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Why logic has not taken a step forward or backward

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ENG **Abstract:** The criticism of Immanuel Kant's logic commenced with the advent of the so-called 'new logic' in the 20th century. One particular passage from the second preface to the Critique of Pure Reason has been a source of contention, where Kant asserted that logic has not taken a step forward or backward since Aristotle (B VIII). In Kant scholarship, one current strategy to avoid this criticism is to relocate Kant within the domain of philosophy of logic or by segregating his general logic from modern formal systems. In this paper, it will be contended that this strategy is too weak, given that the B-preface has currently been analyzed in a markedly divergent manner by the so-called 'methodological interpretation'. In his methodology and history of science of the B-preface, Kant means something different by progress and regression than what his 20th-century critics assume he meant. By examining what Kant and his critics considered to be progress and regress in science and logic, good reasons can be put forward for the argument that Kant was correct in his assertion that logic has not gone a step forward or backward.
Keywords: Kantian Philosophy, History of Logic, Philosophy of Science, Metaphysics, Calculus, Methodology

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1. Introduction

Several times in the history of logic, a break, a revolution or – speaking with the vocabulary of the philosophy of science – a paradigm shift was proclaimed. In this process, certain views and techniques were to be replaced by those of newer groups, i.e. from logica vetus to logica nova, from logica antiqua to logica modernorum, and from old logic to new logic. Seen from today's perspective, no revolution in logic was as strong as the one between logic before the late 19th century and the century after. With Boole in England, with Frege in the continental region and with Peirce in the American area, a new method of doing logic and reflecting on logic opened up.

Even among the early representatives of the so-called 'new logic' in the late 19th and early 20th centuries (e.g. Carnap 1959; Menger 1937), there were remnants of the doctrine of Kantianism that had previously prevailed in the 19th century. Nevertheless, these adaptations were mostly treated as atavisms to be hidden, since the representatives of the revolutionized science had difficulty in finding points of contact with Kant and the Kantian logic. This was characterized by the rapid elimination of all traces of the old logic, the marginalization of traditional philosophers and logicians in particular, and the philosophical search for new paths, which today are grouped under the heading of 'early analytic philosophy'. Most modern logicians already stumbled in their reading of Kant over a passage from the second preface of the *Critique of Pure Reason* (hereafter: B-preface) that still reverberates today and soon became the object of general derision among 20th century logicians. In this passage, Kant claims that logic has not taken a step backwards since Aristotle's time, but that it cannot take a step forward either, since it was already a complete and secure scientific discipline in Aristotle's time.

Huaping Lu-Adler has recently compiled the mockery of this proposition from several well-known histories of early 20th century logic, notably Bocheński and the Kneales, and one could cite many more writings in addition that still occasionally resonate today (Lu-Adler 2018, Intr.). All of the voices compiled from the early 20th century agree (1) that it was once believed to be ridiculous that logic could not develop further. Additionally, they argue (2) that Kant could not have had a single clue about logic, since he traced logic back to Aristotle and did not even mention the equally important Stoics. In order to be able to make Kant's logic the subject of investigation, some modern scholars choose the strategy of highlighting Kant's writings as interesting for philosophy (of logic), but leaving logic to the mathematicians, who could probably have no interest in Kant's logic (Tolley 2017; Lu-Adler 2018). Other authors argue, with different emphases, that Kant's actual logic is transcendental logic and that general or formal logic should be grounded in it (Hanna 2015). These positions can lead to a weakening of the 'formal' Kantian logic, whether intentionally or unintentionally.

The following section presents arguments against this trend, based on the interpretation of the above-mentioned Aristotle passage. From a systematic perspective, it can be stated that Kant's (formal or general) logic is certainly relevant to modern logic, although not to all logics or logicians. In contrast to the period around 1900, the logic of the 21st century no longer depends on demarcations from previous periods, and scholars are rarely criticized for taking a broader view of the history of logic. For many years now, there has been a tendency to take logics such as Kant's seriously again and to analyze them, above all, with modern means. Successfully, for example, Kovač, Lambalgen and others have shown that Kant can certainly be harmonized with modern (non-classical) logics (Kovac 2008; Achourioti et al. 2011; Evans et al. 2019). In an extreme interpretation of these new investigations into Kant's logic, one could even say that Kant was far beyond the demands of early 20th century logic and philosophers, logicians and historians like Bocheński or the Kneales did not have the means to make sense of Kant's approaches for the new logic.

However, one can also take a historical point and argue that Kant was quite right to claim that logic has not gone one step forward and one step back. The accompanying claim is that many 20th-century scholars did not take Kant's general point of view into account and therefore did not even (try to or want to) understand what Kant was claiming in the seemingly ridiculous passage. The aim of this paper is to support this perspective.

We proceed in two steps for this: The first step goes forward and asks why Kant did not see or sense any progress in logic. We will argue for the fact that the progressive attempts in Kant's time all failed and that Kant therefore only refers to the prevailing opinion of his time at the relevant passage. To this end, in Section 2, we will refer to the prevailing opinion of Kant's contemporaries, who critically looked at those issues that 20th century logicians saw as expressions and anticipations of the new logic. The second step builds on the first, but goes backwards and asks why Kant did not see a regression in logic and why logic was already on the secure path of science. To this end, in Section 3, we will place Kant's text passage in the context of the B-preface, also placing the preface in the context of the work as a whole and favouring the currently strongly discussed 'methodological interpretation' in Kantian scholarship. Finally, in Section 4, we will take a broader perspective and ask what progress and regress can mean in the history of science and logic. The argument will be made that Kant's concept of progress differs from that of his 20th-century critics.

