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From Leibniz to Kant

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Between Du Châtelet's Leibniz Exegesis and Kant's Early Philosophy: A Study of Their Responses to the *vis viva* Controversy

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Abstract

This paper examines Du Châtelet's and Kant's responses to the famous *vis viva* controversy – Du Châtelet in her *Institutions Physiques* (1742) and Kant in his debut, the *Thoughts on the True Estimation of Living Forces* (1746–49). The *Institutions* was not only a highly influential contribution to the *vis viva* controversy, but also a pioneering attempt to integrate Leibnizian metaphysics and Newtonian physics. The young Kant's evident knowledge of this work has led some to speculate about his indebtedness to her philosophy. My study corrects such speculations as well as misunderstandings of the *Living Forces*. This corrective result has implications for how to investigate Kant's relation to the ever-evolving landscape of Leibniz exegeses.

1. Introduction

My goal in this paper is to clarify the relation between Kant's early philosophy and Émilie Du Châtelet's work. I do so through a focused examination of their responses to the famous *vis viva* controversy – Du Châtelet in her *Institutions Physiques* (1742, second edition) and Kant in his first publication, the *Thoughts on the True Estimation of Living Forces* (1746–49). The fact that Kant repeatedly mentions Du Châtelet in his debut, coupled with recent studies of her as an influential and unique voice in the discourse on natural philosophy during the 1740s, suffices to make us curious.[1] There have indeed been speculations about the early Kant's relation to Du Châtelet, but, as I shall explain shortly, a more grounded study of that relation is in order.

An important part of this study is to understand what Kant might have sought to accomplish with the *Living Forces*, a question that has received competing answers.[2] Particularly controversial is how this work relates to what Martin Schönfeld calls Kant's "precritical project," defined by the ambition to find "a coherent philosophy of nature" and "to integrate Newtonian physics in a comprehensive and speculative framework" (Schönfeld 2000, 3). To Schönfeld, the *Living Forces* was not a bona fide part of this project, even though, as the starting point of Kant's "precritical philosophy," it would

[1] Kant shows a keen interest in Du Châtelet's dispute with Jean de Mairan (GSK 1: 45–46, 55, 67–68, 92–93, 130–133), a well-known episode of the *vis viva* controversy. I discuss the episode in section 3.

[2] See Adickes 1924, 65–144; Cassirer 1981, 26–32; Shell 1996, 10–30; Kuehn 2001, 86–95. I will also mention other commentaries below.

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"cast a long shadow over Kant's subsequent endeavors" and lead to the precritical project as an "indirect consequence" (Schönfeld 2000, 18–19).

> When writing his first book, Kant had not yet experienced the Newtonian conversion that would dominate his thoughts on nature for the rest of his life, and he had not yet given thought to the grand issues of metaphysics that would govern the precritical project. In this regard, the *Living Forces* occupied a position all on its own. (Schönfeld 2000, 18)

To Michael Friedman, by contrast, the *Living Forces* already "initiates a fundamental philosophical reconsideration of Newtonian physics which is then continued throughout the so-called pre-critical period." The purported reconsideration centers on an attempt "to redefine the nature and method of metaphysics in light of the recent breathtaking advances in mathematics and mathematical physics" and, especially, "to revise the Leibnizian-Wolffian monadology in light of Newtonian physics" by, among other things, "import[ing] Newton's second law of motion into the very heart of the monadology" (Friedman 1992, xi, xiii, 5).[3]

However important it may be to clarify the early Kant's relation to Newtonian physics,[4] it seems problematic to make this a key interpretative concern that determines the place of the *Living Forces* in Kant's philosophical development. For one thing, it is the Cartesian, not Newtonian, physics that gets most of the attention in this text. For another, the more basic philosophical issue at play concerns the relation between metaphysics and natural science (physics) in general, regardless of whether one is a committed Newtonian in the latter area.[5] In that connection, we may very well describe Kant's precritical project, as Schönfeld himself does at one point, simply in terms of a "reconciliation of the perspectives of natural science and metaphysics" (Schönfeld 2000, 17).

Du Châtelet's *Institutions* (*Foundations*), as we shall see, represents an unprecedented attempt at such a reconciliation. This fact, together with an observation of "the apparent overlap between topics treated by Du Châtelet and by the early Kant", has led Katherine Brading to ponder about the connection between their philosophical outlooks.

> Kant's first publication (1749) was his contribution to the so--called "*vis viva controversy*", and this same topic occupies the final chapters of Du Châtelet's *Foundations* as part of a public dispute. Kant is explicitly continuing this debate. [...] Reading on, the similarities seem much deeper and more important than this. Schönfeld's (2000, Introduction) description of Kant's precritical project could be a description of what Du Châtelet sets out to do in her *Foundations*. (Brading 2015, 28, n. 33)

While Brading cautiously suggests that "there is much work to be done on the relationship between Du Châtelet's *Foundations of Physics* and Kant's early philosophy" (Brading 2015, 28, n. 33), Ruth Hagengruber confidently asserts that Kant "dedicated" his debut to Du

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[3] There is in fact no clear textual basis for bringing up monadology here. Kant mentions monads just once, while considering whether striving force is "directed toward all regions" or "entirely indeterminate with regard to direction." He prefers the latter view, citing G. E. Hamberger's claim that "the substantial force of monads strives toward motion equally in all directions" (GSK 1: 26). But Kant does not insist that the substance with striving force be a monad.

[4] The early Kant's attitude toward Newtonianism may turn out to be more nuanced than how Schönfeld and Friedman each has portrayed it. See Watkins 2013.

[5] I refer to "natural science," "physics," and later "mechanics" as though they are interchangeable concepts. Their differences are tangential to the purpose of this paper.

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Châtelet's work and even cites Johann A. Eberhard as later accusing him of "copying from her" – an accusation that would presumably be unsurprising at the time, if Du Châtelet's work was indeed treated, "in Germany at least for a certain period," as "part of the canon" on natural philosophy (Hagengruber 2015, 39).

My analysis will reveal little, however, to encourage the thought that Kant's *Living Forces* was indebted to Du Châtelet's work in any philosophically meaningful way. All in all, Kant's debut shows far less philosophical ambition in comparison with the *Institutions*, especially when it comes to reforming Leibnizian metaphysics in light of the advances in physics at the time.

