CONCEPT CONSTRUCTION IN KANT'S *METAPHYSICAL FOUNDATIONS OF NATURAL SCIENCE*

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ABSTRACT

Kant's reasoning in his special metaphysics of nature is often opaque, and the character of his a priori foundation for Newtonian science is the subject of some controversy. Recent literature on the *Metaphysical Foundations of Natural Science* has fallen well short of consensus on the aims and reasoning in the work. Various of the doctrines and even the character of the reasoning in the *Metaphysical Foundations* have been taken to present insuperable obstacles to accepting Kant's claim to ground Newtonian science. Gordon Brittan and Gerd Buchdahl, amongst others, have argued that Kant's stated aims in this case are not to be taken at face value, and that prior ontological commitments play a hidden but central role in Kant's special metaphysics.

Michael Friedman (1992) has shown how Kant's stated aims can be taken seriously with his ingenious reconstruction of the *Metaphysical Foundations* as a demonstration of the a priori basis for our thinking bodies to be in true motion and in absolute space. However, Friedman does not address the issue of matter theory -- despite the importance of the issue to Kant. I argue that a strict reading of both the stated aims and doctrines of the *Metaphysical Foundations* is possible, since much of Kant's reasoning about the empirical concept of matter can be explained by his views on how the construction of empirical concepts is possible.

Kant's quasi-mathematical constructions are pivotal in Friedman's interpretation. Constructibility is Kant's criterion of acceptability for the concepts of natural science. Yet Kant notoriously fails to construct the dynamical concept of matter, and accepts this failure with an equally notorious complacency. I argue that Kant's criteria of empirical concept construction, apart from any prior ontological commitments, are enough to generate his views on matter. Kant's failure to construct the requisite concept of matter can be ascribed to a missing law of nature, a law of the relation of forces the discovery of which Kant thought imminent. I conclude that matter theory *is* central to the *Metaphysical Foundations*, but that this does not undermine Kant's stated aim of giving the a priori ground of Newtonian science.

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Chapter 1

Introduction

Kant's reasoning in his special metaphysics of nature is often opaque, and the character of his a priori foundation for Newtonian science is the subject of some controversy. Recent literature on the *Metaphysical Foundations of Natural Science* has fallen well short of a consensus on the aims and the reasoning behind the work. Kant claims that his "special metaphysics" constitutes both an a priori grounding for Newtonian physics, and a case *in concreto* for the critical philosophy. Some have charged that the character of the reasoning which is to produce both (or either) results actually serves to make the achievement of one or the other of Kant's stated aims unachievable. I argue that a proper understanding of Kant's reasoning in the *Metaphysical Foundations*, and in particular an emphasis on the role of concept construction, allows us to read the work as a sincere attempt by Kant to carry out his stated aims.

Michael Friedman's ingenious reconstruction of the *Metaphysical Foundations* as a demonstration of the a priori basis for our thinking bodies to be in true motion and in absolute space is a key inspiration for this dissertation. Pivotal in Friedman's interpretation is his emphasis on Kant's quasi-mathematical constructions in the *Metaphysical Foundations*. Constructibility is Kant's criterion of acceptability for the laws of natural science. While many have allowed that this is the role of constructibility, few have dealt with construction in so subtle and productive a way as has Friedman. Others have felt that the criterion was not rigorously applied by Kant, and have therefore tended to take the talk about constructions with a grain of salt. As a result, my dissertation goes into the role of mathematical

construction in more detail than has been common. Notable amongst those who do emphasize construction are Michael Friedman and Gordon Brittan. However Brittan sees the criterion of constructibility as leading to serious internal inconsistencies in the *Metaphysical Foundations*, in particular with respect to Kant's views on matter theory. I argue that the apparent inconsistencies Brittan detects *are* merely apparent, the result of Brittan's own faulty conception of Kant's constructions.

Friedman dismisses the issue of matter theory as a central concern of the *Metaphysical Foundations* -- despite the considerable portion of the work explicitly devoted to the issue. Kant notoriously fails to construct the dynamical concept of matter, and seems to accept this failure with an equally notorious complacency; it is perhaps this complacency on Kant's part that Friedman takes to absolve him from addressing the issue of matter theory. Friedman is correct in his emphasis on and depiction of construction, so far as he goes. But I argue that much of Kant's reasoning about the empirical concept of matter can be explained by his views on how the construction of its mathematical features is possible. The point is to show that Kant's criteria of concept construction, quite apart from any prior ontological commitments, are enough to generate his unusual views on matter. Considered in this way, Kant's failure to construct the requisite concept of matter is ascribed to a missing law of nature -- and his assurance the result of his anticipation of the imminent discovery of -- a law of the relation of forces. I conclude that matter theory is central to the *Metaphysical Foundations*, but that this does not undermine his stated aim of giving the a priori ground of Newtonian science.

I believe it is nearly impossible to write on some one aspect of Kant's critical philosophy in isolation, in such a way that there are no ramifications for the interpretation of other aspects of Kant's writings. This work is certainly no exception. Consider the relation between concept formation and laws of nature (the concept-law axis) which I delineate in the second and third chapters. My analysis of the concept-law axis in Kant's philosophy hinges on its foundation in the so called highest principle of understanding voiced in the first *Critique*, namely, that the principles of understanding follow given the satisfaction of the conditions of

schematism. The purpose of invoking the relation between concepts and laws in this work has to do with the proper understanding of Kant's treatment of the concept of matter in the *Metaphysical Foundations*. But Chapter 3 shows that this relation sheds light on Kant's moral philosophy as well, in particular the "law of nature" formulation of the categorical imperative.

As for the philosophy of physics: most commentators have seen matter theory as a central issue in the *Metaphysical Foundations*. Friedman's reading is distinctive in that he downplays the importance of matter theory. While I find much to agree with in Friedman's interpretation of the *Metaphysical Foundations*, on the issue of matter theory, I part company with him. By more or less ignoring the issue, Friedman avoids what most commentators see as an especially problematic aspect of Kant's philosophy of physics, one that is rendered even more troubling by Kant's admission of failure to construct the dynamical concept of matter, which he deems on other grounds to be the only metaphysically acceptable one.

Gordon Brittan seems to believe that Kant's espousal of a dynamical concept of matter undercuts a reading of the *Metaphysical Foundations* as an attempt at grounding Newtonian science. On Brittan's reading of Kant's notion of concept construction, it turns out that the "Newtonian", atomistic concept of matter is perfectly well constructible, while Kant is forced to admit that the dynamical concept of matter is not: given his continued attachment to the dynamical concept, how could anyone seriously read Kant as a Newtonian? In Chapter 4, I make some effort at displaying the defects in Brittan's understanding of concept construction. Chapter 4 also includes extensive criticism of Buchdahl's reading of the *Metaphysical Foundations*, which has Kant setting aside failure of the Understanding (i.e. of construction) by appeal to laws dictated by Reason. In effect, Buchdahl's reads Kant as giving construction a rather limited role. To my mind, such a reading gives the *Metaphysical Foundations* too much the flavour of dogmatic metaphysics rather than critical philosophy; I believe such a result can be avoided by emphasising the central role of construction and the Understanding in the *Metaphysical Foundations*.

To sum up, I argue that Kant's failure to construct the concept of matter need not be seen as casting either the central role of construction or the goal of a foundation for Newtonian science in doubt. Kant saw the failure in construction as a purely technical problem to be overcome "by a cleverer hand". Of course, reading the *Metaphysical Foundations* in this way leads to some problems that I have only begun to attempt to resolve, for example in my discussions of symbolic constructions and the gap problem in Chapter 2. However, my result is a gain in that it entitles us to read the *Metaphysical Foundations* in a reasonably straightforward way as (1) emphasizing matter theory, as it has seemed obvious it does to most readers, and (2) as an effort at a critical foundation for Newtonian science.

The rest of Chapter 1 places the *Metaphysical Foundations* in the critical corpus, describes the goals Kant sets himself in greater detail, and sets out some of the principles that have guided my interpretation of Kant's special metaphysics.

(i) Physics and Metaphysics

What is a metaphysical foundation for natural science? The many explicit references to Newton, and the fact that it is largely dedicated to consideration of Newton's laws of motion, make it clear that Kant's *Metaphysical Foundations of Natural Science* (1786) aims to provide a metaphysical foundation for Newtonian science. This leaves two questions: In what sense does Newtonian science stand in need of a metaphysical foundation?; and, In what would such a foundation consist?

From his first writings, Kant expressed an enduring enthusiasm for Newtonian natural philosophy. Indeed, before 1760 Kant published mostly scientific rather than philosophical works. But it was never the case that Newtonian science was his only love; he admits that it was also his destiny to fall in love with metaphysics (Manolesco 1969: 90). Over the course of his career, the line Kant drew between the proper spheres of natural philosophy and metaphysics may have wavered, but there was never any doubt that each had its role to play,

and that these could be reconciled. This theme, emphasised by Robert Butts (1984) and traced to Leibniz, is persistent in Kant's philosophy.

While the metaphysics in which he was schooled belonged squarely in the Leibnizean-Wolffian tradition, Kant remarked in his very first published work that he was dissatisfied with the state of that metaphysics. In *Thoughts on the True Estimation of Living Forces* (1747) Kant cites conflict between physical and metaphysical modes of thought, and suggests that it is metaphysics that is in trouble. His diagnosis of the problem -- foreshadowing another recurring theme in his philosophy -- is that metaphysics was striving to expand knowledge, when it should have concerned itself with laying foundations.

That physics stands in need of such a foundation is an opinion we find expressed as follows in the *Physical Monadology* of 1756:

> Clear-headed philosophers have unanimously agreed that those who seriously undertake to investigate nature should be on guard lest anything made with a certain freedom of conjecture and without reason should find its way into natural science, and lest anything be undertaken in it without the support of experience and without geometrical interpretation. Certainly nothing can be thought more useful to philosophy, and sounder, than this counsel. Since hardly any mortal can steadily advance along the straight line of truth without here and there turning aside in one direction or another, those who have to a great extent obeyed this law in searching out the truth have little dared to commit themselves to the deep sea but have considered it better to remain close to the shore, and to admit nothing except what becomes directly known by the testimony of the senses. Setting out on this sound way, we can exhibit the laws of nature but not the origin and causes of these laws. Those who hunt out the phenomena of nature in this manner are to that extent far removed from the recondite understanding of the primary causes; nor will they attain a science of natural bodies any more than those who persuade themselves that by ascending to the summits of higher and higher mountains, they are at last about to touch the heavens with their hands.
>
> Therefore what many say can be properly absent from physics is in fact its only support; it is metaphysics that brings light. [*Physical Monadology*, 475]

At this stage, Kant's ambitions for metaphysics appear to be quite high: metaphysics is to give understanding of the "origins and causes" of laws of nature, and to provide a "science of natural bodies".

But Kant grew increasingly dissatisfied with traditional metaphysics: In 1762 he wrote that "a metaphysics has never been written" [II, 283]. In 1766, he went on to pronounce a

purely epistemological conception of metaphysics [X, 69-73].1 Eventually, there is a final break with traditional metaphysics in the critical philosophy.

In the *Critique of Pure Reason*, Kant presents a radical reconception of the methods and content of metaphysics; so radical that it evoked for Kant the imagery of an about-face, of a so-called "Copernican revolution". Butts' outlines this reversal, as well as its import:

> Metaphysicians used to delude themselves that they could tell us what is worth seeking to know by telling us first what is. After Kant, epistemologists and methodologists tell us what is is a consequence of what is worth seeking to know. Thus the norms of knowing define the norms of being. Ontology follows epistemology. (Butts 1984: 14)

For the critically awakened Kant, metaphysical explanation no longer aims to capture the basically real features of the universe through reason alone, but rather becomes a set of demands of reason in its effort to regulate human inquiry.

After the critical turn, the nature of the project of providing a metaphysical foundation for Newtonian science alters, but the project does not disappear. No longer is it the role of metaphysics to fulfil the task Leibniz set out for it, that of exhibiting the original causes and forces underlying the phenomena of natural science. Kant's recognition of the force of Hume's critique of the basic metaphysical concepts reinforced for him the impossibility of attempting the Leibnizean task without a prior critique of the grounds of the possible extent of human knowledge. Hume asked: "By what right does [reason] think anything could be so constituted that if that thing be posited, something else must necessarily be posited [?]":

> He demonstrated irrefutably that it was perfectly impossible for reason to think a priori and by means of concepts such a combination [e.g., of cause and effect], for it implies necessity. We cannot at all see why, in consequence of the existence of one thing, another must necessarily exist or how the concept of such a combination can arise a priori. Hence he inferred that reason was altogether deluded with reference to this concept, which she erroneously considered as one of her own children, whereas in reality it was nothing but a bastard of imagination, impregnated by experience... [IV, 257]

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1 Letter to Mendelssohn, April 8, 1766 (Zweig 1967: 55).

Kant saw Hume's critique as not only undermining the old procedure in metaphysics, but also as a threat to natural science, rendering it not only empirical, but no better than fiction and fantasy.

Kant "tried whether Hume's objection [to causation] could not be put into a general form, and soon found out that the concept of connection of cause and effect was by no means the only concept by which the understanding thinks the connection of things a priori, but rather that metaphysics consists altogether of such concepts" [IV, 260]. Kant's response to the problem Hume had raised and he himself had generalized began with the identification of the relevant concepts -- "I sought to ascertain their number" -- and then proceeded to try to find the justification for their use -- "I proceeded to the deduction of these concepts." Kant devised a special terminology to try to solve Hume's problem: he distinguished between analytic and synthetic judgments, and a priori and a posteriori. An analytic judgment is one in which there is a (partial) identity between subject and predicate. A synthetic judgment is one in which the predicate "falls outside" the concept of the subject. He revised the old terminology of a priori and a posteriori so that "a priori" means "independent from experience" and "a posteriori" means "derived from experience".

The concepts "by which the understanding thinks the connection of things a priori" are synthetic and a priori. The question of the *Critique of Pure Reason* is: How are synthetic a priori judgments possible? That is, what is our epistemological warrant for making such judgments? Kant's response to Hume in the *Critique* consists in the attempt to show that the propositions of science ultimately rest on a system of principles even more general than the laws of motion set out in Newton's *Principia*. For Kant, these principles, the consequence of the attempt to demonstrate how synthetic a priori judgments are possible, are the principles of his new metaphysics. In this sense, the fundamental propositions that natural science must suppose for its very possibility are metaphysical. The epistemological warrant for Newtonian science, its claim to objectivity and certainty, turns on its critical underpinning.

There is more at stake for Kant in the *Metaphysical Foundations* than the grounding of a conception of science in which he had a long standing interest. The *Metaphysical Foundations* stands in a special relation to the *Critique of Pure Reason*. In the latter work, Kant presents what he calls his "general metaphysics", in the former a "special metaphysics". The special metaphysics supports the general metaphysics by providing a "case in concreto" which exhibits the a priori foundation of knowledge. That is, it gives content to the very abstract concepts and principles of the general metaphysics. Hence, Kant's special metaphysical reasoning reinforces the general thesis of the Copernican revolution, by offering a case study in defence of the claim that knowledge of objects must conform to a subject's faculties. The *Metaphysical Foundations* represents an effort to carry through the critical project in the direction of the empirical concept of matter. For this reason, it must have seemed to Kant to be a crucial test of the correctness of his answer to the question: "How is knowledge possible?".

(ii) The *Metaphysical Foundations* and Newtonian Science

The *Metaphysical Foundations*, then, is important to Kant in two respects: it is to provide the grounding for Newtonian science, and it is to provide an example in concreto of the exceedingly abstract concepts and principles enunciated in the first *Critique*.2 Assuming that Newton had discovered the correct system of the world, which Kant believed Newton to have for the most part done, exhibiting the fit between Newtonian physics and the critical philosophy would provide a measure of the success of the latter. As a grounding, however, the *Metaphysical Foundations* must aim to supply something that is lacking in Newton's system -- if nothing is lacking, the project appears at least somewhat gratuitous. Neither perspective on the project gives portent of any serious disagreement with Newton.

The most obvious addition which Kant sees must be made to Newton's system is a response to Hume's critique. At the base of Newton's methodology is a fundamental reliance

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2 This point is emphasized in (Friedman 1992), pp. 123-124, 161-185.

on induction.3 In light of Hume's devastating argument against induction, Kant saw a science with no further basis standing on tenuous ground indeed. The *Metaphysical Foundations* attempts to lay down the concepts and principles that accounted for, or guarantee, the apodeictic certainty of the laws of physics, without which, according to Kant, physics would not deserve the name of a science. While his views concerning the content and method of metaphysics changed considerably over the intervening thirty years, Kant still believes in 1786 that "what many say can be properly absent from physics is in fact its only support..." [*Physical Monadology*, 475].

There are other points at which Kant wishes to go beyond Newton which give the appearance of more explicit disagreement. Newton believed that there was an infinite, absolute, isotropic space in which bodies were placed by God, and that time is also real and ontologically primitive. Absolute time and space can find no place in the critical philosophy. Friedman (1992) argues very ably that one of the chief aims of the *Metaphysical Foundations* is to give a critical reinterpretation of these concepts.

In addition, Newton is notoriously reticent concerning the causes of gravitation:

> But hitherto I have not been able to discover the cause of those properties of gravity from phenomena, and I frame no hypotheses; for whatever is not deduced from the phenomena is to be called an hypothesis; and hypotheses, whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy. (*Principia*, General Scholium)

While Kant approved of Newton's reticence in describing the cause of the universal attraction of matter, he disapproved of Newton's stronger claim not to take gravity for an essential property of matter.4 Newton thought he could avoid the assumption of an immediate attraction at a distance as an essential property of matter by leaving room for a possible explanation of gravitation in terms of the pressure exerted by an ether, for example. This is

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3 Cf. for example, Rule IV of the "Rules of Reasoning" in the *Principia*, and *Opticks*, Query 31.