2. Progress towards calculus

In the 2010s, there were several studies on individual topics of the B-preface, which proved that Kant was referring to a history of science that summarized the prevailing opinion of his time and partly reflected these opinions right down to the choice of words. It has been argued that the text passage on Copernicus follows the wording and presentation in Lambert and that the paragraphs on Diogenes, Bacon, Galileo, Torricelli and Stahl refers to exact passages from these authors (e.g. Brandt 2007; Lemanski 2016; Hottner 2020). If this hypothesis is correct, that Kant is referencing the prevailing opinion of his time or of the authors listed there, then one must ask whether the concrete descriptions that remain from the B-preface are also based on prevailing doctrines and perhaps even specific passages of text. With regard to the passage on Aristotelian logic in question – hereafter 'Aristotle passage' – I want to further support this hypothesis in this section. The argument will be put forth that Kant had specific facts in mind when he wrote the passage that has since been deemed ridiculous, and that Kant had sound reasons for espousing the associated opinion. The passage in question, which was mostly adopted uncritically by the Kantians of the 19th century, and so strongly criticized by the logicians of the early 20th century, begins with the words:

> That from the earliest times logic has traveled this secure course can be seen from the fact that since the time of Aristotle it has not had to go a single step backwards, unless we count the abolition of a few dispensable subtleties or the more distinct determination of its presentation, which improvements belong more to the elegance than to the security of that science. What is further remarkable about logic is that until now it has also been unable to take a single step forward, and therefore seems to all appearance to be finished and complete. (KrV, B VIII)

In the following, Kant mentions some extensions of logic whose critique was never up for debate even in the 20th century. Kant points out, for example, that some have tried to extend general or formal logic by making psychological, other metaphysical and still other anthropological extensions[1]. Again, there are already studies that indicate that Kant may have had certain logics of his time in mind when he wrote these lines (Tolley 2016). From the perspective of the 18th as well as the 20th century, however, these following passages are unproblematic and are even supported. Rather, it seemed ridiculous in the 20th century that Kant considered logic to be finished, since those projects, such as the formalization of logic and the question of a logic calculus, had already been formulated long before Kant as a research task – as a 'desideratum' in the sense of Bacon – but Kant apparently did not take them seriously at all.

This addresses a topic that was seen as a criterion for progress in logic in the 20th century: the formalization of logic on the one hand and the development of a logical calculus on the other. Both aspects therefore

1 For detailed discussion of Kant's classification of logic see e.g. Zinkstok 2013; Lobeiras 2024.

point towards linking logic more closely to mathematics. Since Leibniz fulfilled both criteria for progress, at least in terms of basic attitude, while Kant fulfilled neither, Kant and Kantianism were perceived as a step backwards in the 20th century (Peckhaus 1997). The Aristotelian passage was thus interpreted as an exemplary expression of Kantian regression in the history of logic.

In this section, however, it will be argued that Kant wrote this passage in 1787 at a stage in the history of logic when both closely related projects that became so fruitful for the 20th century were considered to have failed. Kant knew about these formal projects, but he also knew that they were no longer even up for debate in the 1780s, and to that extent he concentrated on criticizing the still rampant attempts to psychologize or anthropologize logic (Capozzi et al. 2011, sect. 11).

From today's perspective, it is difficult to pin down an exact origin of the formalization of logic and the search for a logic calculus. From the 17th to the 19th century, however, it is not uncommon to find evidence that both approaches received a formative vision through Hobbes' logic. Hobbes wrote in § 2 of *De Corpore*:

> By *ratiocination*, I mean *computation*. Now to compute, is either to collect the sum of many things that are added together, or to know what remains when one thing is taken out of another. *Ratiocination*, therefore, is the same with *addition* and *subtraction*; and if any man add *multiplication* and *division*, I will not be against it, seeing multiplication is nothing but addition of equals one to another, and division nothing but a subtraction of equals one from another, as often as is possible. So that all ratiocination is comprehended in these two operations of the mind, addition and subtraction. (Hobbes 1839, I, p. 39)

Starting from Hobbes, one can establish a long genealogy of the projects of formalization and the search for the calculus. A detailed account of both projects is offered by Peckhaus, who, however, relates the developments of the 18th century primarily to the 19th and 20th centuries (Peckhaus 1997). We summarize some of these key points below and supplement them primarily with views that come from Kant's predecessors and contemporaries. Jakob Bernoulli's *Parallelismus Ratiocinii Logici et Algebraici* was particularly groundbreaking for formalization of logic. It introduces an algebraic method of formalization that was taken up and further developed again and again until the middle of the 19th century. Bernoulli explains here how logical expressions can be converted into algebraic formulae in order to be able to perform calculations in the sense of Hobbes. The importance of algebra from a heuristic perspective was often illustrated in the early 18th century by Newton's *Arithmetica universalis*. Newton uses examples in writing to show that everyday tasks can be conveniently processed by transforming them into algebra and, moreover, that new insights can be generated.

