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Introduction to Kant's Philosophy of Science: Bridging the Gap between the Natural and the Human Sciences

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1. Kant and the Sciences: an Ongoing Dialogue

Deeply fascinated by the scientific developments of his own time, Kant has offered numerous philosophical insights into the methodological and metaphysical foundations of the sciences.[1] First and foremost, Kant is famous for his appraisal of Newtonian physics, which for him was the paradigm case for all sciences properly so-called. Yet Kant by no means only focused on the physical sciences; rather, he pursued more broadly questions of the earth, life, and human sciences and made intriguing observations that have fostered a better understanding of their special character. This special issue is motivated by the belief that Kant's insights have remained relevant from his own time up to the present as a perennial source of inspiration as well as of controversy. A major goal of this special issue is to continue this dialogue between Kant and the sciences, by contributing to a more comprehensive understanding of Kant's philosophy of science with a view to bridging the gap between the natural and the human sciences. This dialogue, we will suggest, can provide a highly promising point of reference for integrating history and philosophy of science.

In this Introduction we first outline the specific research questions and the unifying theme that have guided us in assembling the present collection of papers. Then we give an overview of the papers collected in this special issue, before finally offering some reflections as to how this collection is understood as part of and thus feeds into the more comprehensive aims of integrated History and Philosophy of Science (iHPS).

Kant's philosophy of science has attracted much attention by Kant scholars as well as by scholars of history and philosophy of science. The majority of scholarship has focussed on Kant's notion of "proper science", the exemplar of which is Newtonian physics (Plaass 1965, Hoppe 1969, Friedman 1992, 2013),[2] and has highlighted in particular the relationship between Kant's theoretical philosophy and the foundations of physics (Falkenburg 2000, Massimi 2013). More recently, the focus has shifted towards a greater appreciation of what is today often called the "special sciences", i.e., sciences that are less amenable to the scientific methodology than physics (Gaukoger & Nassar 2016, Watkins 2001), including the study of living organisms (Breitenbach 2009; Goy & Watkins 2014; McLaughlin 1990; Quarfood 2006; Van den Berg 2014) and the study of anthropological issues (Cohen 2009; Frierson 2014;

[1] References to Kant's texts follow the pagination of the Academy edition (AA). References to the Critique of the power of Judgement are abbreviated as CJ, whereas those to the Critique of pure Reason use the standard abbreviation CpR, followed by the A/B editions pagination.

[2] Exceptions are Watkins (2001) and Cohen (2008).

Sturm 2009).[3] While this recent shift has transformed the interpretation, reception and impact of Kant's philosophy of science in important ways, it also poses new questions regarding the unity and the plurality of the sciences (Morrison 2008, Breitenbach & Choi 2017). To what extent, if at all, do these special sciences meet Kant's criteria of a "proper" science, which include (i) apodeictic certainty, (ii) mathematisability, and (iii) systematization (see MFNS 4:467-470 and CpR A832/B861f.)? Could these sciences still be viewed as "improper" science, which for Kant have only empirical certainty, but nonetheless include mathematical description and systematicity? Can Kant offer an underlying conception of science that is adequate to capture all types of sciences and that is nonetheless sufficiently specific to distinguish scientific from non-scientific knowledge? Are Kant's general conception of "law of nature" and his theory of the scientific method applicable to or instantiated by each scientific discipline? How does Kant account for the continuity among as well as the diversity between the different sciences, given that he ultimately projects an architectonic unity of all rational human endeavours? Massimi (2014) and Massimi and Breitenbach (2017) address some of these questions, by emphasizing the role of systematicity in Kant's general philosophy of science and by comparing specifically his views of physics and of biology.

The collection of papers assembled in this special issue considers the full range of scientific disciplines from Newtonian physics to pragmatic anthropology and pays particular attention to the interrelations between these different sciences. It thus aims to develop a more comprehensive view of the system of the sciences that Kant anticipated – a system that consists of both the natural and the human sciences. This more comprehensive view, we suggest, acknowledges the continuity between the different sciences as well as their (relative) autonomy and specificity. To this effect, this collection opens with three papers (Cohen, Falkenburg, Engelhard), which examine issues that are relevant for all sciences, such as their shared normative principles, the general scientific method, and the general notion of laws of nature. The six remaining papers explore particular scientific disciplines, with an eye to their continuity and interrelations with other disciplines.