4 Cf. "Advertisement" to the second edition of the *Opticks*.

the one point on which Kant explicitly criticizes Newton in the *Metaphysical Foundations* [IV, 515]. Without the postulate of immediate and essential attraction, according to Kant, Newton has no way of grounding the proposition that gravitational attraction is directly proportional to mass. As Friedman has pointed out, Kant is here taking issue with Newton "for not daring to be `Newtonian' enough: in denying that gravitation is essential to matter Newton is `set at variance with himself'", (Friedman 1992: 139).

Finally, there is the issue of matter theory. In Query 31 of the *Opticks*, Newton writes:

> [It] seems probable to me, that God in the beginning form'd Matter in solid, massy, hard, impenetrable, moveable Particles...and that these primitive Particles being Solids, are incomparably harder than any porous Bodies compounded of them; even so very hard, as never to wear or break in pieces... (*Opticks*, Query 31)

Kant rejects atomism of this sort in the *Metaphysical Foundations*. Friedman argues that Kant's attack on atomism is not directed at Newton, and that matter theory is not a central issue at all. Now, insofar as Newton accepts some version of the "atoms in the void picture" as the best way to account for nature, Kant in effect disagrees with him. In Chapter Two, I shall argue, contra Friedman, that matter theory is a central concern of the *Metaphysical Foundations*.

In the *Physical Monadology* of 1756, Kant devised a theory which is, essentially, very much like Boscovich's better known modification of atomism, according to which an atom is a field of forces.5 Kant did not use the word "atom" in the *Monadology*, but called the primitive parts of matter "monads", after Leibniz. In Proposition V, Kant holds that monads occupy space by repelling, through their repulsive force, other monads which are drawn to them by their attractive force. The spatial boundary of the monad lies where these two forces are in equilibrium. Kant argued that not only the size, but also the mass of the monad is to be explained by its inherent forces. His explanation of the differences of density of various bodies, which the atomistic philosophy gave in terms of the ratio of empty space to the space

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5 This is discussed further in Chapter Two.

occupied by the corpuscles, appears again in the *Critique of Pure Reason*, (in the Anticipations of Perception which deals with intensive magnitudes) and in the *Metaphysical Foundations of Natural Science* [IV, 525].

One of the chief puzzles associated with the *Metaphysical Foundations* is that this doctrine of matter should be carried over, more or less intact, from the pre-critical period into the very heart of the critical period. In 1756, it is no surprise to find Kant assigning to metaphysics the task of exhibiting fundamental causes and forces in order to complete the work that physics leaves undone, and conceiving of this task as one to be accomplished in accordance with the basic principles of Leibnizean-Wolffian metaphysics. But to find him propounding a doctrine of this sort in 1786, if the retention of such a "metaphysical" conception of matter is what he is up to, appears quite startling. After all, Kant had ostensibly left the apparatus of Leibnizean-Wolffian metaphysics behind in developing the critical outlook.

The issue of Kant's matter theory in the *Metaphysical Foundations* is one which introduces significant exegetical difficulties for any attempt to produce an interpretation of the work entirely consistent with the principles of the critical philosophy. Such an interpretation is possible, however. This dissertation represents an attempt to overcome some of the difficulties through an emphasis on the often neglected critical notion of construction. Attention to Kant's notion of construction helps to elucidate the reasoning behind his attempt at a metaphysical foundation for natural philosophy.

(iii) Metaphysics, Mathematics, and Construction

For Kant's rationalist predecessors, metaphysical explanation was thought to capture the basically real features of the universe by resolute attention of pure thought. While most deemed the mechanical method -- in some one of its many variants6 -- fully adequate to

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6 The classical source of mechanistic explanation, of course, is the ancient atomists. While the mechanical method enjoyed a revival in the early modern period, many of those who

explain the behaviour of material objects, the causes of that behaviour are themselves to be derived from deeper metaphysical causes. The method of metaphysics was to be modelled on that of mathematics; proceeding in this fashion, metaphysics was to attain the certainty that attached to mathematics.

These themes recur in the critical philosophy, but altered in more or less subtle, but always revolutionary ways. In as early a work as the *Inaugural Dissertation*, Kant is to be found denying that a straight parody of the methods of mathematics is adequate to the subject matter of philosophy. Yet, as we shall see, mathematical modes of reasoning play a central role in his *Metaphysical Foundations*. To be sure, Kant denies that purely conceptual thought can lead to knowledge of any kind. But a corollary of this view is the denial that mathematical thought is purely conceptual. Where Kant disagrees without qualification with his rationalist predecessors is over their supposition that we can discover "real causes" underlying those discoverable by science. In his pre-critical period, Kant expresses this disagreement with his rationalist predecessors when he says that the "true method of metaphysics is basically the same as that introduced by Newton into natural science and which had such useful consequences in that field", (Kerferd and Walford 1968: 17). In the critical period Kant reiterates this same conviction when he approves of Newton's abstracting from hypotheses concerning the causes of universal attraction.

The Leibnizeans, in particular Wolff, had accepted the new science as adequately explaining the phenomena. Kant's system aims to enshrine Newton's method as the method of science. But in this system, science is no longer to be founded on a deep metaphysical explanation. Rather, it is to be founded on an account of the ultimate epistemological warrant for our judgments about nature, by exhibiting the appropriate content for the basic concepts and principles of natural science. At the heart of the mechanical method, and responsible both for its success and the authority attaching to its universal and necessary claims, is mathematics. Kant goes so far as to deny that a discipline such as chemistry can aspire to

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accepted it at the same time rejected such central features of the ancient doctrine as void space and impenetrable particles. Very broadly, those who could be described as

any loftier status than that of "systematic art", since is not appropriately connected to mathematics:

> I maintain, however, that in every special doctrine of nature only so much science proper can be found as there is mathematics in it. For in accordance with the foregoing considerations, science proper, especially science of nature, requires a pure part, which lies in the foundation of the empirical part and is based upon an a priori cognition of natural things. Now, to cognize anything a priori is to cognize it from its mere possibility. But the possibility of determinate natural things cannot be cognized from their mere concepts; from these concepts the possibility of the thought (that it does not contradict itself) can indeed be cognized, but not the possibility of the object as a natural thing, which can be given (as existing) outside of the thought. Therefore, in order to cognize the possibility of determinate natural things, and hence to cognize them a priori, there is further required that the intuition corresponding to the concept be given a priori, i.e., that the concept be constructed. Now, rational cognition through the construction of concepts is mathematical. A pure philosophy of nature in general, may indeed be possible without mathematics; but a pure doctrine of nature concerning determinate natural things (doctrine of body and doctrine of soul) is possible only by means of mathematics. And since in every doctrine of nature only so much science proper is to be found as there is a priori cognition in it, a doctrine of nature will contain only so much science proper as there is applied mathematics in it. [*Metaphysical Foundations*, 470].

So to give a foundation of natural science is to exhibit the "pure part" which "lies in the foundation of the empirical part". And this pure doctrine of nature can only be given by means of mathematics.

Kant's metaphysical foundation for natural science must be governed by the constraints set out by the Analytic and the Aesthetic of the *Critique of Pure Reason*. Equally apparent is the prominent role Kant gives to mathematics in this project, and in particular the application of mathematics to nature. For Kant, mathematics must be *about* something just as much as any body of knowledge must be about something. The requirement of data applies to mathematics. A purely formalistic conception of mathematics would leave that science as devoid of content as dogmatic metaphysics. If it is to attain to truth and objectivity, mathematics requires both a system of relations between concepts, and intuitions.

One common reading of the Transcendental Aesthetic claims that the requisite objects are supplied by intuitions of a special sort, namely pure intuitions. After all,

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mechanistic philosophers joined in shunning Aristotelean final causes (or "occult" causes of any kind) in physics.

mathematical truths are a priori, universal, and necessary, not empirical. Space and time are the pure forms of intuition. The Aesthetic is then read as holding that mathematics applies to the objects of sense because it is directly about space and time, and space and time are the forms organizing sense objects.

There are two respects in which such a reading is not completely satisfactory, however. First, as Michael Friedman (1992: 101) has pointed out, Kant denies that pure intuition provides objects and objective reality for mathematics:

> Now the object cannot be given to a concept otherwise than in intuition; for though a pure intuition can indeed precede the object a priori, even this intuition can acquire its object, and therefore objective validity, only through empirical intuition of which it is the mere form. Therefore all concepts, and with them all principles, even such as are possible a priori, relate to empirical intuitions, that is, to the data for a possible experience. Apart from this relation, they have no objective validity, and in respect of their representations are a mere play of imagination or understanding. Take, for instance, the concepts of mathematics, considering them first of all in their pure intuitions. Space has three dimensions; between two points there can be only one straight line, etc. Although these principles, and the representation of the object with which this science occupies itself, are generated in the mind completely a priori, they would mean nothing, were we not always able to present their meaning in appearances... [A 239-240/B 298-299]

Objects for any concept whatsoever, including those of mathematics, can only be found in *empirical* intuition.

The second troublesome feature of any account which restricts its search for Kant's view of mathematics to the Transcendental Aesthetic is that Kant's thoughts on mathematics are not fully developed there. Kant denies that pure intuition can supply the requisite data for mathematics; and drawing such data in any direct way from empirical intuition would falsify the a priori nature of mathematical judgment. Kant holds that the mathematician meets the demand for data through *construction*, a method for exhibiting a pure concept or the pure part of a concept capable of mathematical treatment a priori in intuition.[7] That is, construction provides a second sort of data. In addition to empirical intuitions, we have constructed ideal possible objects applying to the empirically intuited. The objectivity and universality of

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mathematics depends on our ability to construct additional data, to construct objects intuited a priori. Notice also that this account appears to be designed with an eye to explaining the applicability of mathematics.

In relation to a priori determinations of empirical concepts, the pure forms of intuition make it possible to consider objects as magnitudes, as Kant attempts to make clear in the Axioms of Intuition [A 162/B 202]. In this respect, the Aesthetic prepares the ground for Kant's mathematical constructions in the *Metaphysical Foundations*. In construction, concepts of magnitude attributed to the empirical concept of matter are exhibited a priori in intuition. Hence, the pure forms of intuition are invoked in relation to Kant's doctrine of mathematical construction, a doctrine which is central to his reasoning in the special metaphysics of nature. But they do not *replace* constructions.

In The Doctrine of Method, Kant actually defines mathematical knowledge as "the knowledge gained by reason from the *construction* of concepts," and goes on to characterize construction as follows:

> To *construct* a concept means to exhibit a priori the intuition which corresponds to the concept. For the construction of a concept we therefore need a *non-empirical* intuition. The latter must, as intuition, be a single object, and yet none the less, as the construction of a concept (a universal representation), it must in its representation express universal validity for all possible intuitions which fall under the same concept. Thus I construct a triangle by representing the object which corresponds to this concept either by imagination alone, in pure intuition, or in accordance therewith also on paper, in empirical intuition -- in both cases completely a priori, without having borrowed the pattern from any experience. The single figure which we draw is empirical, and yet it serves to express the concept, without impairing its universality. For in this empirical intuition we consider only the act whereby we construct the concept, and abstract from the many determinations (for instance, the magnitude of the sides and of the angles), which are quite indifferent, as not altering the concept `triangle'. [A 713-714/B 741-742]

The final product of a construction, an image in the imagination or on paper, is supposed to represent an empirical intuition -- but it is not the image that is important here, it is the act, or as Butts puts it, the operational transaction of constructing the figure, (Butts 1984: 183n 26).8

Kant's account of construction is most fully set out in the Doctrine of Method [A 712-718/B 741-745].
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As the passage from the *Metaphysical Foundations* quoted earlier shows, Kant thought that the availability of a mathematical idealization was the mark of a science. Constructions are again evident in this work, but now applied to physics. Constructions are required in order to render physical properties susceptible to mathematical treatment, and so the program in the *Metaphysical Foundations* is a detailed account of the various constructions required in order to mathematize the fundamental features of Newtonian physics. It is a general attempt to construct the concepts required in order to apply mathematics to general physical situations.

Kant's doctrine of mathematical construction has a restricted application to "objects considered as quanta". In construction, an object considered as quantum is "created in space and time". What Kant means by this is that pure sensible figures are used to represent particular concepts of quantity. Following the rule of the schematism for representing concepts of quantity, it is a successive generation of points which yields the geometrical construction of magnitude. For example, the successive addition of 5 points represents the concept of 5. As such, mathematics makes its own concepts, for the concepts so constructed are not themselves "given".

Philosophy, on the other hand, does not construct its concepts. Philosophy explicates concepts which are given; concepts such as good and evil, beauty, causality -- none of which have quantitative features which are determinable in relation to the synthesis of the homogenous in intuition. There is no question then, of constructing moral or aesthetic concepts, or even concepts brought under regulative categories such as causality [A 722n]; only mathematical concepts or mathematical parts of concepts can admit of construction.

Kant's view of the applications of the method of mathematical construction is more subtle than is evident in the above distinction. It is true that mathematical concepts are

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Butts notes that Kemp-Smith's translation of Kant's expression of "Handlung" as "act" may give the wrong impression. The word "act" suggests that mental acts are

always constructed concepts, but it is not merely concepts in pure mathematics which admit of construction. In Kant's view, mathematics can sometimes be applied -- at least imitatively -- to empirical concepts discovered by science and given in understanding. In such cases, the analysis of concepts given in experience goes beyond the merely empirical part of a concept, by separating the a priori part of an empirical concept and exhibiting it in construction [A 722n]. Evidence of this procedure can be found in Kant's *Metaphysical Foundations*, where Kant considers Newton's empirical concept of matter mechanically as composed of moving parts, and dynamically as composed of forces. Philosophy is thus given its definition of "matter as the moveable in space" and "matter as filling space due to forces". But such empirical concepts have an a priori part capable of mathematical treatment. Hence, constructions of concepts of quantity of motion and matter are possible, and these demonstrate the basis for cognition of such magnitudes in schematic judgement. Hence, an empirical concept such as matter is not constructed "as given" in empirical synthesis, but it has mathematical content which is capable of a "mathematical treatment".

Kant says that there are two methods involved in mathematical construction. Mathematical constructions are either geometrical or symbolic:

> Mathematics does not only construct magnitudes (quanta) as in geometry; it also constructs magnitudes as such (quantitas), as in algebra. In this it abstracts completely from the properties of the object that is to be thought in terms of such a concept of magnitude... Once it has adopted a notation for the general concept of magnitudes so far as their different relations are concerned, it exhibits in intuition, in accordance with certain universal rules, all the various operations through which the magnitudes are produced and modified. Thus in algebra, by means of symbolic construction, just as in geometry by means of ostensive construction, we succeed in arriving at results which discursive knowledge could never have reached by means of mere concepts.[A 717/B 745]

Most commentators on the *Metaphysical Foundations* agree that Kant's geometrical constructions are crucial to his special metaphysical defense of the extended properties of matter. As Kant himself emphasizes, only geometrical constructions can exhibit a priori the content in a concept which is determined in intuition. In Chapter Two, however, I shall argue that to give a coherent reading of Kant's discussion of constructions in the *Metaphysical*

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essential. Kant instead wishes us to attend to the public transaction involved in such

Foundations, symbolic constructions must also be invoked -- in particular, they are required if sense is to be made of Kant's claim that a mathematical treatment of the dynamical concept of matter is possible.

In the *Metaphysical Foundations*, Kant shows how a priori features of empirical concepts can be reproduced in imagination as constructions. Such a priori constructions may be viewed as reproductions based on pure and pure sensible concepts of the productive imagination. Hence, Kant's constructive procedure "reproduces" those schematic judgements which determine quantitative features of the empirical concept of matter. As Kant sees it, the job of providing a philosophical justification for Newton's results amounts to the demonstration that key concepts and laws of Newtonian science display necessity insofar as they have mathematizable content which can be cognized a priori.

Each chapter of the *Metaphysical Foundations* aims to show a basis in a priori conditions of cognition for specific features of Newtonian science. The Phoronomy shows motion to be a constructible concept; that is, since intuitions corresponding to quantity of motion are given a priori, motion is mathematically representable. The Dynamics brings matter's property of filling space in a determinate degree under the categories of quality, and considers the problem of constructing a dynamical concept of matter. The Mechanics grounds Newton's laws of motion by demonstrating that objects stand in relation with one another according to principles of general metaphysics which follow from constructed concepts of quantity of motion. Finally, the Phenomenology shows that under modal categories, concepts such as absolute space and true motion are justifiable if the results of the first three chapters of the *Metaphysical Foundations* hold.

Most commentators on the *Metaphysical Foundations* agree that the special metaphysics addresses Kant's objections to the formal definitions of certain Newtonian concepts. For instance, Newton has a prominent role for absolute space. But absolute space is not a possible object of experience, and hence violates a fundamental Kantian restriction

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a construction.

on empirical concept formation. A similar objection holds against Newton's apparent preference for a conception of matter as composed of atoms which are described in terms of absolute impenetrability, hardness, mobility, and so on. The consensus is that the apparent ontological commitments of Newtonian physics present difficulties for Kant's attempt to show that Newtonian science can be linked to the sensible and intellectual a priori and necessary conditions of cognition.

(iv) Concept Formation in the First Critique

Before proceeding to examine the respect in which the *Metaphysical Foundations* extends the work of the *Critique of Pure Reason* -- and by the same token, draws on it as a background in the project of providing a critical foundation for Newtonian science -- it will be useful to rehearse some of the key features of the general doctrine of concept formation, and in particular of construction, in the first *Critique*.