For the question of the logic calculus, the approaches from the Weigel school are particularly relevant: Weigel himself developed a geometric method called *logometrum*, thereby replacing Aristotelian syllogistics to a simple constructive decision procedure. His student Sturm tried to extend this project in the early 1660s and allow geometric constructions and calculations, thus going beyond syllogistics (Bullynck et al. 2013). Nowadays, another approach from the Weigel school is particularly well known, i.e. Leibniz's *De Arte Combinatoria*. However, his geometrical, algebraic and arithmetical attempts to generate a logic calculus had only been handed down as ideas and through hearsay in the 18th and 19th centuries. His views and visions became known through the above-mentioned dissertation of 1666, which also outlined Weigel's and Sturm's ideas, through the famous letter to Nicolas Remond of 10 January 1714 (Leibniz et al. 1720, II, p. 129) and through smaller writings by contemporary witnesses (e.g. [Lange 1720]). Leibniz's truly relevant definition of the logic calculus was not published until 1819 (Leibniz 1820a), and was only slowly taken note of from 1827 onwards (Drobisch 1827).

Both approaches got mixed up in the course of the 18th century, but can be understood as two objectives, at least in Kant's sense: Formalization is primarily about a heuristic approach to being able to develop new truths from old ones. The calculus idea, however, went one step further and wanted not only to guarantee the invention of new truths, but also the certainty of all logical operations, in order to establish logical truths from other fields, such as mathematics, as certain and derivable. The aim was to calculate logic purely syntactically and independently of the meaning of the signs.

In the early 20th century, the second ideal in particular flourished again, and Leibniz was quickly seen as a pioneer whose work could only be continued by Frege, Russell and Whitehead. The phase between Leibniz and Frege is thus often regarded as a lost epoch of logic, in which only Lambert and Ploucquet in the 1760s can still be considered a ray of hope. Kant, whose school dominated during this period is regarded as a retrograde obstructor who prevented actual progress. This is evidenced for the 20th century by sentences such as the Aristotle passage. Kant himself is only to blame here, however, insofar as he follows the doctrine of the late 18th century. Let us look first at (1) the heuristic, then at (2) the calculus.

(1) The question of the heuristic possibilities of logic had been a point of discussion since the middle of the 17th century. Leibniz himself was already interested in heuristics in his *Dissertatio De Arte Combinatoria*, but avoided directly overturning the rules of Aristotelian logic by doing so and even criticized those who did (Leibniz 2020, pp. 129ff.). This tendency was repeated in the first half of the 18th century. While supporting the views of interpreting logic as a heuristic, subverting the current Aristotelian rules was considered futile, the way logic was taught continued to be cumbersome (Edelmann 1735, pp. 262ff.) and finding new truths problematic. Kant follows this view and replaces heuristics with critique (Buchenau 2013, chap. 10):

> Darjes has written a book on the ars inveniendi, but neither he nor anyone else has ever invented anything through it. (Kant 1998, p. 279)
> Logic is thus not a universal art of discovery, to be sure, and not an organon of truth – not an algebra, with whose help hidden truths can be discovered. It is useful and indispensable as a critique of

> cognition, however, or for passing judgment on common as well as on speculative reason, not in order to teach it, but only to make it correct and in agreement with itself. (Kant 1992a, p. 534 = AA IX 20)

(2) The prototype of a calculus in the 18th century was the infinitesimal calculus (calculus differentialis), the invention of which was disputed by Leibniz and Newton during their lifetime. Whether such a type of calculation could also be applied to logic was a more far-reaching question than that of the heuristic nature of logic. Nevertheless, the views on what a logic calculus had to achieve were very different and sometimes confused in the 18th century. Even then, it was the general opinion that prevailing logicians such as Wolff and most Wolffians had no clue about a logic calculus, and even Leibniz's ideas on it were only guessed at. Ploucquet and Lambert were those authors who came closest to having an idea of the meaning and usefulness of a calculus in Leibniz's sense. Both favoured geometrical approaches in their first published works, as they saw the arithmetical or algebraic approaches as problematic. Ploucquet claimed that his calculation did not make any progress beyond Aristotelian logic, but only made the scholastic mnemonic obsolete.

A figurative representation in which geometric shapes are used to calculate inferences has been called a logic diagram since Peirce (Moktefi & Shin 2012). Kant made this type of representation known at all in the 19th century, although he did not know the term logic diagram. As this device was considered too intuitive (and sensual), most rationalists rejected 'logic diagrams' in the late 18th century (Lemanski 2021, chap. 2.2). Moreover, it was Kant who sought a posthumous publication of Lambert's few approaches to algebraic calculus (Arndt 1965, pp. V–VII). The 20th-century insinuation that Kant was therefore counterproductive in popularizing a logic calculus is thus unjustified.

