdam: Rodopi, 1984.
Sauer, Werner. 'On the Kantian Background of Neopositivism.' *Topoi* 8 (1989): 111–19.
Savage, C. Wade. 'Carnap's *Aufbau* Rehabilitated.' *Language, Truth and Knowledge: Contributions to the Philosophy of Rudolf Carnap*. Ed. T. Bonk. Dordrecht: Kluwer, 2003. 79–96.
Tennant, Neil. 'The Life and Work of the Early Carnap.' *Scientific Inquiry in Philosophical Perspective*. Ed. N. Rescher. Lanham, MD: University Press of America, 1987. 261–80.
Tsou, Jonathan. 'The Justification of Concepts in Carnap's *Aufbau*.' *Philosophy of Science* 70 (2003): 671–89.
Uebel, Thomas. *Empiricism at the Crossroads: The Vienna Circle's Protocol Sentence Debate*. Chicago: Open Court, 2007.