Kant describes his break with dogmatic metaphysics as the result of his rejection of "the presumption that it is possible to make progress with only a pure knowledge from concepts (philosophical knowledge), according to principles," [B xxxv]. Epistemological integrity, he argues, requires the satisfaction of two conditions: conceptual organization on the one hand, and evidence or data on the other. Any knowledge claim, metaphysical, mathematical, or otherwise, requires the satisfaction of these two conditions. The Analytic and the Transcendental Aesthetic of the *Critique of Pure Reason* aim to give an abstract, general account of these two conditions. The fundamental distinction between concepts and intuitions, and their respective faculties of understanding and sensibility lie at the heart of Kant's positive replacement for dogmatic metaphysics.

The Transcendental Aesthetic aims to describe very general, pre-conceptual conditions applying to spatial and temporal aspects of our experience of physical objects (intuitions). Space and time are not treated as things in themselves, objects to be known independently of our ways of knowing, but as pure forms of our faculty of sensibility. Space

and time are pure intuitions, and pure intuitions are formal or epistemic conditions of *objective* conceptual representations. Kant's pure intuitions are singular and immediate, but provide *universal* spatio-temporal conditions for determining sensible objects [A 320/B 377]. It is by means of such universal marks that concepts supplied by the intellect can be combined with sensible intuitions of objects [A 50/B 74].

Intuition alone is not sufficient for the representation of objects. In the Analytic, Kant describes intellectual conditions which govern our understanding of objects. These conditions are called pure concepts of the understanding. Pure concepts, or categories, unify what is given in intuition, providing the actual representation through which an object can be thought [A 68-9/B 93-4]. Kant identifies twelve categories, which nicely divide into four groups: the pure concepts of quantity, of quality, of relation, and existence. For Kant, understanding an object of experience requires that intuitions be brought under the mathematical categories of quantity and quality. The categories of relation and modality merely regulate how we think *about* empirical objects. Hence, the former categories determine the mathematizable content of empirical concepts; the latter regulate empirical cognitions about objects in relation to such concepts.

As will emerge below, the Schematism chapter is of considerable importance in the current context. But it presents difficult exegetical issues, particularly with respect to the schematism of pure concepts. For now we will move on to two other types of schemata and two other types of concepts. Kant's description of these [A 141/B 180] can be fairly summarized as follows: In relation to *pure sensible concepts*, a schema enables the production of geometrical figures, and this involves the construction of the figure in the pure imagination a priori. Kant says that this latter form of construction is the transcendental condition for the construction of empirical images; and, in relation to *empirical concepts* the schema is said to provide a means for the a priori construction of the figure in pure imagination according to a rule of the empirical concept.

As with pure concepts, Kant's descriptions of pure sensible concepts, empirical concepts, and their schemata are not very detailed. Despite the limitations with respect to

detail, Kant does specify several important relationships between pure, pure sensible, and empirical concepts in connection with schemata. These descriptions provide the basis for an account of the a priori conditions which apply to our judgments about empirical objects. Let's begin by considering how these relationships are exhibited in the Schematism.

Kant says that the schema of a pure concept in time can be regarded as the universal condition for employment of the category and for the possibility of knowledge of objects [A 140/B 179]. Hence, Kant's text strongly suggests that pure sensible concepts and empirical concepts depend directly on the schematism of pure concepts. Kant also says that the schematism of pure concepts determines the unity of the manifold in intuition and, indirectly, the unity of apperception [A 146/B 185]. It is this transcendental synthesis in imagination a priori which makes possible a priori "monograms" of the imagination, or pure sensible concepts. At A 142/B 181 Kant writes:

> ...The *schema* of sensible concepts such as of figures in space, is a product and, as it were, a monogram, of pure *a priori* imagination, through which and in accordance with which, images themselves first become possible. [A 142/B 181]

Hence, both pure and pure sensible concepts are linked to a synthesis in a priori imagination; i.e., a synthesis which establishes the general possibility of thinking objects in the first case, and the possibility of delineating discrete representations of figures in the second case.

The schema of a pure sensible concept is produced in agreement with a rule. For example, the schema of a triangle would apply rules for constructing a triangle. Pure schema appear to condition the construction of such geometrical figures by regulating the structure of the depicted figure in connection with the limitations given by the structure of space. At [B 151-2] Kant distinguishes pure concepts from pure sensible concepts, saying that the former subsume intuitions in a "merely intellectual combination". His usage of the latter expression suggests that the following distinction holds between pure concepts and pure sensible concepts in relation to schemata: Adding a temporal parameter to the pure concept involves a merely "intellectual" combination, but adding a spatial parameter to our representations, i.e., constructing figures in imagination, involves more than a merely intellectual combination. It

does not seem unreasonable to suppose then, that the combination of categories and the inner form of intuition is "merely intellectual" when it does not involve the representation of an image in intuition.

Kant also describes how the schematism of pure sensible concepts relates to empirical knowledge. He says that empirical concepts are linked to the schematism of pure sensible concepts. For Kant, an empirical concept

> ... always stands in immediate relation to the schema of imagination [here Kant is referring to the schema of pure sensible concepts], as a rule for the determination of our intuition, in accordance with some specific universal concept. [A 141/B 180]

According to this description, we can suppose that a schema of pure sensible concepts produces an image in sensible intuition. In addition, Kant indicates that the schema of a pure sensible concept acts as a criterion for assessing images of objects given in empirical intuition (or appearance):

> The image is a product of the empirical faculty of the productive imagination -- the schema of sensuous conceptions (of figures in space for example) is a product, and, as it were, a monogram of the pure imagination a priori, whereby and according to which images first become possible, which, however, can be connected with the conception only mediately by means of the schema which they indicate, and are in themselves never fully adequate to it. [A 142/B 181]

In the above text, Kant implies that through a comparison with geometrical figures constructed in imagination, the extended and distinct nature of empirical objects is determinable. None the less, he remarks that empirical images match geometrical figures produced by the imagination only in an approximate fashion. According to Kant, it is this roughness of fit between pure sensible figures and empirical images which provides for us the certainty that schemata, rather than empirical images underlie our pure sensible concepts. Hence, Kant reasons that

> ...it is schemata, not images of objects, which underlie our pure sensible concepts. No image could ever be adequate to the concept of a triangle in general. [A 141/B 180]

It seems then, that the schematism of pure and pure sensible concepts provide rules which guide us in our empirical judgments about objects. The schematism of pure concepts determines the temporal conditions for producing images of pure sensible concepts. The schematism of pure sensible concepts requires a further determination of an image, the production of an image in the pure imagination a priori in conformity with the pure intuition of space. It is the images produced through the assistance of the schematism of pure and pure sensible concepts which enable us to represent the a priori content of empirical concepts of objects.

In reading Kant's short chapter on schemata for its account of the role of schematism in empirical concept formation, we have discovered that the activity of schematizing concepts partially specifies the meaning of observations. In the case of empirical concepts, the part of the meaning specified, especially by images of the productive imagination, is the geometrically and mathematically tractable part.9 The schemata of pure concepts specify how categories apply to an inner sense of time in empirical cognition; while the schemata of pure sensible concepts specify the meaning of categories in relation to objects given in external intuition. In this sense, the schematism of pure and pure sensible concepts orient us in our cognition of objects.

It is through a second function of judgment, the capacity to understand objects in relation to principles, that we judge objects given in appearance. Like schemata, our capacity for principled judgements about objects arises from pure concepts of understanding.

Two principles apply to constitutive aspects of conceptual knowledge; the Axioms of Intuition and the Anticipations of Perceptions. The principle of the Axioms is that all appearances are extensive magnitudes in terms of their intuition [B 202]. The principle of the Anticipations is that all appearances are intensive magnitudes in terms of sensation [B 207]. Kant's discussion of these principles revolves around the claim that representations of

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9 See Chapter VI of (Butts 1984). Butts describes the role of the schematism in these terms.

determinate magnitude are possible only if a synthesis of aggregates of parts precedes the representation of the whole: The principle of the Axioms merely professes this to be a condition for judging objects to have extension. The Anticipations councils a restricted representation of intensive magnitude, since sensation does not present determinate degrees of intensity through a synthesis of parts.

These two principles imply general restrictions on concept construction in Kant's special metaphysics. The Axioms imply that in relation to pure concepts of quantity, objects can be constructed as extensive magnitudes. This defines the sense in which objects considered as quanta are constructed in the Phoronomy. The Anticipations implies that the construction of quantities thought in relation to qualities is complicated by the manner in which intensive magnitude is given in sensation. In Chapter Two, I suggest that the sense of construction which applies in Dynamics is indeed more complex than that which is defined for Phoronomy.

Two other principles apply to the existence of things thought in understanding. These principles regulate how we think objects, both in relation to one another and in terms of existence. The principle of the Analogies of Experience is that all appearances must stand in a necessary connection with one another [B 218]. In Kant's view, experience is possible through a time order that regulates how we think objects to be related. Kant's Mechanics in the *Metaphysical Foundations* argues that Newton's laws of motion are possible a priori in relation to the Analogies.

The Postulates of Empirical Thought govern our judgments about the existence of objects [B 266]. In the *Metaphysical Foundations*, it is due to such modal judgments that we discover empirical hypotheses which are possible a priori to have content which is necessary and a priori. In the Phenomenology -- which addresses the question of whether there are absolute motions, as indicated by Newton's bucket experiment -- Kant shows how modal judgments define necessity in relation to his a priori foundation of natural science.

Kant claims that principled and schematic judgements form the basis for objective knowledge in understanding [A 157/B 196]. An important restriction on such judgements which is often overlooked is that they bear a special relationship. At [A 136 /B 175], Kant explains that the principles of judgement follow a priori given that the conditions of the schematism hold.10 In the *Metaphysical Foundations*, this same restriction is applied to judgements about the empirical concept of matter. There, Kant's a priori foundation for Newtonian laws follows given the constructibility of quantitative attributes of the empirical concept of matter.

Conclusion

Mathematical constructions play an important, but much neglected role in the *Metaphysical Foundations*. As Butts theorizes, the delineation of special rules for thinking about empirical objects is significant, because it establishes the possibility in general of doing science:11

> If we ask how the general semantical rules of the formalism (the schemata) apply, the answer is that they apply only to the world conceived of as in general a world of measurable physical objects and events in which these objects are ingredient. To become more specific, the formalism must be supplemented by semantical rules of another kind introduced by each special science. The subject matter of a particular science invites us to try various forms of explanation; the choice of things to be investigated, the choice of the domain of individuals over which observational variables will range, is made freely and pragmatically. What guides the choice is a quest for individuals whose interposition will result in `data' in accordance with the theoretical demands of the given science. (Butts 1984: 189-9)

Butts' linkage of the semantical rules for concepts in the Schematism and the construction of empirical concepts in Kant's philosophy of science is very helpful in explaining the role of constructions in Kant's philosophy of nature. For if Butts' interpretation of the role and import of the Schematism is correct, then Kant's constructions in the *Metaphysical Foundations* emerge as an extension of his general metaphysical constraints on empirical concept

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10 Some commentators, such as Guyer, do emphasize the relationship between schematism and principles. See especially Part III of (Guyer 1987).

11 See (Butts 1984), Chapter VI.

formation in the first *Critique*. For constructions reproduce schematic judgements defining spatio-temporal parameters on experience. Hence, they demonstrate the fit between a priori conditions of cognition and the empirical concepts given in science.

However, the singular role of concept construction in Kant's philosophy of nature remains largely uncharted. In the following chapters of this dissertation, I will show how Kant reasons about concept construction in the *Metaphysical Foundations*. Chapter Two describes the sense in which Kant's draws on the critical formalism of his first *Critique* in his a priori foundation for Newtonian concepts and laws. Chapter Three describes the epistemic warrant underlying Kant's justification of concepts and laws in material philosophy. Chapter Four aims to clarify the results of this thesis by relating those results to the secondary literature on Kant. As it turns out, Kant repeatedly draws on his doctrines of space, time, and the categorical structure in his special metaphysical reasoning about constructions.

Chapter 2

Introduction

Kant's reasoning in his special metaphysics of nature is often opaque, and the character of his a priori foundation for Newtonian science is the subject of some controversy. For instance, it has been suggested that certain implicit ontological commitments shed light on Kant's doctrine of body in the *Metaphysical Foundations of Natural Science*. For example, Kathleen Okruhlik (1983) points out that Kant's long held interest in a force ontology may underwrite his desire to ground Newtonian mechanics with a dynamical concept of matter. In Okruhlik's view, Kant's epistemic constraints require the replacement of a Newtonian view of matter with a force ontology. By way of contrast, Michael Friedman (1992) discounts the idea that matter theory plays an important role in the *Metaphysical Foundations*. Friedman credibly locates Kant's dispute with Newton in the failure of Newtonian mechanics to demonstrate the a priori basis for our thinking bodies to be in true motion and in absolute space. Standing in Okruhlik's favour, however, is the fact that a significant portion of the *Metaphysical Foundations* reveals a preoccupation with matter theory. There *is* a theory of matter in the *Metaphysical Foundations*; one which is quite prominent.12

Okruhlik holds that Kant's interest in a non-mechanistic taxonomy is reinforced by a deep prior commitment to a force ontology. Kant's desire to retain some Newtonian concepts

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12 A number of commentators, including Brittan (1978, 1992), and more recently Westphal (forthcoming), have taken matter theory to be the single most important issue addressed by the *Metaphysical Foundations*. The sheer extent of the proportions of the *Metaphysical*

-- absolute space, for example -- is held to be compatible with the overarching framework of relativistic motion and force ontology, since all fall under a methodological goal of reason to achieve explanatory completeness. On Okruhlik's reading, Kant's invocation of absolute space is to be seen as a conceptual tool, resorted to solely in order to achieve explanatory completeness.

Friedman's suggestion that the central issue between Kant and Newton is the latter's assumption of absolute space and absolute motion is most plausible. On many issues -- including the "original cause" of the force of attraction and the ultimate constitution of matter -- Newton felt entitled to an official stance that committed him to no hypothesis. But the assumption of absolute space is basic to his system. For Kant, on the other hand, the concept of absolute space is not easily reconciled with the critical philosophy. For *Newton's* science to act as a case *in concreto* for the critical metaphysics, Kant must in some way show absolute space to be a concept amenable to critical treatment.

Absolute space presents a difficulty, since Kant denies (in Observation 2 to Definition 1 of the Phoronomy) that absolute space can be an object of experience.

> To assume an absolute space -- i.e., one such that, since it is not material, it can also be no object of experience -- as *given for itself* is, since it can neither be observed in itself nor in its consequences (motion in absolute space), to assume something for the sake of experience -- which latter must still always be erected without it. Absolute space is therefore *in itself* nothing and absolutely no object ... [IV, 481]

None the less, Kant's foundation for natural science includes a foundation for absolute space. Although the initial chapters of the *Metaphysical Foundations* highlight the dynamical concept of matter and the relative space of experience, Kant's argument leads up to a defense of absolute space as "an idea that is to serve as a rule for considering all motion therein only as relative." [IV, 560].

Paralleling the main course of the argument in the *Metaphysical Foundations*, Friedman's reconstruction of Kant's argument as directed at the a priori justification of

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Foundations dedicated to matter theory ought to give pause to anyone wishing to dismiss the importance of this issue to Kant.

absolute space, has Kant reasoning along the following lines: The Phoronomy shows that motion can be mathematically represented. The Dynamics establishes that gravitational attraction is both universal and immediate. The Mechanics grounds Newton's laws describing absolute motions a priori in Kant's laws of mechanics. The last chapter, the Phenomenology, shows that the philosophical foundation of relative motion is secure only in relation to concepts of true motion and absolute space. Thus, Friedman holds that the culmination of the *Metaphysical Foundations* is a substantive defence of true motion and absolute space. Friedman's reconstruction of Kant's reasoning in the *Metaphysical Foundations* as a set of constructions which make absolute space a product rather than an assumption of Newton's own system has much to recommend it.

First amongst its virtues is that it relieves us from having to accept any reading of the *Metaphysical Foundations* as reconstructing Newton's laws and the structure of Newtonian space-time within a relational theory of space. To have so fundamentally attacked the correctness of Newtonian physics would certainly have brought the coherence of taking the same science as a case *in concreto* of the general metaphysics into question. Friedman's account of the construction of absolute space allows us to read Kant as *grounding* this Newtonian concept, not correcting it.

Friedman's characterization of the Dynamics is his point of greatest departure from most other accounts. He maintains that Kant's purpose there is to begin to make sense of the apparent/true motion distinction. According to Friedman, if the immediacy and universality of gravitational attraction are proven in the Dynamics, then a method for comparing the masses of primary bodies in the solar system can be developed. The estimation of the masses of primary bodies would in turn, enable an estimation of the centre of mass in the solar system, thus giving objective meaning to the concept of a privileged frame of reference. Given this reading of the Dynamics, Friedman thinks it unlikely that the theory of matter is central. In fact, Friedman doesn't think matter theory is an important issue in the special metaphysics at all, saying:

> There is no doubt that Kant does oppose an "atomism" that assumes "absolute impenetrability" as an original and essential property of matter. There is also no doubt that Kant's disagreement with Newton involves broadly Leibnizean strands of thought. Yet the idea that Kant's central disagreement with Newton is located here, at the level of matter theory, seems to me to be profoundly misleading. (Friedman 1992: 138)

If construing matter theory to be a central issue in the special metaphysics is misleading, no one is more responsible for erecting this "mistaken" impression than Kant. On the face of it, matter theory appears to be central to the *Metaphysical Foundations*. The subject of Kant's Dynamics, for example, seems to be the dynamical concept of matter. There, and in other parts of the book, Kant contrasts the dynamical and mechanical concepts of matter, a theme to which he frequently returns.