In what follows, I argue for this reading in three steps. I begin, in section 2, by considering the *vis viva* controversy that prompted Kant's *Living Forces*. I present the controversy as a complex affair that implicated all three leading systems of the time, namely Cartesianism, Leibnizianism, and Newtonianism. I do so partly to shed a much-needed new light on the context of Kant's first publication, highlighting the *opportunity* provided thereby for constructing a philosophical framework to integrate the best elements of the systems just mentioned.

In section 3, I study how Du Châtelet seized that opportunity and rendered Leibniz's metaphysics in such a way that it would not only be essentially compatible with Newtonianism but also underscore a most advantageous scientific methodology. My study centers on Du Châtelet's treatment, contra her partner Voltaire's, of the Principle of Sufficient Reason. Working from different interpretations of Leibnizian metaphysics, these two committed Newtonians would arrive at opposite conclusions about its relation to Newtonian physics.

In section 4, I look at Kant's attempt to resolve the *vis viva* controversy, giving special attention to his sundry remarks about (Leibniz's) metaphysics. I then compare his and Du Châtelet's responses to the opportunity of philosophical reform presented by the controversy. The comparison will show that the young Kant's philosophical vision was much narrower than Du Châtelet's.

I then conclude by pointing out the implication of my study for a broader interpretative project in which one examines how Kant's philosophical developments might have interacted with the ever-evolving history of Leibniz exegeses.

2. The *vis viva* controversy and the struggles to make metaphysics (ir)relevant to physics

Kant saw the *vis viva* controversy as one of the greatest disputes that divided European thinkers (GSK 1: 16). Some commentators believe that the controversy virtually ended with Jean d'Alembert's *Traité de Dynamique* (1743). Kant's first publication is therefore under-informed and "bookish" (Polonoff 1973, 6) or, worse still, a "false start" and "thorough embarrassment" partly because "d'Alembert had already published a theory that effectively settled the debate three years before Kant turned his mind to it" (Schönfeld 2000, 18).

From the eighteenth-century point of view, however, d'Alembert's *Traité* did not have the effect of settling the debate in 1743. Leonhard Euler's "De la force de percussion et de sa véritable mesure," published in 1746 after being presented (in Latin) to the

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Berlin Academy in 1744, was just one among many indications that the dispute remained "unresolved and hotly contested" (Laudan 1968, 132; also Hankins 1965 and Iltis 1970). More importantly, by then it had become clear that the controversy was never simply a technical one about how to measure force. Rather, implicated therein were *also* some of the most important and most divisive philosophical issues concerning physics – viz. what must be assumed about bodies (e. g. hardness) in order for certain laws of physics to be applicable, the relation between force and motion, God's role in natural order, and scientific methodology. Debates on this last issue will in turn bring into sharp relief the need to manage the relation between metaphysics and physics and, for Leibniz's followers in particular, to clarify his position on this subject.

My following sketch of certain events pertaining to the *vis viva* controversy is meant to accentuate some of the philosophical issues just mentioned.

Leibniz initiated the controversy in a series of publications on Cartesian mechanics. On the surface, it was about whether the "force" of a body in motion should be measured by mv, as the Cartesians did, or by mv^2. At its root, however, this controversy was not just a mathematical dispute over the correct estimation of force but, as Carolyn Iltis puts it, "a fundamental disagreement as to the very nature of force itself," with Leibniz attacking the Cartesian conception thereof as an "inadequate [...] description of the world" (Iltis 1971, 23, 32). An overview of the relevant texts will show that the disagreement went even deeper, reaching the point where a defender of either the Cartesian or the Leibnizian position would have to take a stance about whether metaphysical considerations are relevant to mechanics.

At the center of Leibniz's polemic against Cartesian mechanics is the law of conservation. The two sides agree on the principle that motive force must be conserved in nature, but disagree over the nature and measurement of this force. While the Cartesians equate it to the quantity of local motion and measure it just like the latter, namely by "the product of the body and its velocity [mv]," Leibniz sees a "big difference" between the two, so that "the one cannot be calculated by the other." The forces that are conserved after the collision of two bodies with equal mass, he argues, "are proportional not to their velocities but [...] to the squares of their velocities." That is, the conserved force in such cases must be mv^2. After providing a mathematical demonstration for this law of conservation and placing it "among the immutable foundations of the science of mechanics," Leibniz adds: the "ultimate reason" for this result is that "motion is not something absolute and real in itself" (PPL 296–297, 299–301).

This remark points to a key difference between the Leibnizian and Cartesian brands of mechanics: they presuppose radically different metaphysical outlooks, especially concerning the nature of body in motion and the laws governing all corporeal motions.

In Descartes's metaphysics, motion has a twofold cause. The primary and "general cause" of all motions is God, who on account of his immutability and by "regular concurrence" conserves their total quantity. Meanwhile, each motion has a motive force, as "the particular cause which produces in an individual piece of matter some motion which it previously lacked" in accordance with the three laws of motion that follow from God's immutability. Conceptually, then, motive force does differ from the motion caused thereby: the transfer of a body from one place to another is "opposed to the force or action which brings about the transfer." Descartes prefers, however, to study motion without considering motive force. When he does talk about the latter, he does so in terms of its

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effect and takes it to consist "simply in the fact that everything tends, so far as it can, to persist in the same state" according to the first law of motion (Descartes 1985, 216; 233; 240; 243).

When Descartes speaks of laws of nature, he limits "nature" to matter, as mere extension, along with its qualities. In his view, the only "clear and distinct notions" we can obtain regarding the relevant corporeal qualities are those of shape, size, and motion, which are modified strictly in accordance with "the principles of geometry and mechanics." In that connection, laws of nature are none other than laws of motion and enjoy the same kind of necessity as geometrical principles do, as they "follow inevitably from the eternal truths on which mathematicians have usually based their most certain and most evident demonstrations [… and] according to which God himself has taught us that he has arranged all things in number, weight and measure" (Descartes 1985, 92; 97; 288).

