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Theoretical construction in physics – The role of Leibniz for Weyl's 'Philosophie der Mathematik und Naturwissenschaft'

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ABSTRACT

This paper aims at closing a gap in recent Weyl research by investigating the role played by Leibniz for the development and consolidation of Weyl's notion of theoretical (symbolic) construction. For Weyl, just as for Leibniz, mathematics was not simply an accompanying tool when doing physics—for him it meant the ability to engage in well-guided speculations about a general framework of reality and experience. The paper first introduces some of the background of Weyl's notion of theoretical construction and then discusses particular Leibnizian inheritances in Weyl's 'Philosophie der Mathematik und Naturwissenschaft', such as the general appreciation of the principles of sufficient reason and of continuity. Afterwards the paper focuses on three themes: first, Leibniz's primary quality phenomenalism, which according to Weyl marked the decisive step in realizing that physical qualities are never apprehended directly; second, the conceptual relation between continuity and freedom; and third, Leibniz's notion of 'expression', which allows for a certain type of (surrogative) reasoning by structural analogy and which gave rise to Weyl's optimism regarding the scope of theoretical construction.

1. Introduction

Over the last two decades, Hermann Weyl's philosophical background has become the subject of considerable interest. In particular, philosophers of science and their colleagues have turned their attention to Weyl's relationship to Husserl and phenomenology on the one hand and to the Fichte-scholar Fritz Medicus and transcendental philosophy on the other (see, for instance, Scholz, 1995; Tieszen, 2000; Ryckman, 2005; Sieroka, 2007; 2010b).

Comparatively little attention, however, has been paid to Weyl's engagement with the philosophy of Leibniz. This is all the more astonishing given that in Weyl's *Philosophie der Mathematik und Naturwissenschaft* (PMN)[1]—written in 1926 (published 1927) and marking a culmination point in Weyl's own philosophical development—the author who is mentioned and cited most often is, by far, Leibniz. Part of this gap in Weyl scholarship has recently been filled by Erhard Scholz, who provides a broad overview of Weyl's references to Leibniz in PMN from the perspective of a historian of mathematics. Accordingly, Scholz (2012) focuses on topics such as modern axiomatic mathematics, foundational approaches to mathematics, vector calculus, and the relativity of space.

In contrast, the present paper starts from a slightly different perspective. I will focus exclusively on the second half of PMN—that is, the part devoted to physics—and I am interested especially in the Leibnizian themes underlying Weyl's notion of 'theoretical construction' (or 'symbolic construction' as he would call it in his later writings). This contrast, however, is not an opposition. In fact, I take it that the present paper complements Scholz's excellent work and that my interpretation of why certain Leibnizian themes became important for Weyl around the mid-twenties fits well with Scholz's claim that, in the context of mathematics, the references to Leibniz allowed Weyl to newly position himself within the ongoing so-called *Grundlagenkrise* ('foundational crisis'). After a short phase of enthusiastic support

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[1] "http://www.phil.ethz.ch/en/people/person-detail.html?persid=118839" http://www.phil.ethz.ch/en/people/person-detail.html?persid=118839.

[1] References to Weyl's *Philosophie der Mathematik und Naturwissenschaft* (Weyl 1927) will be given by using the abbreviation 'PMN', followed by page number. Corresponding references to the English language edition, *Philosophy of Mathematics and Natural Science* (Weyl 1949; 'PMNS') will be given together with the reference to the German edition (e.g. 'PMN 88/PMNS 122') – provided that a matching reference in the later English edition exists, for Weyl made both deletions and additions for that edition. Quotations from PMN are translated by the author, and hence may differ from the corresponding formulation in PMNS (this also applies to the quotations from Leibniz which occur in PMN/PMNS). For full references consult the bibliography below.

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for Brouwer's intuitionism, Weyl came close to a formalist position in the sense of Hilbertian finitism.[2] Similarly, as I intend to show, certain Leibnizian themes fit very well with and support Weyl's newly achieved 'constructivist' position, also in the context of physics. Beforehand, also within physics, his approaches relied much more heavily on direct phenomenal access to nature, such as around 1920 when he aimed for a 'purely infinitesimal geometry' upon which to base the whole of physics.

The present paper falls into three sections. In Section 2 I will briefly explicate Weyl's concept of theoretical construction together with part of its historical background. In Section 3 I will collect, in a systematic fashion, those references to Leibniz from the second half of PMN which link directly to Weyl's notion of theoretical construction. This includes, for instance, a discussion of Leibniz's principle of sufficient reason and of his opposition to Descartes's rules of impact—an opposition based especially on non-empirical grounds.

In Section 4 I will explore three themes from Leibniz in more detail because they need contextualisation beyond PMN. That is, I will place them within their original setting in the work of Leibniz as to complement the references given by Weyl and as to provide a fuller picture of the notion of theoretical construction. Further, I will add references to other (later) writings by Weyl in order to show the continuing importance of Leibniz for Weyl's own thinking. These three themes, which for the moment I will furnish only with a brief label, are Leibniz's so-named 'primary quality phenomenalism', the conceptual relation between freedom and continuity, and the existence of so-named 'expressive relationships' which allow for a special kind of analogical ('surrogative') reasoning and which fostered Weyl's 1926 optimism regarding the overall potentiality and scope of theoretical construction.

The paper ends with a short conclusion, indicating the relevance of this Weyl-Leibnizian inheritance for contemporary philosophy of science.