While Friedman may be correct in denying that matter theory is *the* central issue in the *Metaphysical Foundations*,13 it remains that the issue is not of merely peripheral concern and to be set aside. However, this is more or less how Friedman treats it. The considerable energy Kant expends on the topic gives at least *prima facie* grounds for taking it seriously. Part of what makes the issue problematic is the nature of the matter theory in question. On this issue, it remains tempting to see Kant as motivated by a prior commitment to a Leibnizean approach to natural philosophy, and wishing in the *Metaphysical Foundations* to ground Newtonian physics within a broadly Leibnizean framework. In this work, Kant reiterates his "dynamical" conception of matter, first announced in the *Physical Monadology* (1756), in which the impenetrability of bodies is based on a fundamental force of repulsion. Since Newton himself, in Query 31 of the *Opticks*, writes as if he thinks that most likely matter is composed of "solid, massy, hard, impenetrable, moveable particles", it looks as if a serious disagreement between Kant and Newton remains -- hence also the appearance that Kant is subverting his example *in concreto*.

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13 Friedman's denial is aimed at those such as Okruhlik (1983), McMullin (1978) and Ellington (in the Introduction to his translation of the *Metaphysical Foundations*) who argue that Kant's prior commitment to a force ontology of Leibnizean provenance is the central point of disagreement between Kant and Newton, as well as the main thesis to be defended in the *Metaphysical Foundations*.

There are two points which stand against such an understanding of the place of matter theory in the *Metaphysical Foundations*. First, it is far from clear that Kant took himself to be in conflict with Newton over matter theory. While Kant vigorously defends a "metaphysical-dynamical" account of matter while attacking a "mathematical-mechanical" one, Friedman points out that the only adherents of the latter view named by Kant are Democritus and Descartes (Friedman 1992: 138). The view Kant attacks is one such that the ultimate constituents of matter are held to be atoms moving in the void, with the only active forces being those imparted by impacts. Lacking the conceptual space for gravitation, such a theory of matter is hardly to be attributed to Newton.

Second, while it is undeniable that Kant's dynamical conception of matter has a broadly Leibnizean heritage, it is far from clear that the justification (as opposed to the genesis) of the theory of matter in the *Metaphysical Foundations* lies in the Leibnizean approach to natural philosophy. One of the chief aims of this chapter is to trace the *reasons* for Kant's views on matter, and to show that these reasons lie within the purview of the critical philosophy. In short, I shall argue that certain epistemological constraints on his theory of representation, in particular criteria of concept construction, play the most significant role in Kant's preference for a dynamical theory of matter.

While Friedman gives an account of the successful construction of the concept of absolute space, no such account of the dynamical concept of matter shall be forthcoming. In the Preface to the *Metaphysical Foundations*, Kant claims to have exhausted the metaphysical doctrine of body, adding that this is no large accomplishment [473]. However, in the General Remark to the Dynamics, Kant admits that matter, conceived as basic forces, is not constructible [525]; the fact that he follows this admission with suggestions to guide the requisite constructions would seem to indicate that he thought such a construction possible. This shortcoming in his account is not one which Kant considers to bring his metaphysical doctrine of body into question; rather, it is a failure to construct an important aspect of the concept of matter, namely, density [524-525].14 This chapter contains an extensive

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discussion of the problems presented to Kant by the combination of the importance he lays on the concept of density, his dynamical conception of matter, and the difficulties he has in producing the requisite construction.

One standard way of reading the *Metaphysical Foundations* has it that Kant's aim is to give a "realist" interpretation of Newtonian mechanics; where Newton officially refuses to grant fundamental status to gravitation, Kant is said to make a realist commitment to fundamental forces.15 On such a reading, Kant's views on matter theory are to be understood in a similar way -- both realist and Leibnizean. Gordon Brittan has argued that these Leibnizean and realist commitments come into conflict with the notion of construction on the issue of matter theory. Brittan suggests that, while the atomistic concept of matter is constructible, the dynamical concept of matter is one to which Kant has a prior commitment on metaphysical grounds, a commitment which undercuts Kant's realist interpretation when it turns out that the dynamical concept is not constructible.

Aside from the fact that Brittan's understanding of Kant's notion of construction is faulty -- for reasons to be gone into more fully in Chapter Four -- such a reading of the *significance* of matter theory as stemming from realist aims is also questionable. When Kant criticizes Newton in Observation 2 of Proposition 7 of the Dynamics for not postulating attraction at a distance as an essential property of matter, he does so because Newton is not being "Newtonian" enough; without such a commitment, Newton has no way of "grounding" the proposition that gravitational attraction is directly proportional to mass. The mathematical-mechanical conception of matter is also criticized for failing to be sufficiently Newtonian, since the sizes, shapes and motions of its elementary particles are inaccessible to experience. On the other hand, the dynamical explanation is said to be "far more suitable and favourable to experimental philosophy, in that it leads directly to the discovery of the proper moving forces of matter and their laws" [533].16

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15 This point is also made by Westphal (forthcoming: 5).

16 See for example (Brittan 1986).

Both of these points are due to (Friedman 1992: 138-9).

The points made in the preceding paragraphs give initial support to the line to be taken in this chapter: the basic concepts of physics should be fruitful, that is, they should guide research, and Kant thinks the dynamical concept of matter has the advantage here. The explanation for the success of Newtonian science lies in the application of mathematics to phenomena, such application being underwritten by the construction of the basic concepts, including matter, of Newtonian physics. Contra Brittan, Kant denies that the atomistic concept of matter is constructible (for reasons that go back to the *Physical Monadology* and the Second Antinomy)17 -- quite simply, the indivisibility of atoms defies the basic principles of geometry. Kant believed the dynamical concept of matter to be both experimentally fruitful and mathematically tractable. His inability to construct the dynamical concept of matter, however, leaves the mathematical tractability, and hence the scientific acceptability of this concept undemonstrated.

For those who take matter theory to be absolutely central to the *Metaphysical Foundations*, the apparent phlegm with which Kant accepts this failure in construction must be puzzling, for such a failure would then vitiate the entire project. Kant appears to have thought it a problem, but seems not to have considered the failed construction a death blow to the project. While a number of commentators, including Buchdahl, Brittan, and Butts have castigated Kant for his cool in the face of apparent disaster, his attitude seems rather to provide some vindication for Friedman's assessment of true motion and absolute space as more pressing concerns to Kant. Nonetheless, some explanation of Kant's attitude is required -- even if it is not absolutely central, neither is matter theory a trivial issue in the *Metaphysical Foundations.*

The view taken in this chapter is that Kant saw the problem of the unconstructibility of the requisite concept of matter as a purely practical, technical problem, the solution of which awaited improvements in analysis and experiment.18 Remarks from the correspondence, as

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17 Cf. the discussion of Brittan in Chapter 4.

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well as Kant's own suggestions in the *Metaphysical Foundations* shall be drawn on as evidence that Kant was not entirely indifferent to the problem, but thought a solution imminent. One of the most difficult aspects of such a construction is the application of extensive quantitative considerations to intensive phenomena such as forces. The chapter also contains a speculation as to the way in which Kant may have been drawing on the notion of symbolic construction in his attempts to solve the problem and concludes with the suggestion that the problem of matter theory in the *Metaphysical Foundations* foreshadows the "gap" problem of the uncompleted Transition project.

(i) Kant's Construction of Quantity of Matter

In the following section, I will show the significance of Kant's criteria of concept construction to his theory of matter in the Dynamics. On my account, Kant's difficulty constructing quantity of matter compromises his a priori foundation for the law of gravity in the *Metaphysical Foundations*. Here my reading diverges from Friedman's: On my account, matter theory plays a major role in Kant's reasoning, and its shortcomings hinder the completion of his a priori foundation for Newtonian science. However, I argue that the deficiencies in Kant's matter theory can be understood without invoking ontological considerations, and that the Dynamics may be read as part of an a priori justification for Newton's empirical concept of matter.

At [478], Kant concludes the Preface to the special metaphysics by suggesting that his metaphysical foundation of natural science is incomplete. There, Kant claims to have been only somewhat successful in "following the mathematical method" and suggests that it may be possible to bring a "metaphysical portion" of his treatise into "unison with the mathematical doctrine of motion", that is, the part of the treatise with which he was satisfied. His mathematical doctrine of motion, or kinematics, is given in the first chapter of the *Metaphysical Foundations*, the Phoronomy.

See (Duncan 1986: 298). Duncan makes a similar point but fails to adequately address this

The arguments of the Phoronomy characterize the sense in which matter's *motion* can be constructed in relation to categories of quantity. These constructions are mathematical representations of intuitions corresponding to concepts of matter as the moveable in space [470]. Three criteria of concept construction are explicitly stated in the Phoronomy:

a) Matter as moveable is constructible only in so far as motions are given a priori in the intuition of spaces and times [487].

b) Matter as moveable is constructible in so far as features of its motion are subject to a rule a priori for adding two or more velocities [486].

c) Matter as moveable is constructible in so far as features of its motions are mathematically tractable in terms of operations of addition and subtraction [489].

In the argument of the Phoronomy, Kant shows that candidate representations of motion inconsistent with the mathematical tractability defined by these criteria must be rejected 19. For example, with respect to the first condition, a), Kant says that since concepts like cause and effect are thought under the category of causality rather than given in intuition, they are non-constructible. Thus, condition a) serves to identify concepts which are non-constructible. In relation to the second condition, b), Kant insists that rest cannot be represented as a lack of motion, but must be represented as an infinitely small velocity through the composition of motions. As Kant explains at [494], condition b) ensures that matter as the moveable in space can be represented distinctly from relative space itself. In discussing his third condition, c), Kant says that phoronomy always produces a representation of quantity through the *composition* of the homogeneous. Hence, condition c) specifies that quantitative concepts must be mathematically tractable in terms of addition and subtraction because they are always given in intuition as aggregates of parts.

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issue in relation to the construction of scientific concepts.

19 A fourth criterion is:

d) Matter as moveable is constructed through the spatial representation of motion only in so far as it is represented by Euclidean geometrical figures (the fixed geometry of perceptual space) [*Prolegomena*, # 38].

Although condition d) is of general interest to the student of the *Metaphysical Foundations*, it will not concern us much here. Kant does not explicitly state this condition in the Phoronomy. Nevertheless, it is widely accepted that Kant intends geometrical

The above criteria then, define the sense in which motion is constructible as an extensive magnitude. In constructing concepts, we create "objects viewed as quanta" through a homogeneous synthesis which we "create for ourselves" in space and time [A 723/B 751]. Hence, the construction itself goes beyond the empirical concept of matter as moveable and passes to the intuition which exhibits the concept of motion *in concreto*. [A 722n] So constructed, the concept is a priori, and is given in a determinate fashion, without the help of empirical data.[A 724/B 752]

To understand why Kant thinks determinate concepts of quantity are so important to the *Metaphysical Foundations*, we must consider them in relation to his claims about cognizing empirical concepts in the Schematism. For example, Kant claims at [A 147/B 187] in the *Critique of Pure Reason* that the concept of substance has no objective meaning unless it is schematizable. He summarizes the problem thus:

> The categories, therefore, without schemata, are merely functions of the understanding for concepts; and represent no object. This [objective] meaning they acquire from sensibility, which realises the understanding in the very process of restricting it. [A 147/B 187]

Hence, if Newton's laws invoke a concept of quantity of motion, according to the Kantian scheme, the concept must correspond to an a priori construction in intuition. The point of constructing such a concept is to show that features of the concept employed in Newtonian laws has an a priori counterpart conforming to the conditions of the schematism, and hence, that the concept is not an empty one. Without a sensible determination of a concept of quantity, the representation of quantity is useless. As Kant says, "it tells me nothing as to the nature of that which is thus to be viewed as a primary subject." [A 147/B 187] (i.e., concepts without intuitions are empty, and intuitions without concepts are blind [A 51/B 75])

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representations to be Euclidean; for they must reflect Kant's fixed geometry of perceptual space.

In the Preface to the *Metaphysical Foundations* [470], Kant says that the activity of "determining" a concept requires a demonstration of its intuitive basis. Since constructing a concept demonstrates the intuitive basis of the concept, it is by this procedure that an empirical concept is determined in critical philosophy.

Kant's motivation for wanting to construct concepts of quantity is clear. But the Phoronomy, which has dealt only with kinematic properties, is the only chapter in which Kant carries out anything like rigorous constructions. What remaining portion of his special doctrine of body -- the metaphysical concept which in the Preface he claims to have exhausted -- can be but has not yet been mathematically treated, and hence, brought into unison with his constructions in the Phoronomy?

I argue that Kant hoped to show the dynamical concept of *quantity* of matter to be constructible, that it satisfies his conditions on concept construction, thereby uniting this "metaphysical portion" of the *Metaphysical Foundations* with the mathematical treatment of motion. Hence, I see a much greater role in the argument of the *Metaphysical Foundations* for the criteria of concept construction elucidated in the Phoronomy than does Friedman, or for that matter, those who make matter theory more central than he does. The primary work done by the Phoronomy is that it establishes that the kinematical concept of quantity of motion can be represented a priori. But it also states criteria of concept construction which I believe to have much more general significance in the *Metaphysical Foundations*, and in particular, to Kant's dynamical and mechanical concepts of quantity of matter and quantity of motion. On my reading, the *Metaphysical Foundations* reveals that Kant held an interest in attempting to construct ideal counterparts to quantitative features of the empirical concept of matter in Newton's laws within the constraints of the critical formalism. As it turns out, this appears to land Kant with a peculiar conjunction of mechanistic and dynamical concepts of matter.

To begin, consider the textual support for the claim that Kant wanted to construct the dynamical concept of quantity of matter. If Kant thought that constructing the dynamical

concept of quantity of matter could complete his mathematical treatment of the concepts and principles of Newtonian science, then we can expect to find some indication of this in the *Metaphysical Foundations*. Evidence of Kant's concern with constructing the concept of quantity of matter is to be found in the second half of the Dynamics [517-535].

Beginning at Proposition 8 of the Dynamics, Kant discusses the possibility of constructing the dynamical concept of matter, linking this to a law of forces. Kant says that he is unable to construct the dynamical concept of matter. The obstacle to this construction relates to his inability to represent matter according to a "law of the relation of forces". Kant speaks as though such a law describing how opposing forces limit each other is possible, but that the magnitude of this law is unknown. He summarizes the quandary as follows:

> ...from this force [the attractive force], in combination with its counteracting one, namely, repulsive force, the limitation of this latter, and hence the possibility of a space filled in a determinate degree, must admit of being derived. And thus would the dynamical concept of matter as the movable filling its space (in a determinate degree) be constructed. But for this construction one needs a law of the relation both of original attraction and of original repulsion at various distances of matter and of its parts from one another. Since this relation rests solely on the difference of direction of both these forces (inasmuch as a point is driven either to approach others or to recede from them) and on the size of the spaces into which each of these forces diffuses itself at various distances, this law is a pure mathematical problem, with which metaphysics is no longer concerned. Metaphysics is not responsible if the attempt to construct matter in this way is not crowned with success. [517]

This passage shows that Kant thought of the "law of the relation of forces" as a function of the direction of the original forces and the distances between matters 20. The salient feature of

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20 Boscovich, in his 1763 Theoria philosopiae naturalis also spoke of a `law of forces', whose magnitude was conceived as a function of the distance between matters. Boscovich's concept of a law of forces may shed light on Kant's idea of a law of the relation of forces. In §10, Boscovich argues that the distance between matters determines the magnitude and nature of the force acting on a matter. For example, a repulsive force can diminish and actually change into an attractive forces an vice versa:

> Now the law of forces is of this kind: the forces are repulsive at very small distances, and become indefinitely greater and greater, as the distances are diminished indefinitely, in such a manner that they are capable of destroying any velocity no matter how large it may be, with which one point may approach another, before ever the distance between them vanishes. When the distance between them is increased, they are diminished in such a way that at a certain distance, which is extremely small, the force becomes nothing. Then as the distance is still further

the above description is that such a law could legitimate the construction of the dynamical concept of matter. That is, given an empirically determined law of the relation of forces, Kant thinks it would be possible to justify the representation of quantity of matter in terms of direction and distance, each of which meet the criteria for constructing concepts of quantity given in the Phoronomy.

On the basis of what Kant says about constructions in the Phoronomy, the mathematical representation of quantity of matter would depend on the following three conditions: The first condition is that the representation be based on the intuition of determinate things in space and time [487]. This condition is met because the representation is of "the various distances of matter and its parts from one another" [517]. For Kant, bodies, and the distances between bodies and their parts, are possible objects of experience which can be given in sensible intuition. The second condition is that representations be subject to the rule of composition of motions [486]. In the Phoronomy, this condition ensures that the representation of matter reflect the distinction between the appearance of a moving body and the form of space given in intuition. Through a law of the relation of forces, quantity of matter is also described as a function of an opposition between two or more moving things; bodies and parts of bodies. So, in the Dynamics, this condition reflects the distinction between the moving parts *in* a body and the moving body *as a whole*. The third condition requires that the representation be mathematically tractable in terms of the operations of addition and

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> increased, the forces are changed to attractive forces; these at first increase, then diminish, vanish, and become repulsive forces, which in the same way first increase, then diminish, vanish, and become once more attractive; and so on, in turn, for a very great number of distances, which are all still very minute: until, finally, when we get to comparatively great distances, they begin to be continually attractive and approximately inversely proportional to the squares of the distances. This holds good as the distances are increased indefinitely to any extent, or at any rate until we get to distances that are far greater than all the distances of the planets and comets. (Child 1922: 39-43; cited in Jammer 1957: 176)

Important differences exist between Boscovich's view and Kant's view. Kant conceives of two opposing forces which act simultaneously and make possible matter in a determinate degree. Boscovich conceives of one force which acts in two contrary modes at different distances. Nevertheless, Boscovich's view attempts to account for the density of matter and it does this by relating the distances between matters and the law-like interaction of opposing forces. So Boscovich's law of force shares some of the features of Kant's law of the relation of forces.

subtraction [489]. A law of the relation of forces would license the representation of quantity of matter through the subtraction and addition of homogeneous parts.