Central to this special issue is a typically transcendental question that concerns the very relationship between the scientist(s) and nature: what are the epistemic and the metaphysical conditions that are placed upon any scientific inquiry and that shape the very concept of nature – nature in general as well as particular aspects of nature examined in different disciplines? An examination of this question quickly shows that the traditional emphasis on Kant's epistemology, especially on the principles of the understanding, is not sufficient to tackle this question, but that a solution can be found only if we turn to Kant's broader conception of human reason. Reason, unlike the understanding, does not determine knowledge of scientific objects as such, but rather gives indispensable guidelines as to what scientific knowledge as such is and how we ought to pursue it. Kant's conception of reason is by no means confined to the theoretical sphere only, but is essential for practical philosophy, too. A more comprehensive philosophy of science that aims to consider the full range of scientific disciplines thus must rethink the position of the scientist, who is not only an epistemic subject, but also essentially a practical agent. In this sense, several papers take into account Kant's practical philosophy and argue for a strong interrelation between

[3] For the notion of a "special science", see Fodor (1974).

scientific and practical uses of reason (Cohen, De Bianchi, Frierson) with a particular view to bridging the gap between the natural and the human (or pragmatic) sciences.

The central unifying theme of all papers in this collection is the use of regulative principles derived from reason, in contrast to constitutive principles based on the understanding. The role of reason in science concerns first and foremost the use of regulative principles of systematicity, which stipulate assumptions such as that (some specific part of) nature is a systematic whole and that a science is a system of cognitions, as well as the method of analogy and analogical reflection.[4] While these regulative principles and the method of analogy are often associated with the so-called "special sciences", i.e., sciences that are less amenable to a strictly scientific methodology, this collection of papers will show that such principles are an ubiquitous theme across all scientific disciplines (see in particular Pringe, Everett, van den Berg, Kraus). Therefore, they are key to understanding Kant's integrated philosophy of science and to developing Kant-inspired accounts of the sciences. On the one hand, the general principle of systematicity defines what counts as a scientific system in general and how a scientific discipline develops teleologically from a "guiding idea". On the other hand, specific ideas of reason, such as the idea of purposiveness (van den Berg) or the idea of the soul (Kraus), serve as principles to define specific scientific enterprises and carve out a particular part of nature that is to be investigated as the subject matter of a specific discipline. Moreover, the requirement of systematicity is also a regulative guideline for the interrelations among different scientific disciplines within the overall architectonic of reason (Pringe, Everett). In this sense, the principles of reason are central both to understanding the common methodological, epistemic, and metaphysical conditions of all sciences and to accounting for the specific characteristics of a particular science.[5] Inspired by this overarching theme of systematicity, this collection offers a synopsis of Kant's accounts of the major sciences in his time – mathematics, physics, physical geography, life sciences, psychology, and anthropology – and examines their cross-relations, similarities, and characteristic differences.

2. Kant's Philosophy of Science: Integrating the Human and Natural Sciences

The volume opens with Alix Cohen's paper, entitled "Kant on science and normativity", which examines Kant's conception of normativity viewed through the prism of the distinction between the natural and the human sciences. The paper exemplifies the bridge between the natural and the human sciences by showing that both are regulated by one and the same norm, namely reason's demand for autonomy.

[4] With his seminal contribution to the study of Kant's philosophy of science, Gerd Buchdahl (1969) highlighted the central role of systematicity for acquiring scientific knowledge. Two major lines of interpretation have evolved regarding principles of systematicity: first, what one could call *methodological interpretations* stressing the heuristic, hypothetical, and subjective character of these principles (Grier 2001, Kitcher 1986) and, second, *transcendental interpretations* emphasising their (indeterminately) objective, necessary, or even truth-relevant character (O'Shea 1997, Geiger 2009, Ginsborg 2017). Moreover, inspired by Kant's philosophy of science, Michael Friedman has developed a theory of the relative *a priori* on the basis of principles of reason, which accounts for theory change and scientific development (Friedman 2001).

[5] Previous studies have highlighted the role that Kant's metaphysics of nature plays for his theory of natural science and the unity of the sciences, though not with a particular view to the special sciences (e.g., Butts 1986, Falkenburg 2000, Morrison 2008).

According to Cohen, this norm grounds both the pragmatic orientation of the human sciences and the theoretical orientation of the natural sciences.