Leibniz makes a decisive break with this Cartesian view in his "Specimen Dynamicum" (1695), arguing that "in corporeal nature besides the object of geometry, or extension," there is also force. This force is either active or passive, and each of these is in turn either primitive or derivative. Primitive active force, as the "substantial form" or "first entelechy" of bodies, inheres "in all corporeal substance as such." Primitive passive force, constituting the *materia prima* of bodies, represents their endowed capacity to resist penetration and motion. A derivative force is either a "dead force," as mere "solicitation to motion" without actual motion, or a "living force," which is "ordinary force combined with actual motion." It is by these derivative forces that "bodies actually act and are acted upon by each another." They alone are directly connected to determinate motions, in terms of which we must give specific causal explanations of all other material phenomena in accordance with laws of nature (PPL 436–438).

As for primitive forces, though insufficient "to explain the phenomena," they are "necessary […] for philosophizing rightly." Absurd consequences follow, Leibniz contends, if we understand bodies "in mathematical terms only" and strictly in accordance with "the bare laws of motion derived from pure geometry," without any recourse to "metaphysical notions such as active power in form, or of passive power and resistance to motion in matter." To avoid such consequences, we must also consider forces, as something *inherent in bodies*, and the relevant "metaphysical laws." Only then will we have an adequate basis, which goes beyond "logical and geometrical axioms alone," for determining truths about the corporeal nature, including the aforementioned law of conservation (PPL 436, 440–441).

Leibniz takes himself to have thereby found a middle ground between philosophers who invoke an active principle directly to explain natural phenomena and the ones whose view of nature leaves no place for any metaphysical consideration whatsoever. His strategy is to distinguish "immediate and particular efficient causes of natural things" and "the first and most universal efficient cause" (e. g. first entelechy), which pertain to mechanical laws and metaphysical reasons respectively. Although "mechanical laws are themselves to be derived in general from higher [metaphysical] reasons," we must explain all specific corporeal phenomena in purely mechanistic terms (PPL 441).

Now we turn to Newton. Although he did not explicitly reject *vis viva* in his publications, the rejection was widely perceived as implied – hence Du Châtelet's impression that Newton "did not acknowledge *forces vives*, for the name of M. Newton is in itself nearly an objection" (FP 199). With the caveat that there is more in Newton's writings that bears

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on aspects of the *vis viva* controversy – especially on the relationship between forces and motions – than I can delve into here,[6] I shall focus on remarks that are suggestive of his general scientific methodology and view on the relation between metaphysics and physics, so as to pave the way for my later analyses of Voltaire's and Du Châtelet's positions on these subjects.[7]

At the beginning of his *Philosophiae Naturalis Principia Mathematica* (first published in 1687; the third edition [1726; 1999] is used), Newton states: the quantity of motion is the product of quantity of matter and its velocity; by the "inherent force of matter," *vis inertiae*, a body will remain at rest or in uniform motion along a straight line unless a motive force is impressed on it to alter that state; this force is proportional to the motion generated thereby in a given time (Newton 1999, 404–405; 407). But *vis inertiae*, as a merely passive force, can by itself neither bring about any motion nor preserve the same quantity of motion in the world. Newton therefore sees the need to introduce "active principles." He says in the queries to the *Opticks* (first edition in 1704; the fourth edition [1730] is used): "the variety of Motion which we find in the World is always decreasing, [and so] there is a necessity of conserving and recruiting it by active Principles such as are the cause of Gravity" (Newton 1730, 375). While recognizing that "we meet with very little Motion in the World, besides what is owing to these active Principles," Newton claims no knowledge about their causal mechanisms. He might stress one thing, though: they are far from Leibniz's active forces. While the latter belong in Leibniz's metaphysical category of primitive forces, Newton's active principles are part of his physics. He considers these "not as occult Qualities, supposed to result from specific Forms of Things, but as general Laws of Nature, by which the Things themselves are form'd." Their reality is proven not through metaphysical reasoning, but by their "manifest Effects" (Newton 1730, 375–377).

Having nothing more to say about the active principles in question does not bother Newton. In his opinion, it suffices for a universal physics that he has discovered the "impenetrability, mobility, and impetus of bodies, and the laws of motion and the law of gravity" and shown *that* "gravity really exists and acts according to the laws that we have set forth and is sufficient to explain all the motions of the heavenly bodies and of our sea." Following the dictates of "rules for the study of natural philosophy," especially the rule of admitting "no more causes of natural things [...] than are both true and sufficient to explain their phenomena," Newton refrains from feigning hypotheses about the causal grounds of gravitational forces, hypotheses being whatever are "not deduced from the phenomena" (Newton 1999, 794, 943).

As an example of this refrain, while stating that "the small Particles of Bodies [have] certain Powers, Virtues, or Forces, by which they act at a distance [...] upon one another for producing a great Part of the Phænomena of Nature" (this is part of the theory of universal gravitation), Newton professes no insight into how the gravitational forces may be performed – be it "by impulse, or by some other means unknown to me." Accordingly, he resigns himself to using 'attraction' to "signify only in general any Force by which Bodies tend towards one another, whatsoever be the Cause," and studying from natural

[6] For a brief but helpful account of Newton's complicated relation to the *vis viva* controversy, see Smith 2006, 35. On Newton's treatments of forces, see Janiak 2008, 50–86.

[7] For a more extensive and nuanced discussion of Newton's views on the relation between metaphysics and physics, see Janiak 2008, 11–49; 163–78.

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phenomena "what Bodies attract one another, and what are the Laws and Properties of the Attraction" (Newton 1730, 350–351).

Fast forwarding to 1740s, we can see one reason as to why d'Alembert was in no position to end the *vis viva* controversy with his *Traité*. The preface to this treatise suggests a narrow, one-sided interest in mechanics as a (Cartesian) mathematical science, coupled with an eagerness to dodge metaphysical queries altogether. Mechanics owes its certainty to the "simplicity" of its object, he claims, namely "motion and its general properties." If force may be intelligibly considered as one such property, it can only be "the quantity of motion" (*mv*). For we can have "no precise and distinct idea for the word 'force'" except by "restricting this term to express an effect," the effect being motion. Otherwise, the whole question of the measurement of force would come down to "a very futile metaphysical discussion" or, worse still, "a dispute of words (une dispute de mots)." For this reason, d'Alembert circumscribes "motive causes" and considers only the observable phenomena of motion produced thereby. He in fact "proscribe[s] entirely the forces inherent to the body in motion, obscure and metaphysical beings that can only strew darkness over a science clear by itself." While feeling obliged to mention the accounts of motive cause by Leibniz and "a lady illustrious for her genius" (Du Châtelet), d'Alembert is abundantly clear in its "perfect uselessness for mechanics." For mechanics is "more a science of effects than that of causes" (D'Alembert 1743, i, v, xvi–xvii, xix, xxi, xxiii).