Both the notion of a law of the relation of forces and the construction of the dynamical concept of quantity of matter are recurring themes in the Dynamics. Between [519-522], Kant envisions a method for constructing the dynamical concept of matter through the "action and reaction of fundamental forces" which makes possible a determinate degree of a body's filling of its space. Between [522-534] Kant makes numerous similar references: He speaks of the law of the relation of forces [524], the law of the expansion and compression of the parts of matter [522], the law of fundamental forces [525] and the law of attractive and repulsive force [534], never making a marked distinction between these "laws". In the Dynamics, the discussion is crowned by the claim that the dynamical explanation of how "the repulsive force can with regard to one and the same attractive force be originally different in degree in different matters" would account for how the "quantity of matter may as regards the same volume, i.e, density of the matter, admit originally of very great specific differences." [534]

Kant's story of the construction of quantity of matter through a law of the relation of forces culminates in the obscure promise of a representation of matter's density as "specific variety". As Plaass writes, it was important to Kant to present the moments to which matter's specific variety could be reduced a priori, "i.e. the moments [necessary parameters] of the original moving forces and therefore of the different kinds of matter that may occur empirically," (Plaass 1994: 329).21 What Kant appears to maintain is that density can be explained if the attractive force is equal in all materials, while the repulsion of different materials differs [534].22 In this way, Kant's imagined law of the relation of forces would justify the dynamical construction of quantity of matter in relation to density. Hence the

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Plaass's editors explain *"Spezifische Verschiedenheiten*", or specific variety, as "reducible, in the final analysis, to the diversity of possible kinds of attractive and repulsive forces that are characteristic of matter," (Plaass 1994: 48).

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Kant uses this very expression in a letter to Beck dated October 16, 1792 (Forster and Rosen 1993: xxxvi).

envisioned law of the relation of forces would express a formula for determining the quantity of matter associated with the dynamical concept of matter.

Although Kant's text makes it quite clear that he had *some* sort of reasoning in mind regarding the constructibility of the dynamical concept of quantity of matter, it is difficult to imagine exactly what he thought such a construction might be like. In terms of the Phoronomic concept of quantity of motion, Kant's sense of mathematical construction is reasonably clear: Intuitions of moving things in space and time are given in the synthesis of a manifold of parts, and the intuited content related to extended objects can be represented as an extensive magnitude under mathematical categories of quantity [A 162/B 202]. But the situation for *quantities thought in relation to categories of quality* is rather less straightforward.

Nevertheless, if a quantity of matter thought in relation to the dynamical concept of matter is to be meaningful, or "really possible", it must be constructible. In a letter to Tieftrunk on December 11, 1797, Kant rhetorically describes the problem of emptiness by posing the question: "For example, is there anything that is an extensive magnitude while also having intensive magnitude, that is, reality?" [XII, 222-5].23 If the answer is negative, then the dynamical concept of matter must be an empty one. But the *Metaphysical Foundations* gives little reason to believe that Kant thinks the dynamical concept of matter is an empty concept. The critical task is to show that this concept has some a priori constructible content contained within it. The logic behind Kant's discussion of construction in the Dynamics then, must be to show that a construction of extensive quantity of matter is a meaningful reflection of the intensive magnitude due to the net effect of forces on a body.

The problems associated with the failure to construct quantity of matter do not remain localized. In the Mechanics, Kant defines the mechanical concept of quantity of matter as "the number of moveable parts in a determinate space" [537]. But this quantity, considered mechanically, cannot be meaningfully constructed in the geometrical sense; for in the mechanical sense, quantity of matter can only be estimated in relation to quantity of motion

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[538]. As Kant explains at [537], this gives rise to a circularity, since the mechanical construction of quantity of motion depends on the construction of quantity of matter.

Kant addresses the circularity which arises for the construction of mechanical concepts of quantity of motion and quantity of matter by appealing to a method for estimating the communication of motion. This method is justified by the mechanical law of action and reaction which states "that every body, however great its mass may be, must be moveable by the impact of every other, however small its mass or velocity may be" [548]. Regarding this law, Kant says that we might not want to take the "transference of motion from one body to another" literally. "The problem here is how to make conceivable this possibility whose explication rests exactly on the same ground from which the law of equality of action and reaction is derived" [550]. This ground, Kant goes on to explain, is in our thinking of any two bodies which collide, " that there are forces belonging to both (dynamically) before all motion." [550].

So Kant addresses the circularity facing the construction of mechanical concepts of quantity by pointing to a method for constructing the communication of motion; but this method presupposes a dynamical concept of matter, i.e., a concept of matter which is based in force, just as is described in the Dynamics. Ultimately then, it is a successful construction of a dynamical concept of matter which would be needed to complete the a priori determination of the empirical concept of matter.

(ii) Kant's Constructions and Newton's Concepts and Laws

Granted that Kant was interested in, but unable to construct the dynamical concept of matter, how does all of this bear on the hypothesis that the *Metaphysical Foundations* contains a defense of Newton's empirical concept of matter? To see how Kant's interest in constructing the concept of quantity of matter in the Dynamics might pertain to the metaphysical foundation of a *Newtonian* concept of matter, we must turn our attention momentarily to Newton's empirical concept of matter.

Translated in (Zweig 1967).

There are two primitive notions that seem to have dominated Newton's empirical concept of matter; the concept of quantity of matter, which arises from bulk and density, and the force of inertia, the power of resistance to change of motion, and also "the power of persevering in motion," (Cajori 1934: 399; cited in Jammer 1961: 71). As Jammer points out, these two notions are primitive in the sense Newton defines for universal qualities of bodies in Rule III of his "Rules of Reasoning":

> In his Rules of Reasoning, at the beginning of the "System of the world", Book III of the *Principia*, Newton characterizes as universal qualities of all bodies those qualities that "admit neither intensification nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments." Extension, impenetrability, and mobility exist in the whole body because they exist in the parts; they are properties whose range of applicability, so to speak, extends both to fundamental particles and to macroscopic bodies composed of the latter. The same holds, according to Newton, for inertia, whereas gravity, as diminishing with distance from the central body, is not reckoned among the universal properties of matter. (Jammer 1961: 70)

What Newton called quantity of matter or body, we now refer to as inertial mass. This concept, in effect, lumps Newton's two central notions together, expressing the idea that resistance to change of motion is different in different bodies but a constant for the same body. Although Newton realized that different bodies summon different resistances, it is unlikely that Newton himself tied the concepts inertia and quantity of matter together as tightly as we do today when we refer to inertial mass. As Jammer points out, Newton's concept of quantity of matter bears associations which we do not today equate with the concept of inertial mass.24

Some of these additional associations emerge even in Newton's definition of quantity of matter. In Book I, Definition I of the *Principia* Newton states that "The quantity of matter is the measure of the same, arising from its density and bulk conjointly,". Hence, Newton's concept of quantity of matter is expressed as a measure of density and bulk (Cajori 1934: 1). A lack of sensitivity to the distinction between inertial mass and Newton's definition of quantity

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24 See Chapter 6 of (Jammer 1961).

of matter has led to criticism of this definition.25 For if quantity of matter is taken to be synonymous with inertial mass, then Newton's definition appears to be circular, since density itself is just mass per unit volume. But, if Newton does not intend "quantity of matter" as synonymous with "mass" in Definition I, then he appears to have neglected to define "mass" in the *Principia*, one of the central concepts of Newtonian mechanics.

While the importance of defining inertial mass in Newtonian mechanics may seem obvious from a modern perspective, if Newton conceived of the concepts of quantity of matter and force of inertia as distinct primitives, then his inclination to define them separately, and in terms of additional physical concepts is understandable. From our perspective, Newton's definition of quantity of matter in terms of density is surprising,

> ... for Newton, in contrast to "Newtonian mechanics", "inertial mass" is a reducible property of physical bodies, depending on their "quantity of matter". For Newton the concept of *quantitas materiae* is still a concept of physical significance. Now, since bodies of equal volumes possess, in general, different inertial forces, their "quantities of matter" have also to be different. An "intensive", in the sense of volume independent, factor has thus to be identified as responsible for the difference of *quantitas materiae* in bodies of equal volumes, in general. And this factor, because of the property of inertia of being universal, has also to be a characteristic of the smallest particles conceivable. This factor, in a purely intensive, qualitative sense, and irreducible just like the notion of affinity in classical chemistry, is identified by Newton as "density". (Jammer 1961: 72)

In addition, associations between concepts such as quantity of matter, mass, density and inertia were not exactly the same, nor so uniform, in Newton's era as they are today. Jammer points out that Kepler referred to the volume of a body and the density of its matter as the constituent factors of inertia (Jammer 1961: 70). Like Kepler, Newton closely associates density and bulk with the concept of inertia. Newton says that bodies of the same density are those whose inertias are in the proportion of their bulks.26 And Euler is said to have followed Newton when he wrote that "The force of inertia in any body is proportional to

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Jammer (1961: 69) points out that Volkmann and Mach were highly critical of Newton's definition of quantity of matter: on Volkmann's analysis, Newton's definition exhibits the circularity problem to which I refer in the main text. Mach objects not only to the circularity in the definition, but also of the slippery and uncritical use of terms such as "quantity of matter" and "mass" which was commonplace in Newton's time.
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the quantity of matter which the body contains" (Jammer 1961: 88). Hence natural philosophers in Newton's era grouped together a bundle of concepts including mass, density, quantity of matter and inertia, although the precise relationships between the concepts were not always well defined.

In fact, Newton relates the concepts of inertia and density so closely, that it is often unhappily remarked that he defines mass in terms of density, thus reversing what has come to be regarded as the natural order of conceptual priority by making mass secondary to density (cf. Jammer 1961: 66-70). Moreover it sometimes appears, from what was said above, that Newton describes density as anterior in some sense to both the notions of quantity of matter and inertia. While conceptual priority does not always imply methodological priority, it does not seem unwarranted to suppose that Newton expected that the measure of density would be more fundamental than the measure of quantity of matter and inertia. The only sense in which Newton's treatment of density is surprising, is that the concept of density was not mathematically tractable in Newton's time; seventeenth century scientists did not have access to the derivative theory of measurement needed to measure density.27

When speaking of Newton's empirical concept of matter then, I do not mean to refer to the concept of inertial mass as it is understood today. First of all, Newton distinguishes the force of inertia and quantity of matter as distinct and independent primitives. Secondly, the concept of quantity of matter must be understood in the context of the bundle of associations this concept held for Newton and other seventeenth century scientists. Of particular significance is the concept of density, since Newton indicates that it underlies both the concepts of quantity of matter and inertia.

(Cajori 1934: 414), [Proposition VI, Corollary IV, Book III]. As Jammer points out, Newton does not include a formal definition of density in the *Principia*.

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If Newton is thinking of quantity of matter as defined in terms of density, then an account of density in terms of, say, atoms and void, adds nothing to the mathematical -- or procedural -- tractability of the concept. This is not to say that there is a difficulty in principle, since if matter is composed of atoms, then density can be determined by counting up the number of atoms and considering how many of them there are in a given volume of space. But Newton

The fuzziness of the concept of density in the seventeenth century may be at the root of the obscurity in Kant's reasoning in the Dynamics. At this time, density was often conceived in terms of specific gravity, length and time.28 If Kant's concept of the specific variety of matter is tied to that of specific gravity; that is, if the "original forces" through which matter fills its space are thought by Kant to account for specific gravity (and ultimately density), then Kant's construction of the dynamical concept of matter may aim at linking density to the geometrical representation of quantity of matter, a link which is suggested in Newton's definition of quantity of matter. Perhaps it is the goal of constructing these fundamental concepts in Newton's taxonomy which motivates Kant when he suggests that density can be accounted for by the character fundamental forces:

> And since the degree of repulsive force has of itself nothing in common with the attractive force, which is proportional to the quantity of matter, the repulsive force can with regard to one and the same attractive force be originally different in degree in different matters. And consequently the degree of extension of the matters may as regards the same quantity of matter and, conversely, the quantity of matter may as regards the same volume, i.e., density of the matter, admit originally of very great specific differences. [534]

In the *Metaphysical Foundations*, Kant does include the concept of inertia, but here under the rubric of the Mechanics. In the Mechanics, Kant uses virtually the same words as Newton to describe inertial motion, when he says that "Every body remains in its state of rest or motion in the same direction and with the same velocity unless it is compelled by an external cause to forsake this state".29 Kant holds that inertia can be grounded a priori, but only in relation to appearance, and under the category of causality. His treatment of inertia in the Mechanics shows that he recognized the importance of establishing a philosophical foundation for the law of inertia. This recognition, and the choice to ground inertia as a law of mechanics rather than as a dynamical property of matter, point in favour of our viewing Kant

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no more had a method for counting atoms than he had a method for determining density mathematically.

28 (Jammer 1961: 67); Jammer cites (Crew 1928: 124n 12) on this point.

29 Newton says "Every body continues in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed upon it." [Axioms, Law I, Book I] (Cajori 1934: 13).

as interested in providing a philosophical foundation for Newtonian science rather than in underwriting Newton's taxonomy with Leibnizean concepts.

On my reading, then, constructing the specific variety of matter is a key step in the special metaphysical determination of *Newton's* concept of matter30. So it is not entirely clear that Kant's goal in the Dynamics stands at odds with anything essential in Newton, or at least that Kant thought it did. But in Okruhlik's view, Kant's purpose is to reject the force of inertia while retaining a meaningful concept of mass. For Newton, Leibniz and all of Kant's predecessors, inertia was described as a "power" of a body. Kant is thought to have been reluctant to attribute such a "power" to matter, and for this reason to have rejected Newton's formal definition of inertia. But such a rejection of the force of inertia seems to count against the view that Kant wanted to defend a Leibnizean taxonomy for ontological reasons. For, if Kant was *ontologically* committed to a Leibnizean taxonomy, then by all rights, this fundamental Leibnizean property of matter should be described in the Dynamics, along with the attributes of force and impenetrability. This is where the discussion of inertia as one of the chief dynamical properties of matter fits conceptually. Although this is Kant's stated aim in

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It must be acknowledged that on my reading, the distinctions between Leibniz's concept of matter and the Newtonian concept that Kant found in the *Principia* are less pronounced than commentators such as Brittan and Okruhlik suggest. Depictions of Newton's empirical concept of matter are often based on Query 31 of the *Opticks*, where Newton speaks of "solid, massy, hard, impenetrable, moveable Particles". However, as Friedman points out, "Kant disputes the 'common opinion' that Newton is able to do without the assumption of an immediate attraction at a distance as an essential property of matter..." (1992: 139). To the extent that Newton expresses reservations over this point, Kant criticizes him for not being "Newtonian" enough. Despite the passages where Newton himself seems to lean towards an atomistic conception of matter, such as Query 31, Kant appears to take the mark of a Newtonian theory of matter to be the inclusion of forces amongst the essential properties attributed to matter. (See also the Preface to Kant's *Theory of the Heavens*, where he explains that his two forces of attraction and repulsion are "both borrowed from the philosophy of Newton" [I, 234-235], cited in Friedman (1992: 139)). However idiosyncratic it may seem, Kant appears to claim a Newtonian inspiration for his dynamical concept of matter -- it is in this sense that his concept of matter is to be understood as "Newtonian". Even if Newton himself might have disavowed any responsibility for such a view, there is reason to think Kant drew on Newton's *Principia* for his account of concept construction in the *Foundations*, and that what he found there were definitions (Cajori 1934: 1) he read as supporting a force based view of matter [534]. Hence we can understand Kant's method as one of couching his dynamical constructions [517] within Newton's definition of quantity of matter in the *Principia*. On this account we need not turn to Leibnizean ontological commitments or a Leibnizean taxonomy to understand Kant's defense of Newton's empirical concept of matter. While my reading may appear to play on an equivocation in labelling Kant's theory of matter "Newtonian", it does shed some light on Kant's intentions in framing

1747 [I, 117], Kant ignores inertia in the Dynamics, and never attempts to reflect a Leibnizean treatment of inertia.31

There are good grounds then, for supposing that the empirical concept of matter which interested Kant was the Newtonian concept. Indeed, if the above account is correct, then there are strong indications that the constructions which interest Kant are those which can be related to Newton's concepts and laws given in empirical synthesis under concepts and rules. If so, Kant is ultimately defending an empirical concept of matter which is Newtonian. For Kant is defending the construction of concepts of quantity because they are featured in the empirical concepts of Newton's laws.

Kant's juxtaposition of mechanical and dynamical views of matter can be made sense of in light of the criteria and role of mathematical construction, the a priori foundation concept construction provides for laws of science, and even in light of Newton's own description of quantity of matter. Kant scholars have been aware of the importance of all of these elements in Kant's special metaphysical reasoning. So why has this interpretation of the role of matter theory in the special metaphysics not already been canvassed? The chief obstacle to developing this line of reasoning stems from the sort of reading of Kant's dynamical and mechanical views of matter defended by Brittan, in which two grand hypotheses about the nature of matter -- the "mathematical -mechanical" and the "metaphysical-dynamical" -- attributable to Kant's dogmatic predecessors are superimposed onto the empirical concept of matter of interest to Kant and Newton. To be fair, Kant's reasoning about the constructible features of the empirical concept of matter in the *Metaphysical Foundations* is obfuscated by a second theme running through the text; that of the juxtaposition of mechanical and dynamical "modes of explicating matter". These modes of explicating matter are linked to contradictory ontologies by Kant's metaphysical predecessors and successors, and are both

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that theory, namely, that Kant did not see himself as standing in essential disagreement with Newton in this regard.