Brigitte Falkenburg's contribution entitled "Kant and the Scope of the Analytic Method" explores Kant's methodological analogy between Newtonian science and metaphysics of nature. To this effect, Falkenburg investigates Kant's pre-critical views of the use of analytic and synthetic methods both in Newtonian science and in philosophical reasoning. She argues that, although Kant distinguishes between different variants of the analytic method in the pre-critical period, his own use of the method in metaphysics relies mainly on an analogy with Newton's method. Importantly, in her view, Kant never wanted to merge the methodological standards of natural science and metaphysics, but rather suggested methodological analogies between them. Such a methodological analogy can also be found in Kant's Critical period in relation to his transcendental idealism.

Kristina Engelhard's paper, entitled "The Problem of Grounding Natural Modality in Kant's Account of Empirical Laws of Nature", focuses on Kant's notion of empirical laws of nature, which is primarily central for the natural sciences, and discusses the source of such laws' necessity. Engelhard argues that Kant gives both an epistemic and a metaphysical account of laws of nature and that these accounts necessarily complement one another. The epistemic account takes the systematic relations among different empirical laws as the guarantor of their necessity and explains our epistemic access to empirical laws. The metaphysical account views causal powers as the ground of their necessity and thus provides an explanation of their metaphysical grounds. The epistemic account takes the systematic relations among different empirical laws as the guarantor of certain empirical laws being proper laws of nature in our world. In order to make plausible how causal powers ground the necessity of empirical laws, Engelhard suggests a novel reading of the causal powers interpretation along the lines of a genuine dispositionalist conception of the laws of nature.

After these papers that consider Kant's general take on science, our collection moves to the analysis of particular natural and human sciences. It begins with the natural sciences, as these are *prima facie* more properly geared to Kant's standard of a "proper" science.

Focussing first on the criterion of mathematisability, Hernán Pringe, in his contribution entitled "Maimon's criticism of Kant's doctrine of mathematical cognition and the possibility of metaphysics as a science", examines the relationship that Kant conceives between mathematics and metaphysics from a historical perspective. A central claim of Kant's transcendental philosophy is that metaphysics ought to become a science, and yet Kant also claims that the mathematical method that is central for the sciences is substantially different from that of metaphysics. Pringe confronts Kant's take on metaphysics with that of Salomon Maimon, one of the most profound thinkers of the eighteenth century, who challenged Kant's views regarding the different methods of mathematics and metaphysics. In exploring the discrepancies between the two thinkers' accounts, Pringe shows how Maimon is able to secure a different foundation of metaphysics and thereby resolves Kant's problem of the possibility of metaphysics as a science. While Maimon's account is based on a thoroughgoing analogy between sensible and supersensible knowledge, Kant's account must exclude theoretical knowledge of the supersensible from the agenda of science and hence of transcendental philosophy.

Jonathan Everett applies a Kantian account of regulative principles to the history of philosophy of science. In his paper "A Kantian account of mathematical modelling and the rationality of scientific theory change: The role of the equivalence principle in the development of general relativity", he examines the historical role of the equivalence principle in enabling Einstein to mathematically model a relativistic theory of gravitation. Everett argues that the rationality of this process can be interpreted in a similar manner to how Cassirer sought to explain the rationality of theory change. Accordingly, a sequence of scientific theories can be taken as the subject of transcendental inquiry and analysed with respect to regulative ideas such as generality and unity. As a result, this paper develops a Kantian interpretation of mathematical modelling in the sciences and offers an account of the role of conceptual analysis in the development of scientific theories.

The next paper exemplifies that mathematical modelling plays a foundational role not only in physics, but also in the special sciences, as well as in Kant's general system of the sciences. Silvia De Bianchi in "The stage on which our ingenious play is performed: Kant's epistemology of *Weltkenntnis*" shows how the mathematical model of the earth constitutes not only a fundamental constituent of physical geography, but also an important premise of Kant's doctrine of right. In her contribution, the epistemological premises of Kant's physical geography, including that of mathematical modelling, are spelled out and shown to be constitutive of *Weltkenntnis*, the pragmatic knowledge of the world. Moreover, she shows how the use of the mathematical model of the earth influences the foundations of private right and cosmopolitan right, thereby emphasizing the interrelations between *a priori* and empirical sciences, the pragmatic sphere of the geographical knowledge, and the principles of human interactions described by the cosmopolitan law.

Moving to another special science, Hein van den Berg's contribution "Kant and the Scope of Analogy in the Life Sciences" investigates the role that Kant attributed to analogy in the life sciences from a historical perspective. By reconstructing the debates in Kant's time, he shows why Kant did not consider biology to be a proper science. Van den Berg argues that Kant adopted a roughly axiomatic ideal of science and then identifies the relevant differences between biology and physics. Like Everett and De Bianchi, van den Berg emphasises that physics can have apodeictic certainty due to its use of mathematics and of mathematical modelling. Moreover, his contribution sheds light on the methods of a proper science, which for Kant essentially involve explanation, rather than the form of a pure description.