Nevertheless, the accusation remains that Kant did not value these attempts, as can be seen in the Aristotle passage. In fact, it was not Kant who was critical of the idea of the calculus (Capozzi et al. 2011, p. 142), but the authors who tried their hand at a calculus. Lambert himself saw his attempts at an algebraic formalization as unfortunate, but continued to work on them, although he focused on the geometric calculus in publications. He even got into a dispute with Ploucquet in the 1760s about who had first invented the idea of the geometric calculus. For a short time, there was a fear that a similar dispute would break out over the invention as between Leibniz and Newton with regard to the infinitesimal calculus (Bök 1766, p. 152). In the end, however, Ploucquet himself declared that Lambert's calculus did not work and that his own would not fulfil Leibniz's previously known visions. He already saw his heuristic goal of the calculus as problematic:

> It is impossible to give a general method of how one and the same calculus can be safely used in all possible cases without much thought, because the real application is based on the diversity of the tasks, which requires a good mind to discover, but which is not formed by any rules. (Bök et al. 1786, p. 202)
> Therefore, there is no universal calculus that could be used to present the methods by which things are substituted by others things, and a characteristica universalis belongs to the dreams of excellent minds. (Bök et al. 1786, p. 113)

Among the many German-language disputes of the 18th century with philosophical relevance, such as the Fragment Controversy, the Pantheism Controversy, the Atheism Controversy, etc., one can also include a Calculus Controversy, the chronological progress of which was compiled in an anthology by August Friedrich Bök in 1766. Besides Ploucquet and Lambert, Georg J. Holland, Heinrich Wilhelm Clemm, Thomas Abbt, Moses Mendelssohn and others were involved in these disputes. Raspe's and Eberhard's edition of Leibniz's logical writings in 1765 can also be seen as a contribution to this dispute, since six new logical texts by Leibniz were used to pour fuel on the fire (Bök et al. 1786, p. 260). With the publication of the anthology of 1766, however, a prevailing opinion had formed, which Bök probably summarizes most pertinently as follows:

> An invention of this kind, which could be called a real calculus, and with which Leibniz' insatiable inquisitiveness was busy for many years without success, does not seem to belong to the sphere of mortals, and will probably have the same fate as the search for a philosopher's stone, the squaring the circle and the construction of an eternal machine. (Bök et al. 1786, Vorr.)

Bök's statement is the balance of the entire controversy of the 1760s and his judgement is unambiguous: a logic calculus, such as Leibniz must perhaps have had in mind, is an unrealizable absurdity. The comparison with the lapis philosophorum, the quadratura circuli and the perpetuum mobile shows that the assumption of the existence of a logic calculus corresponds to a pre-scientific period. The failure of the Ploucquet-Lambert programme in the 18th century virtually corresponds to the failure of Hilbert programme in the 20th century: Those who, despite knowing better, continue to search for proof of the existence of something impossible are quickly considered naive.

Kant knew the outcome of the calculus controversy, and any further glance at a book on logic or science after the 1760s would have echoed Bök's statement in a modified form. For Bök's assessment is followed by numerous other authors of the time. In the following, only a few examples will be given, which come from various non-Kantian schools:

> Many things have been written about a general art of characteristics that can be invented, about the logic calculus, and the like: I thought we had all that, if only we did not miss the right use of it, because we demand more from the calculus than it can do by its nature. (Karsten 1786, p. 158f.)
> To this method of calculating also belongs this logic calculus, the advantages of which consist in the fact that the inferences are drawn and demonstrated with little effort, that no mistakes are made (except through carelessness, the source of which is immediately discovered), and that the syllogistic is greatly abbreviated. In fact, this method does no more than that, and here still has the error that it

> expresses everything concretely, since the higher has to be thought in an abstract way. Lambert also reproached its inventor with this error, who, on the other hand, found much to criticize in Lambert's art (Eberstein 1794, p. 309f.).
> Even if this calculus does not have the great practical use that its inventor ascribes to it, it nevertheless simplifies the Aristotelian theory of syllogism and makes the whole doctrine of the four figures superfluous. (Schwab 1796, p. 64)

In Kant's time, the history of the logic calculus was a history of failure or disappointment. Even Kant critics, Leibnizians and Wolffians such as Eberstein or Schwab agree with Bök that the project of a logic calculus has failed or is problematic. One can find numerous other judgements from these years that support Bök's claim. This even went so far that influential mathematicians researching combinatorial analysis found the reason for the impossibility of such a calculus in Kantian philosophy:

> That the advantages which Leibniz promised himself from a philosophical ars characteristica and the combinatorial calculus to be applied with it are never attainable is now well recognized, since the essential difference between mathematical and philosophical knowledge and their respective methods has finally been revealed in the most satisfactory way by critical philosophy. (Weingärtner 1800, XIII)

Weingärtner, a student of the renowned mathematician Hindenburg, makes a passing observation that logicians such as Bardili remain unteachable in their attempts at a calculus. However, he does not consider the discussion of such approaches to be necessary. In short, in Kant's time, the calculus was considered a failure or a simplification at best, logic was considered "finished and complete", and the most that could be discussed as progress were extensions of the content of logic, which Kant rejected. The Aristotle passage is thus not Kant's own opinion, but solely the pessimistic reflection of those logicians and mathematicians who in the 20th century were still understood as a ray of hope in dark times.

There is nothing left for us to do in this section but to give the quotation from Bök to which Kant refers in the Aristotle passage:

> Since the time of Aristotle, the history of logic has not travelled to a great and memorable epoch which would have opened a new and convenient path for the mind to a rapid and certain progress in the realm of truth. (Bök et al. 1786, Pref.)