31 Okruhlik agrees that Kant wants to reject Leibnizean inertia; on this count, she reads Kant as rejecting the views of both Leibniz and Newton. What I want to maintain is that Kant's rejection of Leibnizean inertia counts to some extent against the view that Kant is defending a Leibnizean taxonomy in the special metaphysics.

"assumed" for theoretical purposes in Newtonian science. To those who see the argument of the *Metaphysical Foundations* as underwritten with ontological concerns, Kant's preference for a "dynamical" concept is characterized in terms of the dynamical mode of explicating matter defended by Leibniz, and is seen as a rejection of the mechanical view of matter assumed in Newtonian mechanics.

Kant's strange conjunction of dynamical and mechanical representations of matter need not have been motivated by ontological concerns. I suggest that an alternative account of Kant's preference for a dynamical concept of matter is possible. Quite simply, Kant's preference for the dynamical account can be understood in relation to his goal of exhibiting the a priori necessity attached to the concepts characteristic of the laws of Newtonian science, by showing that Newton's concepts of quantity of motion and matter are exhibited in objects given in intuition.

To provide a philosophical foundation for Newton's concept of matter, Kant would have had to construct the quantity of matter. The arguments in Kant's Mechanics show that quantity of matter can only be estimated mechanically in relation to quantity of motion in Newtonian mechanics [538-42]. But the mechanical estimation of quantity of motion cannot stand in place of Kant's exhibition of the mathematical construction of quantity of matter, which must be based on intuition of the quantity of matter itself. Kant's criteria for constructing concepts of quantity stipulate that justifiable representations must exhibit possible objects of experience a priori based on empirical intuition. Hence Kant's preference for a dynamical construction of matter can also be made sense of in light of his desire to show that the cognition of the empirical concept of quantity of matter contained in the law of gravity is strongly determined a priori.

There is an interesting connection between Kant's a priori foundation for Newtonian space-time and the problem of constructing Newton's concept of quantity of matter. The structure of Kant's argument in defence of matter theory echoes the structure of his argument in defence of Newtonian space-time. Friedman shows that Kant's defence of absolute space

in the Phoronomy depends on the a priori foundation in relative motion given it in earlier chapters. Similarly, Kant's philosophical foundation for Newton's concept of quantity of matter has embedded within it the problem of constructing the dynamical concept of matter. That is, parallel styles of argument occur with respect to matter theory and to the structure of space-time in the *Metaphysical Foundations*. Friedman sees Kant's defence of relativistic motion as part of a defence of Newton's formalism. I would add that Kant's account of matter theory is directed at the same end.

Given Kant's views on construction, and Newton's links between quantity of matter, inertia and density, the argument of the Dynamics can be regarded as part of a defence of Newton's concept of matter. The difficulty confronting Kant's readers is that Kant does not make explicit why such determinations of matter are important in his special metaphysics. The reason is that the construction of quantity of matter plays a role in establishing that the a priori constraints which apply to the intuition of quantity of matter are linked to Kant's justification of the necessity attached to the law of gravity.

While Kant succeeded in constructing the kinematical concepts of quantity of motion, he never succeeds in demonstrating that the laws of mechanics follow a priori from the possibility of the mechanical concept of quantity of motion (mv) or in constructing the dynamical concept of matter. Hence, he never secures his philosophical foundation for Newton's laws of motion (and indirectly the structure of space-time), nor does he bring his doctrine of motion into unison with his matter theory. The relevance of this, is that without the construction of quantity of matter, Newton's remarkable proof that all bodies are affected by a force in proportion to their quantity of matter raises a challenge to the critical philosophy which Kant is unable to meet. Without a justified mathematical construction of quantity of matter, Kant is unable to show in the strong sense, that a priori constraints on empirical concept formation play a role in determining the contents of the empirical concept of matter contained in Newton's empirically derived law of gravity. Hence, Kant is unable to demonstrate all of the senses in which constitutive elements and regulative elements in the categorical structures determine science a priori, a demonstration which the critical system anticipates.

For this reason, perhaps, Kant was not unmoved by the problem of constructing quantity of matter: In the Dynamics, he says that the foremost of all the problems in natural science is "the explication of a possible specific variety of matters extending to infinity" [532]. Moreover, while he admits in 1786 that he is "unable to furnish an adequate explication of the possibility of matter and its specific variety from the fundamental forces", Kant continued to mull over the issue for years after he wrote the *Metaphysical Foundations*. In a 1792 letter to Beck, Kant, still caught in the vortex of the problem of constructing matter's specific variety, writes:

> The greatest difficulty is to explain how a specific *volume* of material is possible by the inherent attraction of its parts in the ratio of the *inverse square* of the distance, [in conjunction] with a repulsion, which can only affect those parts which are in immediate contact (not those at a distance), in the ratio of the *cube* of the distance (and hence its volume). Thus the power of attraction depends on density, but density depends again on the power of attraction. Also, density varies in accord with the inverse ratio of repulsion, that is, of *volume*. [XI, 376-7]32

So it seems that Kant continued to consider construction of the concept of quantity of matter a pressing problem. Indeed, this construction may have been for him the ultimate test of the critical system, perhaps constituting, in part, the famous "gap problem".

(iii) The Construction of Quantity of Matter: The Problem of Constructing Intensive Magnitudes

In the Dynamics, the "object thought as quantum" is quantity of matter, and this quantity is conceptually linked to a degree of intensive magnitude, i.e., force. But intensive magnitudes such as forces are not themselves constructible in the sense Kant defines in the Phoronomy; for we do not perceive a determinate degree of intensive magnitude in the "synthesis of the homogeneous" [A 169/B 210]. Moreover, intensive magnitudes are not necessarily additive in the same sense that extensive magnitudes are: For example, 13 1/2 volumes of water will not add up to the density of a volume of mercury; even though a given

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Thanks to R.E. Butts for bringing this passage to my attention at my prospectus defence (March 1993), and for providing the translation of it; and to Lorne Falkenstein for supplying the complete reference for it. The passage is also cited in the Introduction to (Forster and Rosen 1993).

volume of mercury *is* 13 1/2 times more dense than the same volume of water. So the sense of mathematical tractability Kant defines for the construction of extensive magnitude does not apply to intensive magnitude. Indeed, the explicit criteria of construction described in the Phoronomy seem to be intended only for the representation of extensive magnitudes.

So the question is, how can the dynamical concept of matter be a fit subject for construction? For the dynamical concept of matter includes the concept of an extensive magnitude which also has intensive magnitude; and only the former magnitude admits of geometrical construction. One might wonder then, if it even makes sense to think of the dynamical concept of matter as constructible.

One possible clue to this puzzle may lie in Kant's claim that categories of quantity and quality are *both* mathematical and constitutive of knowledge of objects a priori [B 110]. This claim suggests that there is some sense in which concepts brought under the categories of quality are capable of mathematical treatment. Indeed, it suggests that it may be possible to "go beyond the empirical concept" which is understood purely qualitatively and "pass to the intuition which exhibits the concept"; and that it may therefore be possible to mathematically construct quantities related to concepts of quality [cf. A 722]. How Kant might have meant for concepts of quality to be given mathematical treatment is far from clear. Kant certainly does not give a complete account, and there is no prima facie ground to think that such an account is even really possible. There are hints as to how Kant thought such an account might proceed, which I will try to lay out in the next few paragraphs; but I shall have to reserve a complete treatment of this topic for a later date.

I suggest that the primary clue may lie in the Doctrine of Method, where Kant says that there are actually two types of mathematical constructions: 1) geometrical constructions and, 2) symbolic constructions [A 717/B 745]. The former, Kant writes, are constructions of magnitudes (quanta) "as in geometry", and these have to do with the intuition of objects. The latter are constructions of magnitudes (quantitas) "as in algebra", and these are abstracted from the constitution of objects. While constructions of extensive features descriptive of

quantity of motion and matter are clearly of the former, geometrical kind, it is worth considering the possibility that intensive magnitude associated with objects of experience is mathematically constructed in the latter, symbolic sense. In order to assess the suggestion that forces are symbolically constructed, we will look at Kant's view of symbolic construction. It may be that a robust account of his views on mathematical construction can help to explain the sense in which Kant thought matter filling space due to forces could be mathematically constructed.

Construction is described by Kant as a method for exhibiting in intuition the a priori content of a concept. In geometrical construction, a successive iteration of points generates an ideal representation of a given extensive magnitude. Hence, geometrical construction is a method for the spatial representation of an extensive magnitude. According to Friedman, symbolic constructions are also characterized by the repetition of an operation, although the operation which is iterated is not the iteration of points. Symbolic constructions apply to magnitudes described algebraically or arithmetically, and hence, they can represent magnitudes which do not necessarily lend themselves to a geometrical (in Kant's sense) construction.

While symbolic constructions do not exhibit the intuition in space corresponding to a concept, they must be linked to a priori intuition in time. Time, Kant says, is "a rule for the synthesis in imagination for the production of images" [A 162/B 182]. As the most general form of synthesis in intuition, time is the basis for all representations. Kant writes; "The pure image of all magnitudes of the outer sense is space, of the objects of the senses in general, however, is time." [A 142/B 182] In relation to mathematical construction, what this means is that magnitudes which have external determinations are geometrically constructible; but that all representations of magnitude must bear a relation to time. The implication is that both extensive and intensive magnitudes can be exhibited a priori in time.

Both Friedman (1992: 115-16) and Winterbourne (1988: 62) argue that Kant's symbolic constructions link algebra and time. Friedman thinks that the idea behind symbolic

construction is to represent a magnitude, e.g., an algebraically described magnitude, in so far as it exhibits the successive progression underlying the number series or the operation of a calculus (Friedman 1992: 119).

The one extensive discussion that Kant gives us of a symbolic relationship occurs in the *Critique of Judgement*. There Kant shows us that beautiful objects and the good will are analogues; indeed, he argues that a beautiful thing is a symbol of a good will. According to Cohen (1982: 233) "a beautiful object is an indirect presentation of the idea of a good (free) will". In Cohen's view symbolic concepts supply ideas which have no basis in possible experience with "marks", which provide in principle for their application to objects. But Kant indicates that symbolic constructions can be linked to geometrical constructions on the condition that the concept symbolized is

> "supplied with an intuition such that the procedure of judgement in dealing with it is merely analogous to that which it observes in schematism. In other words, what agrees with the concept is merely the rule of this procedure, not the intuition itself." [V, 352]

Thus, for Kant, symbolic constructions of magnitude can be linked to geometrical constructions of magnitude just in case the concept symbolized agrees with the rule of the procedure for geometrical constructions. Typically obscure, this description doesn't tell us much about the sense in which the symbolic construction can agree with the rules for geometrical construction.

Indeed, as Winterbourne points out, Kant appears to have two lines of reasoning about the relationship between symbolized concepts and schematism. On the one hand, Kant says that symbols may serve as "marks" or "visible signs" which merely express an analogy to a concept [V, 221]. In such a case, the symbolized concept carries the "analogy to that which is observed in schematism". This analogy, Kant tells us, is drawn from the "rule of the reflection" of the symbolic concept. [V, 352] Therefore, in this instance, the rule of reflection which determines the agreement between the symbol and the concept is expressed by the symbolic concept. As and example of this, Kant writes:

> Thus a monarchical state is represented by a living body if it is governed by laws native to the people, and by a mere machine, like a hand mill, if governed by an individual absolute will; but in both cases only symbolically. For between a despotic state and a hand mill there is certainly no similarity, but there is a similarity in the rules according to which we reflect upon these two things and their causality. [V, 352]

On the other hand, Kant says that symbolic constructions are possible, which implies that an inversion of this relationship between the concept symbolized and the rules for presentation in intuition can occur in symbolic instantiation. While in the former case the connection between a concept and its symbol is merely by analogy to the rule of procedure for the concept, the latter case suggests a determinate relationship between schemata and symbolized concepts.

Winterbourne has a suggestion for sorting out the distinction between the two cases which is helpful for making sense of Kant's notion of symbolic construction. Winterbourne suggests that these two lines of reasoning reflect Kant's distinction between determinant and reflective judgment:

> An explanation for this confusion may be the Third Critique's concern with so-called reflective judgment, in contrast to determinant judgments. What Kant says is that if a universal, in the form of a rule, principle or law, is given, the judgment which subsumes the particular instance under it is determinant: if, on the other hand, the particular instance only is given, reflective judgment concerns finding a universal for it....Now since rules of synthesis of a priori imagination are presupposed in all construction of mathematical objects, such objects must present their concepts, and make them determinate, in a way that is quite different from reflective judgment by means of "symbols", which as Kant says, is representation by "mere analogy". Kant's general theory of mathematical construction mitigates any consideration of algebraic notation as mere marks, even though such notation is "conventional". These symbols are important for Kant as practical devices: but the a priori locus of mathematical construction is the procedure of imaginative synthesis. (Winterbourne 1988: 64)

Winterbourne's analysis suggests that in the case of a determinant judgment in which particulars are subsumed under rules, the rule of construction for a sensible concept must determine the agreement between a concept and its symbol. The implication for the argument in the Dynamics is that the rules of geometrical construction for representing a quantity of matter must determine the symbolic construction of force. Hence, Kant's algebraic law of the relation of forces could only be symbolically constructed if it expressed agreement with rules for the geometrical construction of quantity of matter.

The symbolic construction of the concept of force might require that a construction of quantity of matter similarly furnish marks which provide in principle for the application of concepts of force to objects. Hence, a symbolic construction of force would not involve a direct representation of a degree of intensive magnitude through the successive iteration of points; rather, it would involve linking degrees of intensive magnitude to marks exhibited in the geometrical construction of the concept of quantity of matter. In this way, the geometrical construction would symbolize the idea of a fundamental force, and by providing a determinate representation justify the assumption that forces are in principle applicable to objects of experience. What this would imply for the construction of the dynamical concept of matter, is that "an extensive magnitude which is also an intensive magnitude" would have a two step mathematical construction. In the first stage, a geometrical construction of the extensive magnitude of a body would exhibit the distances between, and directions of, the moving parts of a body. In the second stage, a symbolic construction would justify the assumption that degrees of intensive magnitude are determined a priori in relation to temporal intervals, showing that intensive magnitudes are meaningfully determined by the spatial intervals described in the geometrical construction of quantity of matter.

The example of a musical interval may help to clarify some of these issues.

a b c

m n

Imagine a string, running between points a and c, on the fingerboard of a guitar. Next, imagine a finger stopping the string at point b, such that the distance m is half the distance n. When plucked the portions of string between points a and b and b and c will produce harmonious notes. As far back as Pythagoras the relation between the harmony and the ratio has been noticed and deemed significant. The ratio in question is called the musical interval.

In music, the quality of each note is expressed on an ordered scale of harmonic relationships; it is a measure of the "positions" the respective notes have on a musical scale. Distance can then be regarded as a serial ordering, capable of expression in terms of

numerical proportions. First, consider how this will work with respect to our guitar string. When it is expressed on a guitar string, the musical notation symbolizes a genuine quantitative relationship. Now consider our symbolic expression of the interval with respect to the sounds of the notes in question. While the interval is quantitative in musical terms, it is the quality that each note possesses -- its pitch -- which determines the interval. After all, the interval is a measure of the relationship that the notes have, qualitatively, to one another.

What speaks in favour of the suggestion that Kant may have envisioned a symbolic construction of forces, is possibility of the symbolic representation of qualities, and the mathematically tractable representation of certain objective relations between qualities, i.e. the relations between notes is expressible as a ratio. Like the musical interval, Kant's dynamical construction would be meaningful only if it expressed some invariant relationship such as proportionality between ratios of intensive magnitudes and the representation of the extensive magnitude of a body. Completing such an account, however, would require that formidable obstacles be overcome. While it is possible to envision a set of principles underlying the symbolic representation of musical notes and the relations between them, or forces and the relations between them, it is not quite so easy to see how these principles are then to be related to -- in fact, shown to adhere to -- the principles of mathematics. Unless the constructions are suitably mathematical, it is difficult to see how they could convey the necessity that Kant's constructions in the *Metaphysical Foundation* are intended to establish. There is no doubt that if Kant had such an account in mind, it faced formidable difficulties, difficulties inherited by the interpreter who wishes to follow out the hints that he does have such an account in mind.

And there are hints in the text of the *Metaphysical Foundations* that Kant considered his mathematical doctrine of quantity to include symbolic representations of the degree of intensive magnitude: When Kant says that the general doctrine of construction related to categories of quantity represent three "moments" furnished by space [IV, 495], he may have in mind the sense of "moment" he defines at [A 168/B 210] in the Anticipations of Perception. There Kant defines moment as *the degree or intensive magnitude of reality associated with*

something in the field of appearance.33 If Kant's use of the term "moment" to describe the general doctrine of quantity is intended to associate the intensive magnitude given in appearance with the representation of extensive magnitude in geometrical construction, we have a more complete picture of the sense in which both intensive and extensive magnitude have content which can be exhibited a priori: On the one hand, there is the representation of distance between points and direction of motion as extensive magnitude. On the other hand, there is an iterative procedure generating line and direction through which the temporal element associated with intensive magnitude is symbolically represented. By treating each spatial interval as symbolically related to a degree of intensive magnitude, the mathematical representation abstractly represents degrees of intensive magnitude as "moments furnished by space".

However, it doesn't appear that Newtonian science contains a law expressing a representation of intensive magnitude which agrees with the rule for geometrical constructions, and from Kant's point of view, it may be that the symbolic concept of force remains inadequately linked to a geometrical construction of quantity of matter. If so, Kant's problem in justifying the dynamical concept of matter is defined by the need to show how a geometrical construction of extensive magnitude of matter due to force can be appropriately linked to a determinate law of force for it to be symbolically constructed. So what the law of gravity could not provide, and what Kant may have sought in the law of the relation of forces, was a symbolic construction of forces bearing a meaningful relationship to the procedure of geometrical construction of quantity of matter.