Our special issue then concludes with two papers devoted to the human sciences.

Katharina Kraus argues in her paper entitled "The soul as the 'guiding idea' of psychology: Kant on scientific psychology, systematization, and the idea of the soul" that Kant's Critical philosophy allows for viewing empirical psychology as a theoretical improper science in its own right. Her argument is based on considerations of systematicity and of the regulative principles of reason. According to her, Kant's conception of psychology is based on the transcendental idea of the soul. This idea serves as the guiding idea of psychology in that it delineates its subject matter, viz. a person's mental life, and pursues the systematic unification of psychological laws. In consequence, Kraus claims that psychology qualifies as an intrinsically systematic, though improper and explanatorily incomplete, natural science. Moreover, psychology serves extrinsically the ends of pragmatic anthropology insofar as it saves

the phenomena of the mental from the reduction to other empirical phenomena, e.g., the brain, and thereby contributes to the causal explanation of action.

Patrick Frierson, in his "Towards a research program in Kantian positive psychology", develops a Kantian philosophy of science for contemporary psychology. In his paper, he takes up a contemporary challenge to Kant's view of empirical psychology, according to which Kant's view is undermined by his morally loaded notion of character. In response, Frierson shows how this challenge can be met if one adequately accounts for the intricate relationship between empirical-anthropological and moral-philosophical elements in Kant's account. Frierson uses this debate as a springboard for developing a proposal of a distinctively Kantian research programme in positive psychology and hence displays an example of the continuing relevance of Kantian considerations in philosophy of science more generally.

3. A Kantian Outlook on Future Perspectives on Integrated History and Philosophy of Science (iHPS)

This collection of papers displays a vivid example of integrated History and Philosophy of Science (iHPS). So we would like to conclude with a final reflection on the general approach and goal of iHPS. The crucial idea of iHPS is that history and philosophy have a special affinity with respect to the sciences and that each can effectively advance our understanding of the others. By examining Kant's accounts of science in general and of particular scientific disciplines – both in its historical context and regarding its philosophical relevance – this collection of papers serves precisely the purpose of iHPS. By approaching in different ways the typically transcendental question concerning the very relationship of scientists – as theoretical cognizers and practical agents – and nature in general, the papers highlight different aspects of the conceptual, cultural, and historical preconditions of scientific conduct in general.

In reviewing the results of the studies collected in this special issue, it turns out that the clear cut between what Kant calls proper (*eigentliche*) and improper (*uneigentliche*) natural sciences (*Naturwissenschaften*), as well as between the notion of "science" and those of "natural history" (*Naturgeschichte*), "natural description" (*Naturbeschreibung*), and "pragmatic science" (*pragmatische Wissenschaft*), is far less clear than initially claimed by Kant himself (see MFNS 4:467ff. and Anthropology 7:119). Rather, Kant's actual view is substantially more complex and seems to allow for a continuous spectrum of relatively autonomous scientific disciplines. The notion of a "proper science" assumes the role of a guiding idea and each discipline seems geared to its standard of scientificity. That is, each discipline realizes the criteria of certainty, mathematisability, and systematicity to a greater or lesser degree and in its historical development naturally strives towards a greater realization of them, though perhaps acknowledging certain principled limitations. In this sense, Kant's philosophy of the sciences invites us to rethink the alleged gap between the natural and the human sciences in new ways.

Within the natural sciences, the studies in this volume suggest that we find a set of what one may classify as "hybrid" or "transitory" disciplines, such as chemistry, physical geography, and biology. First, these disciplines draw on *a priori* mathematical cognition, but only to a rather limited extent; they need to be complemented by adequate empirical descriptions. Thus, these fields contain

considerably less mathematics and hence less apodeictic certainty (or even have a lack thereof tout court) than physics. The progressive inclusion of mathematics is a key aspect that could have led to transform chemistry into a proper and independent science from physics (McNulty 2014, 2015, 2017). Second, these "hybrid" fields display a certain extent of systematicity, which – no doubt – for Kant is a criterion of proper science. Yet, to reach full systematicity, a discipline needs to be guided by *a priori* rational principles, or ideas of reason, such that its empirical contents can be oriented towards and eventually integrated into a systematic whole, i.e. a systematic science (see CpR A832/B861f.).