D'Alembert's offhand dismissal of metaphysics begs the very question about its relation to physics that was implicated in the *vis viva* controversy from the start. Nor could his oft-cited phrase 'une dispute de mots' serve to simplify the controversy. This phrase, as Andrea Reichenberger has shown, had already been "widely-used" to portray the controversy as a "semantic dispute" without, however, thereby reducing it to "a pointless quibble over semantics." The query about the nature of force or other related metaphysical issues did not and would not go away just because some found it inessential to mechanics. Rather, the protraction of the *vis viva* controversy suggests a need to scrutinize the metaphysics of the three leading natural philosophies of the day – the Cartesian, the Leibnizian, and the Newtonian (Reichenberger 2012, 158–59).[8]

Thus, the *vis viva* controversy left its participants in the 1740s with an excellent opportunity to think deeply and systematically about the philosophical issues implicated therein. Du Châtelet would rise to this occasion as an independent, visionary thinker.

3. Between Leibnizian metaphysics and Newtonian physics: Du Châtelet contra Voltaire

In 1741, an exchange took place between Du Châtelet and Jean de Mairan, then secretary of the Paris Academy. The exchange included De Mairan's response to Du Châtelet's criticism of his anti-Leibnizian arguments about force and her point-by-point rebuttal. Both documents were appended to the 1742 edition of her *Institutions* and its German trans-

[8] Reichenberger also thinks "the common categorization between the Cartesian, Leibnizian and Newtonian school is oversimplified," though, as can be shown from a "deeper look at the [*vis viva*] controversy" (Reichenberger 2012, 160). Part of what would complicate the matter, as she goes on to show, was Du Châtelet's attempt to combine Newtonianism and Leibnizianism.

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lation (1743). Details of Du Châtelet's treatment of the *vis viva* controversy (in the final chapter of the *Institutions*) aside, what intrigues me is Reichenberger's following characterization of her conciliatory approach, she carried out "a reformation of metaphysics as science" to provide the framework for integrating Leibnizian and Newtonian sides of the controversy. More specifically, Du Châtelet's plan was to integrate "Leibniz's *vis viva* theory into Newtonian mechanics" (Reichenberger 2012, 158). I defer to Reichenberger's analysis for how this specific integration works and how a reformed metaphysics is supposed to ensure its feasibility. In what follows, I consider only Du Châtelet's philosophical framework in its broad strokes, insofar as it is to bring Leibnizianism and Newtonianism together.[9]

We saw earlier that Newton had little to say about the cause of attraction besides calling it an "active principle" and inferring its reality from manifest phenomena. What was to him a disciplined refrain from feigning hypotheses about this principle would, however, be viewed by many as a reason to reject his theory of universal gravitation. According to Judith Zinsser, Du Châtelet's *Institutions* was to address this "principal weakness" of Newton's theory in a way that her fellow Newtonians – including Voltaire, who popularized Newtonianism with his *Elémens de la philosophie de Newton* (1741, expanded edition) – had failed to do.[10] That is, it would offer "metaphysical, causal explanations for the phenomenon of attraction, how and why it worked as it did" and do so by "giv[ing] Newtonian mechanics the metaphysical foundations the Englishman had failed to sort out" (Zinsser 2009, 105).

A different picture emerges, however, if we take a closer look at Voltaire's defense of Newton and then read the *Institutions* in that connection. The disagreement between the two Newtonians runs deeper than Zinsser suggested, especially over the following questions. First, how far should we go inquiring about the causal grounds of natural phenomena? Second, how are we to interpret Leibniz's metaphysics and its supposed relevance to physics? Third, more generally speaking, what counts as a proper "metaphysics" for physics and how are we to adjudicate between competing versions thereof?

On Voltaire's part, he defends Newton's system against its Cartesian and Leibnizian critics respectively. He has a ready answer to the Cartesians: we are equally ignorant about the cause of Cartesian impulsion and that of Newtonian attraction. If the latter, as a "universal property" of matter, is dismissed as an "occult quality" in the sense of being a "real principle for which no reason can be given," impulsion fares no better in this regard. Still, there is a sense in which attraction is not occult, i. e. not chimerical: Newton established it "by the most sublime and most exact mathematical demonstrations." All things considered, then, we must be content with his discovery of "this visible attraction for which neither he nor any other philosopher could find the reason" (Voltaire 1741, 185–188).

A Leibnizian would criticize this contentment for violating the Principle of Sufficient Reason (PSR), by which we must "penetrate as far as possible into the heart of the causes." Voltaire responds by denying PSR of its normative claim here. This principle, he contends,

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9 I follow a common narrative in referring to Du Châtelet's plan of merging Leibnizianism and Newtonianism. See Barber 1967, Hutton 2004, and Hagengruber 2012b, which represent varying accounts of Du Châtelet's relations to Leibnizianism and Newtonianism respectively.

10 The 1741 edition of Voltaire's *Elémens* has a newly added part on metaphysics.

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cannot take us as far as it pretends to in our causal inquiries. Monadology is a case in point, which resulted from Leibniz's quest for the sufficient cause of extended beings, a cause that must be other than extension (to avoid circular explanation). Taking Leibniz's view to be that extended beings are literally "composed" of simple monads, Voltaire dismisses it as contradictory and absurd. Can one posit, he asks rhetorically, that "a drop of urine is an infinity of monads and that each of them has ideas, however obscure, of the entire universe"? Leibniz's system is but a product of "sheer imagination," then, in the labyrinth of which one wonders off following the thread of PSR only to "march methodically towards error" (Voltaire 1741, 62–65).