Before turning to Section 2, however, let me briefly add two comments. First, even though Leibniz will turn out to be a central figure in Weyl's account of the historical and systematic development of 'theoretical construction' in physics (and indeed beyond), this does not imply that Leibniz is the last, let alone the only, figure in that development. In PMN the discussions of Leibniz (in the context of the concept of theoretical construction) are often followed and 'transcended' by comments on further developments in philosophy, such as phenomenology and transcendental philosophy.[3] Accordingly, the present paper is not meant to challenge the work mentioned at the very beginning, which emphasises Weyl's reliance on Husserl and Fichte. My aim is rather to add a further dimension to our understanding of Weyl's philosophical background.[4]

The second comment concerns the exact period of Weyl's reading of Leibniz. Unfortunately—and in contrast to Weyl's engagement with Husserl and Fichte, for which there are lots of related notes and correspondences in the ETH Zurich University Archives—there is comparatively little historical material on the exact nature of Weyl's studies of Leibniz. However, there is some evidence to pinpoint at least the time when Weyl engaged in reading Leibniz. In a retrospective comment in his 1954 'Erkenntnis und Besinnung' Weyl identifies the mid-twenties as the period during which his 'study of Leibniz became of considerable importance' (GA IV: 647)[5] and writes that, with the preparation of PMN, he had been 'indulging in philosophical reading, like a butterfly flying from one flower to the other, anxious to suck a little honey from each' (GA IV: 648). In fact, Weyl never treated Leibniz extensively in any of his earlier writings, whereas in PMN he cited and referred to Leibniz not only most often but also most accurately. Nearly every time Weyl mentions Leibniz, there is a page reference to the standard Leibniz editions. In contrast, philosophers Weyl had discussed previously in other writings tend to be referred to in PMN in a rather 'lax' or 'generous' manner. That is, Weyl rarely gives exact page references, which suggests that in these cases he may have been writing 'off the top of his head' rather than by careful (renewed) reading and exegesis. The work of Leibniz, on the other hand, was somehow very close and dear to Weyl when writing PMN. This then strongly suggests that Weyl's intensive and close reading of Leibniz took place around 1925/26.

2. Weyl's 'theoretical construction': some terminology and topics

'Theoretical construction' as understood by Weyl consists in positing a coherent system of scientific concepts.[6] When writing PMN he assumes the main range of application to be that of the exact sciences, but, as I will discuss below, he takes theoretical construction to be extendible to more or less all areas of human life and enquiry.[7]

Key terms in this explication of the notion of theoretical construction are 'positing' and 'coherent system', which are meant to illustrate Weyl's transcendental philosophical legacy and his debts to (formalist) mathematics. Let me use this section in order to expound this claim.

Theoretical construction is about forming a whole coherent set of concepts, and the formation of an axiomatic system in mathematics might count as a paradigm case—at least if mathematics is understood in the broad sense of being the general enquiry into structures and relations. By the same token, theoretical construction is a rational or rationally guided enterprise and not a naïve trial

[2] As regards primary sources, see, e.g., GA II: 143–180 versus GA III: 147–149. ('GA' refers to Weyl's *Gesammelte Abhandlungen* (Weyl 1968), cited by volume [Roman number] and page [Arabic number]. For full references see the bibliography below.) Discussions in the secondary literature are to be found, amongst others, in Van Dalen (1995), Tieszen (2000), and Sieroka (2009).

[3] To provide just one example: in the chapter on 'Subject and Object' Weyl claims that during the last two centuries the general philosophical discussion went 'beyond Leibniz because of the transmutation of the old metaphysical notions [*Seins-Begriffe*] of substance and causality into *methodological principles* for the construction of the actuality of experience [*zum Aufbau der Erfahrungswirklichkeit*]' (PMN 88/PMNS 122). It is not by accident that the term 'methodological principles' here reminds one of similar claims in the work of Ernst Cassirer and other neo-transcendentalist philosophers. Regarding classical transcendentalist authors, there are affirmative references in PMN regularly to Fichte, occasionally also to Schelling, and there are also several (usually dismissive) references to and brief discussions of Kant.

[4] I do think though that the particular constructivist fashion in which Weyl presents and understands Leibniz is much closer to his Fichtean (rather than to his Husserlian) leanings. But the discussion of this issue must be left for some other occasion.

[5] An English translation of 'Erkenntnis und Besinnung' can be found in Weyl (2009: 204–221), entitled 'Insight and Reflection'.

[6] See, e.g., PMN 87–88/PMNS 121–122, Weyl (1934: 40–59), and also Weyl (1934: 55): 'Hence logical thinking and logical inferring is not the core of theoretical procedure as performed in mathematics and the sciences, but rather the practical management of symbols in accordance with certain rules.' Cf. also Ryckman (2005) and Scholz (2006).

[7] Arguably, it is this kind of extension from science to daily life which makes Weyl talk about 'symbolic' instead of 'theoretical' construction in his later writings (see, e.g., GA IV: 289–345). The most detailed explication of Weyl's later notion of 'symbol' and 'symbolism' is to be found in GA IV: 527–528. Here Weyl's understanding of how humans represent the world by means of symbols is a very broad one, influenced amongst others by the work of von Humboldt, Jaspers, and especially Cassirer. For Weyl, just as for Cassirer, the use of (ordinary) language is already a 'symbolic construction' given that it allows us to represent the external world by means of speech – that is, by means of man-made audible signs. (I take it that, in contrast, one would not be tempted to call ordinary language a 'theoretical construction' – simply because, other than in the case of the exact sciences, there is not much theoretical reflection involved in the use of ordinary language.)

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