If one looks at the case of chemistry in Kant's late system, as he outlines it in particular in the *Opus postumum*, one notices – in agreement with Friedman (1992) – that the relevance of chemistry in Kant's reflection is growing (see OP AA 21:369; 610; 633; 623; 625; 453; 623 and AA 22:149; 263) and that Kant is open to a progression or development of chemistry towards or into a proper science, satisfying in particular criteria (1)–(3). This observation is confirmed by Kant's attempt to include the so-called organic forces in an overall system of moving forces and his claim that chemistry is the science of the inner forces of matter ("die Wissenschaft der inneren Kräfte der Materie"; see OP AA 21:453). What emerges in his late work is the idea of a science of "transition" (*Übergang*) that unifies all empirical sciences by constructing an *a priori* system of moving forces that govern both animate and inanimate matter. The fact that Kant was clearly open to the possibility of chemistry turning into a proper science makes us pose the questions: would Kant have been open to grant the same progression to physical geography or to biology? And would this new openness have changed his view on the distinction between proper and improper sciences?

A similar development in Kant's work can be observed with respect to the human and/or pragmatic sciences. In the 1790s, Kant appears to open to the possibility of unifying empirical and *a priori* sciences that are concerned with human nature. For instance, in the *Critique of Judgement*, Kant argues that the progress of culture (*Kultur*), including the arts and the sciences, (see KU AA5: 430), is deeply connected to the historical dimension of ethicoteleology and our moral destination on earth (see AA 5:433), as well as the pragmatic notion of the knowledge of the world (*Weltkenntnis*).[6] In this sense, as current studies in this volume suggest, even anthropology and empirical psychology seem geared towards, or at least crucially informed by, the criteria of proper science, especially that of systematicity.

Overall, the current results suggest that a more comprehensive reconstruction of Kant's philosophy of science brings out interesting similarities within the natural sciences, as well as between both the natural and the human sciences, and thus offers a more complete view of science that bridges the alleged gap between the different disciplines. On the one hand, it is certainly true that, from an internalist viewpoint (i.e., internal to a particular science), to most scientific disciplines one cannot attribute the same status of apodeictic certainty or of systematic unity that is attributed to Newtonian physics. However, on the other hand, from a more comprehensive and

[6] Kant uses the term *Weltkenntnis* in the lectures on Physical Geography (AA 2:443) and in the Critical period it appears also in the KpV (AA 5:36) and in the KU (AA 5:439; 441). The term, however, assumes the more technical meaning in the Physical Geography (AA 9:157-159) and the Anthropology from a pragmatic standpoint (AA 7: 119; 120; 122) by denoting the pragmatic knowledge of the physical world as a whole, namely it denotes the type of knowledge of our planet and its characteristics in order to fulfil our goals on it.

externalist perspective that includes the historical and ethical dimension of human scientific conduct, it becomes clear that the progress of a certain field can lead to its transformation into a science. This happens once a field progressively implements the methods of mathematics and makes use of the rational principles supplied by metaphysics, thereby constructing a coherent whole of scientific cognitions, i.e. a system, rather than a mere aggregate.[7] In turn, such an externalist perspective reveals that both the human and the natural sciences (whether proper or improper) play a fundamental role in the cultural and social development of human life in general and in human moral perfection in particular.

In conclusion, we hope that this special issue will enrich the field of iHPS studies by examining the historical and pragmatic dimensions of Kant's system and integrating these dimensions with his philosophy of science. In this sense, we hope to inspire further research in philosophy of science that also considers the historical development of scientific disciplines, rather than only the philosophical nature of their scientific theories as final products. This progression in the making of a science is necessarily historical and cultural, and it has a necessary link with ethics and pragmatic considerations that cannot be left aside. The future research we hope to stimulate would help in articulating what we have here called an *externalist perspective* in studies in the philosophy of science and would reconsider Kant's philosophy from such an externalist perspective by emphasising its historical and cultural dimension. We suggest that this specifically iHPS approach not only would enable a fresh look at Kant studies, but would also open new perspectives in current philosophy of science by excavating the crucial connections between the human and natural sciences regarding their historical and ethical preconditions, and in turn by acknowledging that both constitute an important aspect of human culture and of the practical sphere of human society.

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[7] According to such an externalist perspective on Kant's philosophy of science, one can also read the last attempt at constructing a science of *Transition* (Übergang) *from the metaphysical foundations of natural science to physics* as a contribution to a conceptual framework that is able to encompass the empirical content of particular and experimental sciences in a system.

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