Overall, Voltaire portrays Leibniz and Newton as having opposite *methods* for causal inquiries. Leibniz is said to have followed the dictate of PSR to investigate real causes for such phenomena as bodily motions and mind-body union – but to no avail. What has Leibniz "proved," Voltaire asks, "by all these new efforts?" – That he had "a great genius," for sure. But had he thereby "enlightened" anyone? Newton, by contrast, at least knew "how to doubt" and "hardly ever formed a judgment that was not founded on either mathematical evidence or experience." His method of analysis, by which general conclusions are induced and tested on none other than experiential basis, is the only one appropriate for *us* to reason about objects in nature, while knowledge from first principles pertains strictly to God (Voltaire 1741, 21–25, 45–52; see Newton 1730, 380).

As for Du Châtelet, she sees physics as an edifice that requires collective effort for its sound construction: while some lay the "foundations [...] by means of geometry and observations," others, including her, "survey the plan of the building." Her plan, as is often understood, is to put Newtonian physics on a proper metaphysical footing. Accordingly, she begins the *Institutions* with an exposition of core elements of Leibnizian metaphysics and gives PSR the central place, with which Leibniz is said to have "provided a compass capable of leading us in the moving sands of this science" (FP 123). To counter Voltaire's anti-Leibnizian rhetoric, she must make clear that the metaphysics she is about to expound is not meant to indulge our runaway imagination but rather to guide our intellect in an ongoing quest to penetrate phenomena. She must also explain, or at least indicate, what constitutes a true metaphysics for physics and how to establish it as such.

It is worth adding here that "metaphysics" was a shifty notion in the eighteenth century. On the original Aristotelian account, metaphysics is first philosophy in that it studies the first causes and first principles of things. In Wolff's *Philosophia Prima sive Ontologia* (1736), only ontology or general metaphysics (as opposed to special metaphysics) is first philosophy properly so called. As a science of being qua being, it supplies immutable principles to all other sciences insofar as they are to be treated demonstratively (aka. scientifically).[11] Presumably, Du Châtelet was familiar with that conceptual scheme (she read Wolff's *Ontologia*), and Voltaire would deny the possibility of a general metaphysics while allowing there to be some kind of special metaphysics for physics.

[11] PP, Prœfatio; Prolegomena, §§ 1–9. See Lu-Adler 2018 for a relevant account of Wolff's – as well as Kant's – relation to "ontology," a seventeenth-century invention. Wolff's special metaphysics includes cosmology, psychology, and natural theology. I will not use 'special metaphysics' in Wolff's limited sense, though. Rather, as it will become clear shortly, I am using this term in the loose sense of a metaphysics for a special domain of inquiry.

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To be specific, Voltaire's intention in the metaphysics part of the *Elémens* is to compare Newton's metaphysics with Leibniz's and show that the former alone is valid (Voltaire 1741, 73). This comparison presupposes that physics has its own metaphysics, although there may be good and bad versions thereof. This presupposition would eventually find its articulation in the popular *Encyclopédie* edited by d'Alembert and Denis Diderot. In the unassigned entry "Métaphysique," metaphysis is identified as "the science of the reasons of things." In this sense, "everything has a metaphysics" or, to borrow the terminology just introduced, there is a special metaphysics for any given science. There is no acknowledgement of general metaphysics, though, which would have to abstract from differences among various domains of inquiries and study being qua being. In fact, a metaphysics is "despicable" if it consists in "empty and abstract considerations about time, space, matter, and spirit." It is altogether different, however, if considered "from its true point of view" (D'Alembert & Diderot 1765, 440). What this true point of view may be, the entry does not say. Presumably, what differentiates a good or true metaphysics from a bad or false one is not so much whether it treats subjects like space and time as *how* it treats them. Voltaire's comparison of Descartes and Newton helps to illustrate this point: while the two share an account of "the first principles of matter" according to which there is an indifferent and uniform primary matter, Newton arrived at this system *in a different way* than Descartes did – not from abstract metaphysical principles, but on strictly mathematical and experiential grounds (Voltaire 1741, 50–51).

Notably, the first chapter of Du Châtelet's *Institutions* is on principles. Insofar as every science, being an interconnected system of knowledge, has "first principles" on which other truths depend, she argues, it is important to be "attentive to principles, and the manner in which truths result from them" (FP 124–125). It is not obvious what is meant by 'principle' here. As a then-standard practice, one could use this term to signify both things and propositions. For instance, by Kirsten Walsh's analysis, the foundational principles of Newton's system include both "ontic-principles," which are "powers, forces, or dispositions that function as causes of phenomena" and are "foundational" due to this causal primacy, and "propositional-principles," which are foundational as premises for the demonstration of other propositions (Walsh 2017, 196, 200). Voltaire's reference to "the first principles of matter" was to ontic-principles. Du Châtelet also seems to have such principles in mind when, in a later chapter on the elements of matter, she talks about "the first principles of things" and refers to force as a principle of action (FP 168, 173).

But the absolutely first principles – first not just relative to a specific science – introduced in chapter one of the *Institutions* seem to be neither ontic nor propositional in Walsh's sense. They have three related characteristics. First, they are principles of human cognition (connaissance), as the title of the chapter suggests. Second, they are "self-evident." Third, they are universal, in that we all "naturally follow" them in reasoning. There are two such principles: the principle of contradiction as the principle of all necessary truths, and PSR as that of all contingent truths. While geometry depends only on the former, natural sciences depend on PSR. Certain principles about nature follow from PSR. One is the principle of indiscernibles, which in turn "banishes from the universe all similar matter." (Recall Voltaire's claim about primary matter being uniform.) The other is the principle of continuity, which is "one of the most fruitful in physics" as in, for example, theorizing about optical phenomena, discovering and demonstrating "true laws

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of motion," and determining whether there are perfectly hard bodies in nature (FP 124, 128–138).

These foundational principles are unmistakably Leibnizian. Unlike Voltaire, Du Châtelet does not treat their application to physics as a matter of reasoning from first principles. They do not figure as premises in deductive inferences about natural phenomena. Rather, they seem to serve the following functions. First, they provide standards for determining a special metaphysics for physics, which treats ontic-principles that are specific to physics, such as those of body and motion. (Du Châtelet's remark about the principle of indiscernibles suggested this function.) Second, they limit what kind of hypotheses we can seriously entertain about possible causes of certain phenomena before subjecting them to experimental tests. Third, they (especially PSR) determine the boundaries of physics as a causal-explanatory science of natural phenomena. I shall briefly explain the last two, again by way of contrasting Du Châtelet's approach with Voltaire's.