3. Regression to Aristotle

We have seen in Section 2 that several criticisms of the Aristotle passage are unjustified: Kant, on the one hand, was interested in certain calculi and even made them public in the first place, in particular Euler's geometrical approach and Lambert's algebraic calculus. On the other hand, Kant is only a representative of a certain period in which calculi have been considered impossible since the 1760s. If Kant had continued to work on a calculus during this period, he would probably have been considered just as unteachable as someone who still wanted to prove the completeness of higher-order logics after the 1930s or who still wants to derive judgements of metaphysica specialis from any calculus today.

Nevertheless, the historical facts presented in Section 2 should not yet pardon Kant for modern logic. For although the first sentence of the above quotation first of all merely asserts, unsuspiciously, that logic has not taken a step backwards since Aristotle, this part might have sounded equally absurd to logicians of the 20th century. Here, regression and progress are closely connected: If one understands – as was often done in the first half of the 20th century – Aristotelian logic as a fragment of first-order logic and Stoic logic as the forerunner of propositional logic, Kant only points to one fragment of classical logic in the Aristotle passage. For the Krakow, the Münster school and the Lwów–Warsaw in particular, there is a primacy of propositional logic over first-order logic that goes so far as to put even the premise-conclusion structure of syllogistics into a form of propositional calculus.

From the perspective of the 20th century, however, Kant has a small part of the fragments of modern classical logic in mind, as he only mentions Aristotle. Thus, Kant's Aristotle passage is insufficient, as he fails to acknowledge Stoic (or propositional) logic and only focuses on the development of classical first-order logic. Kant's mention of the unsuccessful regression demonstrates his inability to anticipate the advancements made in the 20th century.

These systematic theses from the 20th century historiography of logic will now be revised in this section. The claim is that Kant was right to refer only to Aristotle and not to Stoic logic, and that good reasons can be given for calling his main thesis of the Aristotle passage still true today. Furthermore, most 20th century historians of logic will be accused of having considered Kant's statement only in isolation and of not having considered the context of the text passage.

The latter is not surprising, however, insofar as Kant's interpretation in the first half of the 20th century read the entire B-preface in the light of the epistemological subject-object divide. It was only in the second half of the 20th century that this neo-Kantian interpretation was found to be contradictory and alternative, much liberal readings of the B-preface were developed, most of which focused on hermeneutics and the theme of freedom. The logicians and historians of the 20th century are therefore not to blame for misunderstanding Kant, since the B-preface is difficult to interpret and a demonstrably false interpretation dominated up to the 1970s (Lemanski 2012; Meer 2021).

The starting point of our argumentation is the more textual interpretation based on the philosophy of science, which has only become established since the 21st century. This methodological interpretation was founded in the 2000s (Brandt 2007) and then further developed (Lemanski 2012; Moledo 2017). In addition, there were further important contributions to this direction (Olson 2018; Hottner 2020, chap. 3; Meer 2021). This interpretation is based on several premises: (1) In the B-preface, Kant outlines the methodological principles of a philosophy of science in the first paragraph. (2) He then provides examples from the history of science, starting with the Aristotle passage and ending with the Copernican turn. (3) The rest of the B-preface applies this theory to the relationship between critique and metaphysics. In terms of philosophy of science, the B-preface thus demonstrates a method that resembles a *trial & error* procedure: In the critique, one establishes categories, principles, ideas etc. as a kind of "experiment" or trial and then checks in metaphysics whether this experiment has been successful. The following paragraphs elaborate on these three points and attempt to standardize the vocabulary used in the above studies.