The foregoing illustration of the sense in which Kant may have envisioned a meaningful mathematical construction of the dynamical concept of matter is merely speculative. Kant does refer to a construction of the dynamical concept of matter, but he

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According to Beck (1988: 353n 6):

> "*Moment* is a technical term from Kant's logic, meaning, (among other things) a basic conceptual component in the sufficient condition of something. The four moments in the analysis of the judgement of the beautiful correspond to the four major categories of quantity, quality, relation, and modality."

So the moments are defined by the categorical structure.

gives his readers only clues as to how he thought such a construction might proceed. Still, on this reading, we have an explanation of Kant's remarks to the effect that his demonstration of the mathematical method is incomplete. For the construction of the dynamical concept of matter would only be demonstrated by means of a specific linking of the symbolically constructed force and the geometrical construction of quantity of matter. Moreover, the construction of the mechanical concept of matter itself depends on the dynamical concept of matter for its justification. And since there is no law of the relation of forces, there is no obvious justification for thinking that the symbolic construction of intensive magnitude and the geometrical construction of extensive magnitude is licensed by the nature of the relationship between fundamental forces and quantity of matter. Conceived as such, there is no ready solution for Kant. Nevertheless, we can at least define his problem: The dead end Kant reaches for the construction of the dynamical concept of matter is that a geometrical construction of quantity of matter could not bear any direct relationship to a symbolic construction of the intensive magnitude associated with force except given the appropriate law of the relation of forces.

(iv) The Construction of Quantity of Matter and the Gap Problem

The unresolved problem in matter theory is often viewed as the final chapter of what was necessarily a doomed project. Locating Kant's difficulties in completing his *Metaphysical Foundations* in matter theory aligns favourably with a number of standard readings of the work.[34] But it is not necessary to identify the source of these difficulties as the ontological assumptions Kant shared with his predecessors. Indeed, the problem in Kant's matter theory is one of the chief pieces of evidence in favour of ascribing the ontological views of his predecessors to Kant. The preceding sections of this chapter have attempted an alternative explanation of Kant's difficulty, finding its source directly in the critical philosophy and the doctrine of construction. This alternative reading of the problem also promises to be of use in

34 See for example, Okruhlik (1983), Brittan (1986), McMullin (1978), Ellington (1985), and Westphal (forthcoming).

making some sense of Kant's more arcane comments on the a priori foundations of physics and the gap problem.

A number of Kant's claims, especially in places like *Metaphysical Foundations* [515-517] and his 1792 letters to Beck, appear to support my reconstruction of Kant's problem. In his letters to Beck, Kant himself says that he agonized over the relationship between a body's specific variety and his a priori system of physics. In addition, at *Metaphysical Foundations* [515], Kant approves of Newton's hesitance to speculate concerning the causes of gravity, saying that Newton "rightly abstracted from all hypotheses in answering the question regarding the cause of the universal attraction of matter; for this question is physical or metaphysical, but not mathematical". He later reminds us that Newton's propositions were incompletely developed and "led to the expectation of ever new additions" [XXII, 518] -- apparently because Newton did not fully develop the system of moving forces. The evidence does seem to favour our viewing Kant to be both searching for physical laws of force and an a priori foundation for the dynamical concept of matter.

Kant's discussion of the gap problem in the *Opus Postumum* repeatedly brings together an analysis of quantity of matter, fundamental forces, and the a priori foundation for natural science: There he appears to be brainstorming -- looking for ways to complete his a priori foundation for physics. He considers attraction and repulsion as superficial forces of cohesion and elasticity, and as penetrative forces of gravitation and heat. He also reconsiders the concept of quantity of matter thought in relation to this system of forces, invoking ultimate media such as the calorique and ether, as ultimate explanations for quantity of matter due to forces (Forster and Rosen 1993: xxxix). What Kant claims to be looking for is a doctrine of body which can illuminate the "possibility of establishing a priori a system of empirical representations (which otherwise appeared impossible) and of anticipating experience *quod materiale*" [XXII, 502].

Given an understanding of how Kant's mathematical construction of quantity of matter fails in the *Metaphysical Foundations*, Kant's goals in the *Opus Postumum* become somewhat

less obscure. Remarkably, we find the same problems Kant describes for the construction of quantity of matter in the *Metaphysical Foundations* to be a recurring theme in his final work. In 1792, Kant supposes that the net effect of gravitational and original attraction differs in relation to the repulsive force, which itself "differs in different matters", and that this might account for the specific variety of matter. It is this aspect of the gap problem which leads to a circle. As Kant writes:

> I would of course set up the solution of this problem as follows: that attraction (universal, Newtonian) originally is equal in all materials while only the repulsion of different materials differs, and thus constitutes the specific differences of density. But this leads in a certain way to a circle I can't get out of and about which I must try to understand myself better. [XI, 376-77]

To Kant, this circularity suggests that some further elementary law must account for the specific variety of matter. Fruitlessly seeking an escape from this circularity, he hoped a solution could be found in the explanation of quantity of matter due to moving forces in terms of the ultimate medium filling the whole world-space, or ether. As Werkmeister puts it, such a transition would

> " constitute itself a special system, namely, that of the moving forces of matter --[a system] which, being connected above with the metaphysical foundations and below with physics (the rational principle with the empirical), forms a bridge across a gap (hiatus) without which the tendency [toward transition, i.e., the demand of reason] could not achieve its goal. (Werkmeister 1980: 114)

When considered in connection with the speculation that the gap in Kant's system is due to a missing law of physics, we may understand the goal of the transition in the following way: In Newtonian science, the law of gravity itself depends on quantity of matter (density); but Kant's sought after justification is for a construction of a quantity of matter (viz. specific variety of matter) which is conceptually linked to a dynamical concept of matter which is itself explained in relation to the net effect of intensive magnitudes. If transcendental philosophy could lead Kant to discover a physical law of forces which would describe the ratio of forces in relation to a ratio of distances between parts of a body and distances between bodies, then Kant could properly complete the construction of his dynamical concept of matter.

Admittedly, the sense in which Kant's transcendental philosophy was envisioned as a transition to physics remains very opaque. Indeed, Kant may have extended his view of the role of transcendental philosophy in relation to physics in the *Opus Postumum*, imagining that the correctness of the critical system could guide him to the elementary law he needed to complete his construction of quantity of matter. While not itself a scientific endeavour, such a transition required that Kant use his system of a priori representations as a clue to finding a scientific law which would advance his cause.

This reconstruction connects Kant's problems in the *Metaphysical Foundations* and *Opus Postumum*, uniting them in light of the goal of constructing concepts of quantity contained in empirical laws of science. For Kant's transition project appears to be driven by a desire to complete the system linking a priori representations, appearance and physics outlined in the *Metaphysical Foundations*. Although these difficulties originate in his special metaphysics, Kant seeks a solution in a "special physics". There, his search for an ultimate physical law is guided by critical philosophy, but leads to a study of physical laws governing matter's motion.

If this account of Kant's special metaphysical reasoning and its significance is accurate, then Kant's a priori justification of Newtonian science may indeed be at the source of the transition project. Kant may have thought that if all the forces acting on a body were accounted for, the specific variety of matter would be determinable through the law of the relation of the original attractive and repulsive forces. This would justify the construction of the dynamical concept of matter by establishing a constructible relationship between its intensive magnitude and extensive magnitude.35

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Lorne Falkenstein has asked how this project could be carried out without invoking atoms and void: "you have to first be able to pick out 'a body' in order to be able to talk abut what forces act on 'a body,' but how do you define what makes something a body without assuming that there are particles of body delimited by void?"

Kant is willing to allow that the world as it appears to us contains bodies, i.e. "impenetrable extension" [A 284/B 340, B 278] separated by and moving around in empty space. But this does not mean that the final account of things must, in Kant's view, contain or in particular depend on either absolute impenetrability or void space. Of empty space, Kant writes that "so far as it is *limited by appearances*, that is, empty space *within the world*, is at least not contradictory of transcendental principles and may therefore, so far as they are

Conclusion

If we take Kant's difficulty in constructing the dynamical concept of matter in the Dynamics to be intimately related to his theory of mathematical construction and his a priori foundation for Newton's laws, there are interpretive advantages. To conclude this chapter, I will briefly summarize these advantages.

One benefit of my view is that it gives genuine significance to Kant's expectation that a metaphysical portion of his special metaphysics could be further unified with his doctrine of motion: For all matter is given in appearance in motion, and the dynamical construction of matter would represent matter as moveable. Hence in meeting the criteria for mathematically constructing concepts of quantity, the dynamical concept of matter is united with Kant's doctrine of motion.

Another benefit of this reading is that it provides an alternative to reading ontology or Newtonian methodology into the Dynamics simply in order to make it coherent. While each of these interpretations seems partly true, Kant's opaque reasoning about matter in the Dynamics makes the most sense in relation to his criteria of mathematical construction. For now we can understand why Kant's mathematical construction of the dynamical concept of matter failed; it failed because the system of moving forces didn't supply an appropriate law of forces -- a law which could link Kant's symbolic construction of force and geometrical construction of quantity of matter.

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concerned, be admitted. This does not, however, amount to an assertion of its possibility," [note to A 431/B 459]. Given that Kant ends up with a dynamical concept of matter, it is not too great a stretch to suppose that Kant's feelings towards impenetrability are much the same. As Kant says at A 731/B 759, "... the definition in all its precision and clarity ought, in philosophy, to come rather at the end than at the beginning of our enquiries," to which he adds in a footnote: "Philosophy is full of faulty definitions, especially definitions which, while indeed containing some of the elements required, are yet not complete. If we could make no use of a concept till we had defined it, all philosophy would be in a pitiable plight," [A 731/B 759 n].

In addition, my reading relates Kant's goal of establishing the necessity of laws in Newtonian science to his mathematical representation of parts of concepts featured in Newton's laws. While I would agree with the view that, for Kant, Newton's law of gravity has epistemic warrant in virtue of its being part of a system of laws, I also want to maintain that epistemic warrant is linked to the constructibility of the concepts of quantity the law presupposes. Hence, the ability to demonstrate a basis in intuition for thinking a dynamical concept of matter is of considerable value to the demonstration that a sense of a priori necessity can be attached to Newton's law of gravity.

Finally, Kant's concern for the mathematical construction of the dynamical quantity of matter sheds light on the transition project of the *Opus Postumum*. There, Kant continually attempts to bridge a gap in his critical system, an endeavour which can be partly understood in light of his difficulty constructing the dynamical concept of matter.

In conclusion, let me briefly review my argument: Kant's aim in his special metaphysics was to provide an a priori foundation for Newtonian science. In his view, such a foundation was achieved by exhibiting the a priori content of concepts and laws essential to Newtonian science. Since matter's determinate quantity is essential to Newton's defense of the law of gravity, one of Kant's goals was to link a geometrical construction of quantity of matter to the symbolic construction of force. However, the obstacles facing Kant's construction of the dynamical concept of matter can only be understood in relation to Kant's criteria for mathematical construction.

Chapter Three builds on the above analysis of Kant's special metaphysics. In it, a comparison is made between Kant's arguments about concept construction and laws of nature and his other reasoning about concepts and laws. As we will see, Kant's treatment of the construction of quantity of matter differs in an important respect from his treatment of "incomprehensible" concepts such as absolute space and good and evil. The point will be to gain a broader perspective on the role of mathematical construction in Kant's a priori foundation for Newtonian science.

Chapter 3

Introduction

In Chapter Two, it was shown that conditions on empirical concept construction ultimately rooted in the understanding constrain the a priori foundations Kant is able to provide for Newtonian science.

Constraints proceeding from this direction -- via the critical formalism -- should not really be surprising. Yet constraints come from quite another and less apparent direction as well. The argument of the Dynamics implies that natural laws must exist before a priori conceptual underpinnings can be exhibited for them. Moreover, the construction of the dynamical concept of matter in terms of matter's specific variety could not be carried through for lack of "the law of the relation of forces." [IV, 517] The existence -- or the absence -- of natural laws can also condition concept construction.

Natural science's silence regarding a "law of the relation of forces" proves to be an impediment not only to the construction of the dynamical concept of matter, but also to a "perfect" presentation of the critical underpinnings of Newtonian science. Kant remarks at 478 in the *Metaphysical Foundations of Natural Science* that he hoped his own mathematical treatment of matter could be completed by a cleverer hand --one capable of bringing into unison the "metaphysical portion" (the dynamical treatment of matter) and the " mathematical doctrine of motion" (i.e., its construction). Indeed, the success of Kant's critical foundation for

Newtonian science appears to depend on his establishing an a priori justification for empirical concepts featured in laws of natural science.

The important axis running between concepts and laws is not unique to Kant's philosophy of nature. Rather, the connection between concepts and laws is a central theme of the critical philosophy.36 The relationship between concepts and laws is central not only to the theoretical branch of Kant's philosophy, but to the practical branch as well. In the preface to the *Critique of Practical Reason*, Kant asserts an important relationship between concepts and laws in practical philosophy: "....though freedom is certainly the *ratio essendi* of the moral law, the latter is the *ratio cognoscendi* of freedom" [V, 4n 1]. What Kant is saying here is that the speculative discovery of freedom leads to the insight that there is a moral law; However, in addition to this, practical philosophy provides an a priori justification of duty in relation to the moral law, and hence, an objective basis for the concept of freedom. So, the intimacy of the concept-law relationship is very explicit in this context.

The aim of this chapter is to compare the axes running between concepts and laws in Kant's a priori foundations for natural and moral knowledge. I will show that in more than one instance, a parallel can be drawn between Kant's treatment of the concept-law relationship in his moral and natural systems. The parallel consists in this; each system contains "incomprehensible" concepts which inhibit the normal a priori justification of laws by means of appeal to the a priori content of concepts. The critical justification of these "incomprehensible" concepts which Kant does provide in these circumstances contain a significant similarity: In each instance an appeal is made to a system of laws grounded a priori by the understanding, and the system of laws provides an objective basis for the so called "incomprehensible" concepts.

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In the preface to the second edition of the *Critique of Pure Reason*, Kant introduces the critical philosophy as an investigation into how objects may conform to intuition and concepts of objects to experience. He goes on to say that "...the new point of view enables us to explain how there can be knowledge *a priori*; and, in addition, to furnish satisfactory proofs of the laws which form the *a priori* basis of nature..."[B xix].

Nevertheless, the analogy between arguments establishing objective bases for concepts in the moral and natural philosophies is limited. Kant does not, for example, appeal to his a priori justification of the system of Newtonian laws to secure an objective foundation for the concept of quantity of matter. He must have thought that the case of the construction of the quantity of matter is different in some important respect from the above cases of "incomprehensible" concepts. This disanalogy provides a clue to the distinct role concept construction plays in the a priori justification of Newtonian science. Let's begin by characterizing Kant's critical foundation for moral philosophy.

(i) The Paradox in the Critical Examination of Practical Reason

While constraints on empirical concept formation limit the success of Kant's representation of matter, his difficulties in providing an a priori justification for concept formation are not restricted to the doctrine of body. In the *Critique of Practical Reason*, Kant again describes problems of concept formation. There, Kant hints that the difficulties facing a critical account of moral concept formation are more profound than those facing his account of empirical concept formation. Practical reason, unlike theoretical reason, can never consider its object empirically. Kant explains in Of the Typic of Pure Practical Judgment that the morally good is "...something which, by its object, is supersensuous; nothing corresponding to it can be found in sensuous intuition..." [V, 68]

Given the lack of sensuous basis for moral concepts, practical reason cannot follow the example of theoretical reason, which furnishes the philosophical foundation for law(s) by exhibiting the a priori content featured in schematized or constructed concepts. Kant says that our inability to proceed from concepts to laws in moral philosophy gives rise to paradoxical implications for the "critical examination of practical reason":

> The paradox is that the concept of good and evil is not defined prior to the moral law, to which, it would seem, the former would have to serve as foundation; rather the concept of good and evil must be defined after and by means of the moral law. [V, 63].

In other words, the paradox for a "critical examination of practical reason" is that moral knowledge a priori is not proven in relation to a determination of moral concepts defined prior to the moral law; instead, the reverse is true. This paradoxical circumstance arises for practical reason because no sensuous basis for concepts of good and evil is possible. And, if no sensible access to moral objects is possible, then moral concepts cannot be a starting point for the critical examination of morality.

Notwithstanding the impediment to practical philosophy posed by the inaccessibility of moral concepts, Kant assures us that an application of critical philosophy is possible in the practical context. For the moral law is actually "within us", and by proceeding *from* the moral law *to* concepts, the moral possibility of actions described by maxims can be gauged [V, 81]. Thus, the insight behind the *Critique of Practical Reason* is that the moral law can serve as a foundation for a priori knowledge of moral concepts.

The paradox of practical reason then, leads Kant to emphasize laws in his *Critique of Practical Reason*. There, Kant's moral philosophy focuses on the critical examination of formal characteristics of laws. For Kant, such formal characteristics can act as "determining grounds" in assessing moral possibility. The most obvious of these, and the one most frequently attached upon, is universalizability. Universalizability acts as one formal measure of the moral possibility of a subjective maxim.

Less well emphasized is the way in which Kant's "formula of the law of nature" supplies the clue to another formal characteristic for evaluating subjective maxims of action; the subsumability of moral maxims under the moral law. Indeed, the consistency test for maxims proposed by Kant is properly understood only when the subsumption requirement specified in the formula of the law of nature is taken into account. For example, once the role of the formal characteristics of laws in Kant's consistency test is understood, the temptation to see his examples of moral problem solving as illicitly relying on utilitarian considerations is removed. Moving toward such an understanding, via a detailed presentation of Kant's

solution to the "paradox" of practical reason, will provide the basis for our later comparison of the relationship between concepts and laws in Kant's moral and natural philosophy.