In Voltaire's view, the only knowable cause of gravitation is God. Even then, we can only say *that* He is the cause, not how He has made gravitation work or why it works in such and such ways. For God created the universe and directs its course with "absolute liberty" and no particular reason. If one protests that "we must not resort to God in philosophy," this principle is valid, Voltaire claims, only with respect to "things that must be explained by proximate physical causes" (Voltaire 1741, 6–7, 134; also 21–25).

Du Châtelet disagrees. To her, physics is an unceasing human effort to gain an ever deeper understanding of nature. We are still in this science, she notes, "like this man blind from birth whose sight Chiselden restored." The time may "never come entirely" that we see things with clarity, for "there are probably some truths not made to be perceived by the eyes of our mind." But this limitation cannot and should not stop us from always trying to learn more and penetrate further. If physics is, as it were, "made for man" as a science that "turns upon the things that constantly surround us," the human mind – with PSR as a natural principle by which we inquire about contingent matters – will not rest content until it finds a cause that contains "the sufficient reason for" the phenomena, namely the reason that "makes it possible for an intelligent being to understand why" they are the way they are (FP 116, 120, 131).

More often than not, the requisite causal explanation can neither be straightforwardly induced from the empirical data at hand nor be deduced from already ascertained principles. The proper course to take is not to halt the inquiry by citing, as Voltaire did, our inability to be thoroughly certain about the true causes of natural phenomena. Rather, "one is obliged to be content with probable reasons to explain them." That is, one must "frame hypotheses to explain the phenomena, the cause of which cannot be discovered either by experiment or by demonstration." Hypotheses are essential to scientific progress in such cases. We just have to use them well, by making sure to develop our hypotheses in a methodical manner, so that they are (i) in line with PSR and other foundational principles identified so far, (ii) adequately informed by the relevant facts that we already know and by an analysis of the *explanandum*, and (iii) amenable to experimental tests, by which we can determine their degrees of probability (FP 147–149, 151).

This account of scientific methodology gives a new significance to Newton's refrain from speculating about the cause of gravitation. While Voltaire took it to suggest that, in principle, physics can only go so far in its causal inquiries, Du Châtelet has a different lesson to draw. To her, physics is a process of human endeavor that neither begins nor

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ends with Newton. If he made important discoveries about gravitation based on the path-breaking work done by his predecessors (especially in astronomy), ensuing generations of researchers must pick up where he left off. For everyone involved, successful discoveries come only from the audacity to conduct difficult inquiries with informed hypotheses, even if at times, when compelled by experimental evidence, one may have to abandon them and start all over again. For, in "seek[ing] the reason for [a phenomenon] by means of hypotheses, [...] the efforts made to find the truth are always glorious, even though they might be fruitless" (FP 152). In these terms, although there is no guarantee that we will ever identify the true cause of Newtonian attraction, we must still look for the most probable candidate through rigorous applications of the method of hypothesis.

Here we have a case of how to make a principle of Leibniz's metaphysics, PSR, pertinent to physics without affecting its status as a system of purely physical explanations (that is, no general-metaphysical principles play any direct explanatory role therein). Du Châtelet's rendering of the principle may be seen as part of a considered apology for Leibniz's metaphysics. Having situated it in the polemic context defined by Voltaire's anti-Leibnizian rhetoric, I am skeptical about an old portrait that attributes her integration of Leibnizianism and Newtonianism partly to her being "less critical and more easily attracted [than Voltaire was] by speculative theorising." Nor does it seem fair to treat her *Institutions* as just another example of "the difficulty [...] of establishing [within the context of eighteenth-century rationalism] any clear frontier between scientific knowledge and philosophical speculation" (Barber 1967, 209, 222). She in fact problematized, to say the least, the assumption that "philosophical speculation" – often an unflattering reference to metaphysical consideration – was so irrelevant to scientific inquiries that one must break free from it while pursuing scientific knowledge. On her reading, a Leibnizian principle like PSR points to a fundamental *feature of human reason*. This principle drives scientific progress, as it naturally propels us to seek sufficient-causal explanations of phenomena and do so indefinitely (since we can never be sure about having reached the end). Du Châtelet's concern was only to rein in undisciplined exercises of this natural tendency by a proper method of hypothesis, which requires that the causal-explanatory inquiries proceed in lockstep with suitably designed experiments.

By this analysis, Du Châtelet's Leibniz exegesis partially resembles the mature Kant's self-proclaimed "true apology" for Leibniz's metaphysics, according to which PSR is not a principle "construed objectively (as a natural law)," but "a merely subjective one, having reference only to a critique of reason" (ÜE [1790], 8: 247–248, 250).[12] This resemblance, besides the fact that the early Kant evidently took interest in the *Institutions*, makes one wonder whether his philosophical outlook was somewhat inspired by Du Châtelet's. We shall have a rough answer to this question after an overview of Kant's remarks about (Leibniz's) metaphysics in his first publication.

[12] Kant characterizes PSR as one of the "three peculiarities" of Leibniz's metaphysics, the other two being Monadology and the doctrine of pre-established harmony (ÜE 8: 247).

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4. Kant's treatment of (Leibniz's) metaphysics in the *Living Forces*

Kant's *Living Forces* exhibits a conciliatory, independent-minded posture similar to Du Châtelet's. In the name of "the freedom of human understanding," he ventures "to think nothing of the reputation of a Newton and a Leibniz, if it should oppose the discovery of truth, and to obey no persuasions other than the force of the understanding." He portrays the *vis viva* controversy as an internal conflict of human reason "embodied differently in astute men." To resolve it is then to "reconcile reason with itself [...] and to find the truth, which is never wholly missed by reason's thoroughness (Gründlichkeit)" and requires only "a little absence of partisanship, and a brief balance of one's intellectual inclinations" (GSK 1: 7–8, 149, 181).