1) Kant first describes the method purely systematically in the first paragraph of the B-preface (KrV, B VII). The metaphors in this paragraph (sicheren Gang…gehe, in Stecken geräth, zurückgehen, andern Weg, Herumtappen, diesen Weg) are deliberately chosen and allude to the fact that 'method' (methodos) already meant nothing other than 'path' in the ancient philosophy of science. The "secure course" (sichere Gang) of a science is judged by its success, i.e. whether the result can be verified or falsified. If this success is falsified, i.e. if the science "gets stuck" (in Stecken greaten), one has to "go back" (wieder zurückgehen) to the beginning and change the 'hypothesis' or the trial conditions. In Kant's words, "a new path" (andern Weg) is taken. If not everyone is convinced of the new method yet, one is still at the stage of "groping about" (Herumtappen). The secure course is then found by abandoning some things as "futile". The correct path is found by discarding what is deemed futile. Kant describes this process as a *modus tollendo ponens*, where one can choose between paths *A, B, and C.* After choosing, paths *A* and *B* are proven to be incorrect, leaving only path *C* as the correct one.
2) Kant exemplifies in the following ten paragraphs that such a method is reflected in the history of science and that a certain method (*C*) is repeated again and again. In this history of science, the successful paths are represented by theoretical approaches of successful scholars or scientists. Kant introduces a new metaphor here that points to a rational process and to inspiration and intuition (B xi ff: ging ein Licht auf, einsehen, Einfalle, ersten Gedanken). Let us first skip the Aristotle passage and look at mathematics and physics: In geometry, science got stuck because various paths (say *A* and *B*) failed. These paths were characterized by tracing what can be seen "in this figure" of e.g. a triangle (*A*) or tracing "its mere concept" (*B*) (KrV, B XI). About Thales, however, "a new light broke upon" (KrV, B XI f.) and thus he brought forth something by "a priori concepts" and by construction (*C*). In physics, too, various paths failed, since reason was guided by nature "in leading-strings" (*A*) or worked according to "accidental observations" (*B*).
Then it was Galileo in mechanics, Torricelli in hydraulics and Stahl in chemistry for whom "a light dawned" (KrV, B XIII) and who found a different way (*A*). This led to an "advantageous revolution in its way of thinking", which was heavily reliant on the respective researcher's "inspiration". Their success was due to their use of "principles" and "experimentation" when studying nature. The history of physics, including astronomy, follows this method. For millennia, astronomy was hindered by the induction of data in the form of star catalogues resp. "catalogi stellarum" and by the ordinary observation of the motion of the celestial bodies. However, Copernicus proposed a new approach and asked whether one "might not have greater success" and "try whether we do not get farther" (KrV, B XVI), if astronomy were organized in a theory-driven rather than a data-driven way. The field of astronomy did not advance significantly and became increasingly static as a result of the interpretation of data from star catalogs (*A*) or the ordinary observation of the motion of the celestial bodies (*C*). In all these approaches, the theory was derived from the data. However, it was the establishment of a new theory-driven approach (*C*), which was subsequently validated by the data, that led to this scientific revolution. Success proved Copernicus right.
3) After these paragraphs, Kant adopts the philosophy of science described in (1) and the history of science described in (2) as an opportunity to propagate the same change for metaphysics. Metaphysics, too, had come to a standstill, was not a real science and therefore had to be revolutionized. One must therefore do as Thales did in mathematics, as Stahl did in chemistry or as Copernicus did in astronomy. Metaphysics should therefore itself be regarded as a trial or experiment (B xviii). The categories, principles, regulative ideas, etc. in the three Critiques function as concepts a priori and planned hypotheses, which are then applied to the "metaphysics both of nature and of morals" (KrV, B XLIII). If this application is successful, the hypothesis was correct. The categories in the Critiques are thus not simply gathered inductively as in Aristotle and then applied as infallible, but their success is shown in the correspondence with the respective subject area, that is, to what extent the foundations of the Critiques are applicable in the metaphysics of nature and morals. To test the success of the experiment, the categories and all the tables based on them are then applied, for example, in the *Metaphysical Foundations of Natural Science* and the *Metaphysics of Morals*.

These are the three cornerstones of the 'methodological interpretation' of the B-preface. In this preface, Kant is thus not concerned with the subject-object relationship, as many neo-Kantian-influenced authors in the 20th century thought, but with the normative proposal of a revolution from an unsuccessful data-driven to a successful theory-driven metaphysics, which is derived from the descriptive history of science.

As much support as this methodological interpretation has enjoyed in the last ten years, the question now arises as to how this corresponds with logic, which has already gone a "secure course of science" since Aristotle? And to what extent can this interpretation revise the Kant image of 20th-century logicians? Kant, like many other logicians to this day, does not really comment on a logic before Aristotle. The educated scientist knows that there were researchers like Hipparchus or Ptolemy before Copernicus or that Aristotelian theory was dominant before Galileo. Before Aristotle, however, no completely preserved treatises on logic are known. It is nowadays evident that there were numerous logical approaches and applications prior to Aristotle (Schumann 2023), yet there is no extant textbook of logic prior to the *Organon*. In this respect, Kant is right from the perspective of modern science when he claims that logic has been deductive and therefore certain since the beginning, because Aristotle's *Organon* is the prototype of deductive, theory-driven research. A real scientific revolution in the sense of a change from data-driven ways (*A*, *B*) to a theory-laden method (*C*) is not known in the history of logic, even today.

But that does not mean that Aristotle had no illumination or insight when he conceptualized his *Organon*. Kant does not speak of any discovery in logic in the *Critique of Pure Reason*, but already in his early writing on formal logic, the *The False Subtlety of the Four Syllogistic Figures*. One has always read this treatise as a plea for a reduction to the first syllogistic figure, but one can also see in it an attempt to reconstruct an original insight that someone has when formalizing non-perfect inferences with the help of a combinatorial procedure (Alves 2021, p. 280; Caperno 2019). With the help of this combinatorial procedure, it was once recognized that there are certain rules in logic and that one therefore does not have to detect syllogisms or inferences of reason (*Vernunftschlüsse*) inductively:

> The person who first wrote down a syllogism in three lines arranged one above the other, and looked at it as one would look at a chessboard, and who then attempted to establish what would happen if one changed the positions of the middle term – that person, when he discovered that the transposition yielded good sense was as much taken aback as someone detecting an anagram in a name. (AA II 56f. = (Kant 1992b, p. 100)

It is possible that Kant had Aristotle in mind when referring to this "person" as Kant sees a combinatorial as well as intuitive idea in organizing syllogism by so-called 'figures' (Kant: AA XVI, 727; cf. also Wesoły 2012). But the context also suggests that he was referring to a scholastic author who recognized rules in formalization, which then led to scholastic modi such as Darii, Ferio, etc., as the scholastic method of reduction has some similarities to 'anagrams'. However, the name mentioned here, similar to Thales, holds no weight. What is important is the recognition of rules in the data and proceeding in a theory-laden manner. In the given quotation, Kant criticizes the vanity of such discoveries but acknowledges the establishment of scientifically viable methods in logic. The quotation also describes Kant's own combinatorial approach in *The False Subtlety*.