This attitude shapes how Kant deals with Leibniz's metaphysics in the three-chapter treatise. In chapter one (GSK §§ 1–19), Kant indicates his support for the core tenets of the Leibnizian doctrine of living forces – that they are real, conserved in a physically interacting world, and measured by mv^2 – and the basic metaphysical framework presupposed thereby. But he also finds it necessary to modify the doctrine to make it "certain and definitive." To this end, he begins by clarifying the "metaphysical concepts" of force. He takes there to be an active force as such (*vim activam* überhaupt), an essential metaphysical force that inheres in a body and is the origin of all its motions (GSK 1: 17–19).[13] He then divides all corporeal motions into two kinds. The first, "free" motion, "has the property of conserving itself in the body to which it is communicated, and of persisting infinitely if no impediment opposes it." The force expressed therein must then be a living force, as "an internal source of an intrinsically imperishable force that performs its action over time." The second kind of motion requires only an external, dead force and "disappears as soon as this force ceases to sustain it." This distinction differs from the original Leibnizian one: while the latter was cast in terms of whether motion is actualized (see section 2 above), Kant views the absence or involvement of actual motion as inessential and intends his new distinction to serve for his "main purpose of improving on the Leibnizian measure of force" (GSK 1: 28–30; see 1: 33–39).

Kant ends chapter one by noting that "our metaphysics is [...] only on the threshold of a properly founded cognition (Erkenntniß)" and that a "merely metaphysical" contemplation cannot promise anything decisive or irrefutable. So, he decides to take a lengthy mathematical excursion in chapter two (GSK §§ 20–113) to examine the representative proofs that the Leibnizians so far have constructed for the doctrine of living force. This examination, Kant hopes, "may perhaps, through the application of mathematics, have more claim to persuasion" (1: 30, modified translation).

Kant thereby signals a degree of sensitivity to the kind of anti-metaphysics sentiment that we saw earlier in d'Alembert's disparaging reference to "futile metaphysical" considerations about force. As Kant subsequently puts it, the 'Naturlehrer' of the day could reject a view simply for having a "metaphysical" basis (GSK 1: 61). Accordingly, while deeming it "evident that the very first sources of nature's operations definitely have to be

[13] I translate "überhaupt" as "as such" to reflect Leibniz's conception of active force as "force in the absolute sense," a primitive power that "endures in each and every corporeal substance." A derivative force is an alterable modification of the primitive one (PE 252, 254). Kant follows Leibniz in treating active force as metaphysically prior to living force.

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a subject of metaphysics," he stands ready to offer "a method to please those who mistrust anything that has even the appearance of metaphysics and who consistently insist on experience as the ground of conclusions." That is, he seeks to demonstrate the reality of living forces and its correct estimation from experiments and observations and do so "with mathematical precision" (GSK 1: 150; see 1: 176–179).

The application of a proper method is key to Kant's search for an "intermediate position which concedes that both parties [the Cartesians and the Leibnizians] are to some extent right" (GSK 1: 32). This method promises to resolve the *vis viva* controversy by revealing so-far-hidden errors on both sides:

> [it] allows one to decide in each case, by a general consideration of the principles on which a certain opinion is built and by a comparison of this opinion with the implications drawn from those principles, whether the nature of the premises really contains everything that the doctrines that are drawn as conclusions require. (GSK 1: 93)

In short, by this method Kant is to investigate whether the principles / premises of a proof are "sufficient and complete for the conclusion" that it is constructed to establish (GSK 1: 97).[14]

Kant's investigation reveals to him that the Cartesians and Leibnizians presupposed different conceptions in proving their respective theories about how to estimate force. Explicating those conceptions and their implications is Kant's focus in chapter three (GSK §§ 114–163). He drives a wedge between mathematics and nature, which allows him to expel living forces from mathematics only to admit them into nature and to show that, while mv is the only true measurement of force in mathematics, mv^2 alone is true of force in nature. The possibility of this resolution comes from a distinction between mathematical and natural bodies:

> mathematics defines its concept of body by means of *Axiomatum*, requiring of them that they be presupposed in its body, even though they actually prohibit and exclude certain properties from it, properties that are still necessarily found in bodies in nature; hence a body in mathematics is a thing utterly distinct from a body in nature, and something can therefore be true of the latter that still does not belong to the former. (GSK 1: 139–140)

Force is the differentiating property: while "mathematics admits force in the body only insofar as force was caused in it from the outside," namely a dead force (mv), a body in nature has "an altogether different constitution." This body has a living force, whereby it "bases its motion sufficiently on itself" and "will, on its own, preserve the motion that it has, freely, permanently, undiminished, and to infinity." This force cannot be produced by an external cause but must "acquire determinations pertaining to the measure by the square from the inner source of the body's natural force." That is, it must be mv^2 (GSK 1: 140, 143–145).

Finally, just as Kant began chapter one with a measured endorsement of Leibniz's metaphysics of nature, so does he conclude chapter three with an expression of indebtedness to Leibniz's groundbreaking work in this area. "I could have done nothing," he professes, "without the guiding thread of the splendid law of continuity, [...] which was

[14] It is unclear whether this method is of the same kind as the one I mentioned in the preceding paragraph. Commentators have given radically different assessments of the significance of Kant's references to "method" in the *Living Forces* (see Cassirer 1981, 27–28; Polonoff 1973, 60).

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the only tool for finding the exit from this labyrinth" (GSK 1: 181). There is no room here to examine how the law of continuity might have helped Kant to find his way through the *vis viva* controversy (see 1: 37, 105, 145–146, 155–156, 166), to assess the quality of his mathematical arguments,[15] to see whether he has actually succeeded to resolve the controversy (most historians would say no), or to determine the degree of his adherence to Leibniz's metaphysics (see Schönfeld 2000, 41–42).

Now I return to the question about Kant's connection to Du Châtelet. Notably, in the *Living Forces*, the only one of Kant's pre-critical publications that contains references to Du Châtelet's work, she figures primarily as a mathematical scientist taking Leibniz's side of the *vis viva* debate. How Kant views the rest of her *Institutions* is hard to tell. If I was right to observe, at the end of section 3, a certain resemblance between Du Châtelet's treatment of PSR and how Kant would interpret it several decades later, the Kant of the 1740s seems to have little to offer on this subject. And, while he shares her view that the principle of continuity is one of the most consequential Leibnizian-metaphysical principles for physics, he takes its legitimacy for granted in a way that she did not. More generally, although he is obviously aware of the anti-metaphysics tendency among the *Naturlehrer*, he is far less responsive than Du Châtelet was to the need to provide a systematic apology for Leibniz's metaphysics or at least to clarify its relation to physics.

Meanwhile, as what Hartmut Hecht claims to be an "established fact," Du Châtelet – besides her mentor Pierre de Maupertuis and occasional correspondent Euler – played an instrumental role in the early developments of the exegetical approach examined in this paper, namely that of interpreting Leibniz's philosophy "from a natural science point of view."[16] This approach supposedly originated in the French-speaking parts of Europe before Du Châtelet et al. introduced it to German academic circles in the 1740s. Moreover, her *Institutions* has a pioneering feature not shared by her peers' work: if Maupertuis and Euler were primarily concerned with specific "aspects of natural science," she sought for "a systematic philosophy" to underscore the best scientific practices of the day (Hecht 2012, 61–62).

Here, then, we see a most remarkable difference between Du Châtelet's and the early Kant's responses to the *vis viva* controversy. In section 2, I presented the controversy as an intricate philosophical affair that, from the start, involved not only specific metaphysical issues, such as the nature of body qua the subject matter of physics, but also the very relation between metaphysics and physics. As such, it presented later participants with an exceptional philosophical opportunity. If Du Châtelet used the occasion to transform Leibniz's metaphysical system – or, perhaps more aptly, to uncover its true meaning – and thereby accommodate it to the best physics of the day, the younger Kant (born in 1724) was preoccupied with the technical aspects of the controversy. In this regard,

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[15] By one verdict, the *Living Forces* "consists for the most part an excruciating enumeration of flawed objections to flawed arguments" (Schönfeld 2000, 20, with textual analysis at 36–55).

[16] Euler's contribution in this regard was a 20-page pamphlet, *Gedancken von den Elementen der Cörper* (1746), which by all accounts quickly proved to be "a volley in a metaphysical battle that Euler had much to do with initiating" (Wilson 1992, 410). It propelled intense debates not only over monadology, furthering the Voltaire-style objection that I mentioned in section 3, but also over the larger issue of how to interpret Leibniz's metaphysics and its relation to physics (see Clark 1999, 438–444; Broman 2012). Kant's *Physical Monadology* (1756) is typically understood as a response to the challenges raised in Euler's pamphlet. If so, Kant's response was almost a decade late – another case in point for what I am about to say at the end of this paper.

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his approach was more like Maupertuis's and Euler's. The remarks about (Leibniz's) metaphysics found here and there in the *Living Forces*, as I sampled them above, were still a far cry from the systematic reflections on its meaning and validity that would define his mature philosophy.

So, in all likelihood, neither Du Châtelet's innovative Leibniz exegesis nor her broader project of merging Leibnizian metaphysics and Newtonian physics got Kant's attention in his earliest endeavor. If he was indeed aware of certain Naturlehrer's hostility toward the Leibnizian-style metaphysics, we saw him mostly playing along, despite his belief otherwise. Although the opportunity was present, he was far from ready to initiate the grand project of redefining Leibnizian metaphysics in light of Newtonian physics that Friedman attributed to him, a description that indeed better captures Du Châtelet's *Institutions*.

5. Conclusion

My focus in this paper was to study how Kant's first publication related to and compared with the Leibniz exegeses in its background, especially the unparalleled version submitted by Du Châtelet.

I began by looking at the *vis viva* controversy behind Kant's debut. It was a protracted historical event that involved many important philosophical subjects on top of complicated issues of mechanics. By 1740s, any serious participant in the controversy would be confronted with not only the relevant mathematical and mechanical problems but also certain issues fundamental to a modern philosophy of science, such as what makes a proper scientific methodology and how to manage the relation between metaphysics and physics. Partly for this reason, the controversy was still live when Kant entered the fray. It presented him with an opportunity to confront the fundamental issues just mentioned and do so in a systematic manner.

In section 3, I took my cue from Reichenberger that Du Châtelet answered the said opportunity with a philosophical framework to bring together Leibnizianism and Newtonianism. I focused on how she made Leibnizian-metaphysical principles foundational to physics. I examined her treatment of PSR in particular, positioning it vis-à-vis Voltaire's arguments that pitted Leibnizian and Newtonian approaches to physics against each other.

In section 4, I overviewed Kant's attempt to resolve the *vis viva* controversy. I gave special attention to his treatment of (Leibniz's) metaphysics, which I then compared with Du Châtelet's. In the final analysis, what Kant had to offer fell far short of her revolutionary initiative to reconcile Leibnizian metaphysics and Newtonian physics.

In this way, I hope to have cleared out an interpretative space that sits between those who have read too much into Kant's debut and those who have thought too little of it or basically ignored it. One take-away of my study is that Kant, who strived to be an independent thinker from the very start of his career, had to take in the evolving landscape of Leibniz exegeses on his own terms. If I was correct in suggesting that he did not materialize the opportunity provided by the *vis viva* controversy to develop a systematic-philosophical framework as Du Châtelet did, it was less a failure or lack of sophistication on his part than an indication that his early self was preoccupied with specific issues

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within natural science. To a greater or lesser extent, the same may be said of Kant's numerous publications on natural science throughout the 1750s and in much of the 1760s. Although he would insert suggestive philosophical reflections here and there in specialized treatises, he would not thereby disclose any resolution to construct a comprehensive philosophical system – with, say, a reformed Leibnizian metaphysics at its foundation and a thought-out account of scientific methodology – to go with Newtonian physics.[17] This kind of construction would be a later development, during the decade or so leading to the publication of the *Critique of Pure Reason* (1781), which Kant would eventually tout as "the true apology for Leibniz" in a polemic with Eberhard, a self-branded Leibnizian (ÜE 8: 250). Only then, having made his so-called critical turn, would he consider how his approach to metaphysics compared with trending Leibniz exegeses at the time and declare his own as the truly faithful one. Further explication of this interpretative hypothesis is the subject of another paper.[18]

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[17] For a comprehensive and highly informative study that bears on this subject, see Laywine 1993.

[18] I thank Katherine Dunlop and an anonymous referee for their helpful comments on the first version of this paper. Whatever infelicities may remain in this revised version are solely mine.

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