One might argue that the fundamental methodology of logic remains largely unchanged to this day. Typically, one defines an alphabet, well-formed formulae, establishes axioms or rules of inference, provides a model by assigning truth values to statements, and finally proves the system's completeness and correctness. Even after the successful implementation of the first formal systems of modern logic, it was common for subsequent logicians to revisit and streamline axioms or eliminate unnecessary rules of inference, often employing combinatorial methods and *trial-and-error* approaches. A notable example is the history of axiom reduction following the *Principia Mathematica*, significantly advanced by logicians such as Sheffer, Nicod, and Meredith. Despite these enhancements and new insights, the core of logic remains deductive and laden with theoretical underpinnings. Reflecting on Kant's assertion, one could contend that logic has been consistently approached in a specific manner since Aristotle's time, without substantial regression or backward steps being considered.

It could also be argued that a reinterpretation of Aristotelian logic, as undertaken by logicians such as Corcoran, Smiley or Tennant, would not have been possible at all without an unchanging foundation of method. The deductive and theory-laden method thus creates a stable framework within which certain innovations can take place, including the transition from the old to the new logic.

If one agrees with the argumentation presented thus far, it is unnecessary to explicitly reference the Stoics in the Aristotle passage. The Stoics also approached the investigation of propositional logic with a preconceived plan, as Kant described. They have used the same method as Kant, who also saw it in Aristotle or in the person who was surprised by the regularities found by changing the position of syntactic objects. Additionally, Kant was familiar with Stoic logic (and parts of modal logic), as evidenced e.g. by the *Jäsche Logic* §§25ff., §§75ff. However, Kant did not find it necessary to incorporate Stoic logic into the Aristotle passage, despite the Stoics' significant expansion of formal logic.

Furthermore, contemporary research into the history of logic demonstrates that the Stoics, like Aristotle or the Aristotelians, did not invent a specific logic; rather, they merely created a canonical knowledge as given in later textbooks. Furthermore, some of this knowledge can already be derived from Aristotle (Bobzien 2002), while other sources are considerably older (Schumann 2023). Consequently, the omission of the Stoics in the Aristotle passage does not necessarily reflect a lack of awareness by Kant. The sole problematic aspect of the history of science in the entire B-preface is the attachment of scientific revolutions to certain proper names. After all, Thales, Stahl and Torricelli are no less controversial than Aristotle.

This argument can even be supported by further details if one looks into the physics passages of the B-preface. At first glance, it is astonishing that Kant mentions Stahl as revolutionary for chemistry, although it should have been clear to Kant at this point that Stahl's chemistry had been completely replaced by Lavoisier (just as Thales was probably superseded by Euclid). Kant, however, is not actually concerned in the B-preface with the content and correctness of the explanation that separates a secure science from a pre-scientific one, but solely with the method. Stahl's attempt at explanation did not prevail in chemistry, but Stahl's method paved the way for Lavoisier and therefore marks the transition from alchemy to chemistry for Kant (Hottner 2020, chap. 3).

It is precisely this methodological relationship that can now be applied to Aristotle and his successors. However important and decisive changes these Aristotle's successors may have made, Aristotle remains the one who elevated logic to a secure science. In this way, Kant even safeguards himself against his own failure. Even if it should turn out in the 19th century that his theory of categories is in need of improvement, he will remain 'the Stahl of metaphysics'. This means, he will be the first to have introduced the deductive procedure into metaphysics even if his philosophical experiment is falsified in terms of content. The last sentence of the first paragraph of the B-preface also points to this: it is already a merit to find the theory-driven path "even if we have to give up as futile much of what was included in the end previously formed without deliberation" (Bxvii).

Moreover, in the Aristotle passage, Kant himself does not say a word about the fact that he formulated a strong critique of the scholastic method with *The False Subtlety* or that he made far-reaching changes in his logic lectures. Kant thus also hides his own merits in logic, although it must be mentioned that it was not logic but metaphysics that was the goal of his revolutionary reflections. Nevertheless, it is conceivable that Kant would have formulated the Aristotle passages in a similar manner today, even if he were aware that his logic would be classified as paraconsistent. This would not alter the deductive and scientific character of Aristotelian logic. Certainly, Kant would be more cautious in his choice of words today, but in substance it remains true that logic was already practiced as a secure science "from the earliest times" (B viii).

4. Progress and Regress in Logic

This paper presented an argument that Kant's passage on the history and philosophy of logic can withstand the criticisms of many 20th-century interpreters and the methodological interpretation of the B-preface to the *Critique of Pure Reason* was supported. In the 20th-century it was often said that Kant's view of formal logic was untenable, as he had already dismissed the possibility of progress in logic in the B-preface, such as the formalization of logic or the idea of a logical calculus, and had not considered developments such as Stoic logic. To this day, this criticism is reflected in some areas of scholarship, as Kant's general or formal logic is sometimes considered deficient or inferior to transcendental logic.

In recent years, several studies have challenged the view that Kant's formal logic is outdated. These works have shown that Kant's formal approaches can be interpreted at a contemporary level with the help of paraconsistent logic. However, the issue that arose from the introductory passages of the *Critique of Pure Reason* over a century ago persists. In other words, updating Kant's formal logic does not provide context for his statements on Aristotelian logic.

In this paper, we have re-evaluated the passage from a historical perspective and used the so-called 'methodological interpretation' to present an alternative view of the relationship between formal and transcendental logic in Kant. For historical reasons, it has been right for Kant to say that logic did not take a step forward in his time. For systematic reasons, however, it is also justified to say that logic has been a secure science since Aristotle, since Kant is not concerned with extensions of content in the B-preface, but it is (as the whole *Critique of Pure Reason*) a "treatise on the method" (B xxii).

The preceding argument illustrates the strong dependence of assessments and value judgments about certain logics and logical topics on the respective age and the prevailing ideas about what logic is as a discipline and how logical thinking can be explored. Although the overall revolution of logic is – as Kant has shown – a deductive one, within this deductive enterprise there are in turn individual transformations by which topics and views are valued differently.

Up to now, we have so far been quite careless with the concepts of revolution, paradigm, transformation, break etc. From the somewhat broader perspective, however, it makes sense to introduce a more precise distinction, i.e. the difference between revolution and non-revolutionary changes which may be called paradigms, trends, modifications, additions, improvements etc. If we define that a revolution describes the change from a pre-scientific period to a secure science by a change of method, then that is what Kant had in mind in the B-preface. If, on the other hand, we mean a particular course correction within secure science, then we are talking about non-revolutionary events.

From the perspective of methodological interpretation, one can say that a revolution is the transition from a groping, inductive and data-driven method to a secure, deductive and theory-laden course. As with the *modus tollendo ponens*, there are certain inductive procedures, e.g. *A* or *B*, for working scientifically. But in many areas of science, after a while someone has a revolutionary idea and a completely new method *C* is applied. From this perspective, switching from methods *A* and *B* to *C* would be a called 'a step forward' and from *C* back to *A* or *B* a 'step backwards'. However, the non-revolutionary changes then take place within method *C* or, in other words, after *C* has been accepted. These non-revolutionary changes are course changes that take place within the revolutionized method. However significant these changes of course may be, they do not change the fundamental method, e.g. *C*.

Kant spoke of revolutions in the preface of the *Critique of Pure Reason*. The Aristotle passage only mentions non-revolutionary changes or trends in passing, such as the mixing of psychology and logic. However, even this is not regarded by Kant as a regression, since it is only non-revolutionary additions that take place in logic.

Within modern logic, there is a whole series of different non-revolutionary improvements, which can be of a technical or content-related nature. Examples could include the dissolution of the subject-predicate structure in logic with Frege, the beginnings of proof theory with Hilbert, model theory with Tarski, the formal development of paraconsistent logics since Jaśkowski, natural logic since Van Benthem or diagrammatic logic according to Shin. Although such improvements exist and although they are very important, they do not constitute revolutions in the sense of the B-preface.

In the Aristotle passage and its context, Kant is concerned with a complete change of the scientific method, rather than with improvements or trends. In the context of the B-preface, revolution refers to the shift from an unstructured, data-driven approach to a systematic, theory-based transformation. Of course, in today's data-driven age, we can debate whether Kant was right. But here the point is not to evaluate the criterion for science, but to understand what Kant considered science to be.

The distinction between revolutionary and non-revolutionary change in science should also make it clear that Kant sees a completely different criterion for progress and regression in logic or in the other sciences than his critics in the 20th century. The author of the B-preface means something different with 'progress' than his later commentators.

In the B-preface, progress or step forward means a scientific revolution brought about by a change of method from data-driven to theory-laden research. This is not in accordance with the concept of progress as understood by Kant's critics of the 20th century, as the transition from the so-called 'old' to the 'new logic' does not entail a shift from the inductive to the deductive method. In doing so, Kant also negates the criteria for progress that his critics have previously criticized him for. From this perspective we have now adopted, the logical calculus is a significant improvement, and the associated technical achievements are enormous. Nevertheless, the deductive method of logic remains. Furthermore, the emergence of Stoic logic from Aristotelian logic is not a revolution like the transition from inductive-preceding astronomy to a deductive one where instead of the data, which are later generalized, a general hypothesis is first formulated, which is then tested on the data.

For Kant, a revolution has already occurred in fields such as mathematics, chemistry, physics, and astronomy. However, metaphysics has yet to undergo this process. The model for a secure science is formal logic, which has been deductive and theory-laden since its founder. Kant's objective is to demonstrate that progress could be achieved in the field of metaphysics if general statements were not derived from individual observations, but if a theory were first established and then tested against reality. If one sees this context of the B-preface, the role of the Aristotle passage and also Kant's statements about formal logic appear in a new light. The reliability of formal logic is based on the fact that it was already the methodological model for those sciences in which, after many regressions, a solid method has finally led to progress. Formal logic is the science to which all other sciences must orientate themselves.

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