Kant's examples of moral problem solving in the *Foundations of the Metaphysics of Morals* are intended to show us how to evaluate subjective maxims like "I will assist others, if they are in need".37 Those maxims on which it would be moral to act are consistent with the moral law. According to the standard reading of Kant's examples of moral problem solving, the moral law rules out acts based on maxims which, when universalized, produce a contradiction. In addition, maxims a rational being would choose not to act on after considering the implications of the universalized maxim are prohibited. Given only these guidelines, many have objected to the categorical imperative as a test of maxims. This issue remains a persistent bugbear of Kantian ethics.

Typical criticisms of Kant's consistency test include the claim that it collapses Kant's ethics into utilitarianism. Mill suggests that Kant's failure to show the universalization test produces contradictions precipitates the collapse of Kant's moral law into a consequentialist ethics. Mill charges that

> ...when he begins to deduce...any of the actual duties of morality, he fails, almost grotesquely, to show that there would be any contradiction, any logical (not to say physical) impossibility, in the adoption by all rational beings of the most outrageously immoral rules of conduct. All he shows is that the *consequences* of their universal adoption would be such as no one would choose to incur. (Sher 1979, Chapter 1)

Along much the same lines, Ross (1954: 47) maintains that Kant's test is merely a rule-utilitarian prohibition of those rules which tend to produce bad consequences. Some would see such a result -- the collapse of Kant's ethics into utilitarianism -- as a virtue. For example, this point has been argued by Hare (1981) and Narveson (1967).

What is common to the aforementioned criticisms is the allegation that the universalization test does not do enough work: If it produces no contradiction with the moral

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37 The translation used is that in (Beck 1988).

law, then it doesn't show us which maxims reflect what Kant calls "perfect duties"; in addition, if it doesn't offer criteria for evaluating cases where inconsistencies between maxims and the moral law are supposed to arise, then it offers no indication of which maxims correspond to Kant's "imperfect duties". Even more devastating is the suggestion by as sympathetic a commentator as Paton, that if we take Kant's consistency test in the law of nature formulation literally, then Kant's arguments aimed at showing that it is inconsistent to think certain maxims as laws of nature are "completely broken-backed" (Paton 1953: 149). On Paton's view the formula of the law of nature requires that we take a subjective maxim like "I will commit suicide, if life offers me more pain than pleasure," and universalize it, thereby treating the maxim's content as if it were necessary in the same way that the law of gravity can be said to be necessary, since it has universal application to all bodies:

> Hence, if we universalize this maxim of a law of nature, we are supposing that self-love, which is the cause of life, should in certain circumstances be the cause of death. We are in short conceiving a law of nature to admit of arbitrary exceptions, and so we are falling into a contradiction. (Paton 1953: 148)

Paton claims that Kant's analogy between the moral law and natural laws can't be made sense of if we interpret Kant as referring to causal natural laws. The reason is that merely conceiving a maxim to admit of no exception, as a causal law admits of no exception, does not produce the contradiction Kant claims it will produce.

Paton does have a suggestion which purports to redeem Kant's test of maxims. His suggestion is that we interpret Kant's reference to natural laws as referring to teleological natural laws:

> When we are asked to conceive a proposed maxim as a law of nature, we must conceive it as a teleological law of nature; for it is a maxim of *action*, and action as such (quite apart from moral considerations) is essentially purposive. Furthermore, we are asked to conceive it primarily as a law of *human* nature, even if we are setting it against the background of nature as a whole; and human nature must be regarded as essentially purposive. All of this was apparently so much taken for granted by Kant that he fails to state it explicitly, and so tends to mislead his readers. (Paton 1953: 151)

While Paton is unimpressed by Kant's analogy between the moral law and the causal natural laws which govern the interaction of bodies, his suggestion that the analogy can be saved by taking "nature" in the formulation to refer to some sort of teleological, Aristotelian system of laws is one for which little textual motivation can be found. Moreover, if the scope of inquiry is widened to include what Kant says about causal natural law, it is possible to take Kant's analogy seriously. In fact, taking the analogy seriously not only gives a reasonable picture of how Kant thought maxims were to be tested, it can be seen to provide *Kantian* responses to the issues of conflict of duties, the alleged collapse into utilitarianism, as well as explain the perfect/imperfect duty distinction.

The most familiar version of the formula of the law of nature is stated in the *Foundations of the Metaphysics of Morals*: "Act as though the maxim of your action were by your will to become a universal law of nature" [IV, 421]. In the *Critique of Practical Reason*, Kant expresses the law of nature formulation more precisely:

> Ask yourself whether you could regard your proposed action as a possible object of your will if it were to take place in accordance with a law of nature in a system of nature of which you were yourself a part. [V, 69]

Since the *Foundations* was intended as a popularized account of Kant's defense of the moral law in the *Critique of Practical Reason*, in just the same way the *Prolegomena to Any Future Metaphysics* is a popularized version of the results of *Critique of Pure Reason*, we may take the *Critique of Practical Reason* to be authoritative.38 As it happens, the formula of the law of nature is given a prominent role in Kant's defense of the moral law in the second *Critique*. For, in treating the subjective maxim as formally like a law of nature, we obtain explicit guidelines for testing its moral possibility.

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38 Kant indicates in the opening sentence of the *Prolegomena* that the book will serve as a guide in understanding the first *Critique*. Indeed, the arrangement of the materials in each work is similar, although the presentation of ideas in the *Prolegomena* is less dense and the book "presupposes what the *Critique* was meant to prove" (Beck 1988: 153). Beck says of the second *Critique* that "It is related to the *Foundations* as the first *Critique* is to the *Prolegomena*," (1988: 301). As Kant writes in the Preface to the second *Critique*, the *Foundations* "only gives a preliminary acquaintance with the principle of duty and justifies a

While it is true that the consistency test by analogy to laws of nature makes little sense as Paton construes it, there is no need to turn to an account of teleological laws of nature and the purposiveness of human action to make sense of this version of the moral law. For on the critical account of laws of nature, Kant's reference to "Gesetze der Natur" [V, 122] in the formula of the law of nature makes sense as a reference to causal natural laws. Indeed, we can find within Kant's critical account of the necessity of causal laws (that is, such laws of Newtonian mechanics as universal gravitation) the unity of nature which Paton wrongly supposes to derive from teleological laws and the purposiveness of human action. I will show that if we re-cast subjective maxims in what Kant calls "formal respects" as laws of nature, we obtain a richer, more charitable picture of what Kant had in mind by his consistency test.

Kant's consistency test requires that subjective maxims be universalized when they take the form of a law of nature. The universalization requirement is made explicit in the first formulation of the moral law: "Act only according to that maxim by which you can at the same time will that it should become a universal law" [IV, 421]. The critics are quite right, however, in pointing out that universalization is not sufficient to enable us to test a maxim's consistency with the moral law. But nor is it sufficient to capture Kant's own description of what is essential to causal natural laws. At least one other characteristic of causal natural laws can be added to the list of necessary conditions for the consistency test by analogy to causal natural laws; natural laws must be subsumable under a unified system of nature. Analogously, subjective maxims must be subsumable under the moral law.

Because Kant does not explicitly describe in his ethical writings how the *necessity* of laws of nature transcendentally requires their subsumption in a system of nature, this aspect of the analogy to natural laws has been overlooked. What Kant does say in the formula of the law of nature is that the maxim must be judged as "a law of nature in a system of nature". But, what else could subsumption come to *except* this? If we consider how Kant ties the

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definite formula of it" [V, 8]. In contrast to this, the second *Critique* aims to derive a moral law

necessity of laws of nature to their being part of an "order of nature",39 the significance of this segment of the formula of the law of nature will become apparent.

In the *Critique of Pure Reason*, Kant argues that empirical laws must be thought of as necessary because reason regards them as part of a systematic and unified theory of nature. Buchdahl (1992) has established this point in some detail.40 In the passage below, Kant describes the relationship between particular empirical laws and the unity of the "order of nature" in just this way:

> ...that we are justified in declaring all possible cognitions -- empirical and others -- to possess systematic unity, and to be subject to general principles from which, notwithstanding their various character, they are all derivable -- such an assertion can be founded only upon a *transcendental* principle of reason, which would render this systematic unity not subjectively and logically -- in its character of a method, but objectively necessary. [A 648/B 676; Meiklejohn's translation]

According to Kant then, reason demands that we regard our experience of nature as part of an empirical system such that particular laws are subsumed under more general ones. Thus Kant views empirical law-likeness as being the result of an embedding in a system or theory

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from the fundamental conditions of practical reason.

39 In correspondence, M. Morrison has pointed out that there are two ways to interpret the claim that the necessity of causal laws is linked to their being part of an order of nature. "One is that the necessity of particular causal laws is somehow determined by those laws being part of a system ..., the other is that the kinds of causal relations specified by the second and third analogies are necessary because they provide the form of what is for us, a 'nature' that is unified by reason." In the present context, it is the former sense to which I am appealing -- the subsequent discussion of Buchdahl should make this apparent. I concur with Buchdahl in holding that there is an important sense in which the necessity of laws of nature is imposed from the top down, as it were, by Reason. But this is not the sense in which Kant proposes to provide a critical grounding for the laws of Newtonian physics, according to this dissertation. As I attempted to make clear in Chapter 2, the grounding comes from the bottom up via Kant's quasi-mathematical constructions, and is hence the work of the understanding. Here the necessity is traceable, via the analogies, to the categories (cf. Friedman 1992: 178-179); I argue that if there is to be a *critical* grounding for the laws of physics, it must be of this latter sort. Again, I do not mean to imply that Buchdahl is dead wrong, but merely that in emphasizing "top down" necessity, he overlooks construction, where the real critical work is being done. Chapter 3 is supposed to delineate the role and limits of just the sort of necessity Buchdahl concentrates on.

40 Buchdahl (1972: 157) writes:

> In so far as empirical generalizations are to be called laws they must be regarded as necessary. And Why? In virtue of 'the principles of the unity of the manifold' -- which

which is characterized by having only a few general principles. Despite the gulf between Kant and the positivists on the issue of laws of nature, we can find a similar point, in the familiar terminology of twentieth century philosophy of science, made by Hempel.

On Hempel's account, empirical laws are valid in so far as they are subsumable under a general theory -- a theory being a unified small set of general laws. Moreover, for Hempel, empirical laws serve to reinforce the unity in natural science by "connecting events in patterns which are usually referred to as explanation and prediction" (Hempel 1965: 232). Hempel argues that when the subsumption requirement is met, predictions and explanations of empirical instances of a law will not fail to hold:

> Thus, the explanation of a general regularity consists in subsuming it under a more general law. Similarly, the validity of Galileo's law for the free fall of bodies near the earth's surface can be explained by deducing it from a more comprehensive set of laws, namely Newton's laws of motion and his law of gravitation, together with some statements about particular facts, namely about the mass and the radius of the earth. (Hempel 1965: 247)

So, like Kant, Hempel draws an essential link between the status of laws, subsumption and the unity of natural science. This similarity between Hempel and Kant provides a certain amount of clarification of what Kant meant by his subsumption requirement. Moreover, the similarity shows that Kant's conception of laws of nature is not entirely discontinuous with that of twentieth century philosophy of science.

For Kant then, laws of nature are "formally" characterized as both universal in form and subsumable within a unified system of nature. The formal analogy between the moral law and laws of nature, I claim, should be read as including both of these characteristics of natural laws. Laws of nature exhibit the unity of nature in formal respects because they are subsumable. Indeed for Kant all of nature, as conditioned or unconditioned causality belongs, as the formula of the law of nature implies, in one unified theory of reality:

> is here a reference *not* to the unity of the understanding but to reason or reflective judgement.

> Two things fill the mind with ever new and increasing admiration and awe, the oftener and more steadily we reflect on them: the starry heavens above me and the moral law within me...The former begins at the place I occupy in the external world of sense, and it broadens the connection in which I stand into an unbounded magnitude of worlds beyond worlds and systems of systems and into the limitless times of their periodic motion, their beginning and their continuance. The latter begins at my invisible self, my personality, and exhibits me in a world which has true infinity but which is comprehensible only to the understanding - a world with which I recognize myself as existing in a universal and necessary (and not only, as in the first case, contingent) connection, and thereby also in connection with all those visible worlds. [V, 161-2]

The point which is too often overlooked in Kant's description of the awe-inspiring unity of the moral and natural worlds is that this unity is only comprehensible through the understanding: For the unity of the two worlds is described by universality and subsumption, the formal characteristics shared by laws of nature and maxims which express duties. Hence, it is in virtue of the formal analogy to universality and subsumption that causal natural laws shed light on the duties which stem from the moral law within us. In no way then, are we forced to turn immediately to teleological natural laws or the purposiveness of human action in order to understand the analogy to laws of nature. For Kant's account of causal natural laws itself offers us an understanding of the way in which the unity in nature plays a role in the consistency test in the law of nature formula.

Consider Kant's own examples of actual duties. When Kant applies the consistency test to the maxim: "when I believe myself to be in need of money, I will borrow money and promise to pay it back, although I know that I can never do so", he unsurprisingly finds the maxim wanting. In his discussion of the example, Kant says that such a maxim universalized would make promising impossible, as "no one would believe what was promised him but would merely laugh at all such utterances as being vain pretences". While many have been tempted to regard Kant's remark as an appeal to ill consequences, real work is done in this example by the consistency test. In fact, the universalization test is both necessary and sufficient to produce a logical contradiction. Kant shows that there could be no meaning to a general practice of promise keeping if promises were not regularly kept. The contradiction arises from both willing that there be a practice of promise keeping -- that *all* promises will be kept -- and at the same time willing that *some* promises will *not* be kept. Hence, a maxim like

"I will break promises when it suits me" could not "hold as a universal law of nature and be consistent with itself". This is what makes promise keeping a "perfect duty". Maxims, the negation of which fail on universalization Kant calls perfect duties.

Not all maxims which pass the universalization test, however, are duties. Kant himself holds that a maxim to the effect that one should not help those in need of aid could be universalized without yielding a contradiction. Again, Kant makes remarks that could be interpreted as an appeal to consequences, noting that such a maxim universalized would deprive one of the love and sympathy of others in some cases. If there really is no more to the consistency test than universalizability, then Kant would seem to be driven to appeal to evil consequences. Yet Kant frequently denies that his is a consequentialist theory; so there must be more to the consistency test than universalizability. In the *Foundations*, Kant appeals to his theory of the nature of "rationally willing" to show how the consistency test works for an imperfect duty such as this one. Yet this appeal is an obscure one. Whatever Kant has in mind when he appeals to what we are capable of rationally willing is not clear.

Taking into account the subsumption requirement suggested by the analogy to laws of nature, we can sort out any confusion about why we must assist others in need without appeal to consequences and perhaps make sense of how rationally willing figures in our evaluation of subjective maxims. For if Kant intended our judging of the universalized maxim as a law of nature in a system of nature as a subsumption requirement, then we can perform the consistency test in the law of nature formulation by rationally willing in a truly Kantian way: While it is not logically impossible to imagine ourselves to be governed by a law such as "No one will assist another in her time of need", Kant would argue that we could not consistently subsume the imperative that people should act on such a maxim under the moral law. For the moral law requires that a rationally self-interested person will a maxim like "I resolve to assist others, if they are in need" to hold universally, and such a maxim could not be consistently subsumed under the moral law *together with* the maxim "No one shall resolve to assist another in her time of need".41 Subsumption under the moral law then, admits of no

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inconsistencies or contradictions. According to Kant, no order of things conditioned by the moral law would have us aim for the highest good in such an inconsistent, self-defeating way [V, 110]. As a result, the two maxims would not both be subsumable within one coherent reality governed by the ends of practical reason.

Hence, the sense in which *telos* figures in the consistency test is due to the unity of subsumption which bridges laws of nature and the moral law. Ultimately, the fact of our good will enables us to gauge subsumability, but there is no need to appeal to teleological laws to understand the analogy to laws of nature in the formula of the law of nature, since the subsumption of a natural law is a measure of its necessity within one teleological reality.[42]

Critics of Kant's consistency test have failed to pay attention to the unity of nature which makes subsumability a criterion of the necessity of laws of nature. Because universalization alone is not enough to show how Kant's examples of moral problem solving work, it has seemed possible to force Kant's ethics to collapse into utilitarianism. Paton shows sensitivity to these problems, for he tries to save Kant by appeal to teleological laws of nature and human purposiveness in action. But an enriched picture of Kant's consistency test shows that we can indeed make sense of the analogy in the formula of the law of nature as an analogy to genuine laws of nature. Hence it is not necessary to go outside the critical formalism to defend Kant against these criticisms.

Kant's procedure in his discussion of the moral law has seemed to many to tread dangerously close to circularity. What the examples show us is how to use the test of maxims to elicit the pure practical law underlying moral maxims. That is, Kant is using maxims we know to be morally correct to get at the moral law, the very principle that is to establish the objective validity of the moral law. Kant appears to be begging the question. Kant's strategy in the Transcendental Analytic appears to some to bear a similar defect. To these unsympathetic readers, Kant's deduction appeals to the fact that we have knowledge to defeat skepticism. The appearance of circularity dissolves with the understanding that Kant's aim is not in either case to derive particular judgements, moral or epistemological, but to show that we have a right to make such judgements.

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Note that the appeal to the fact of the good will as a criterion of subsumability is not as problematic as an appeal to what a rational being is capable of willing, which is considerably more obscure. By the section of the *Critique of Practical Reason* entitled Of the Typic of Pure Practical Judgement where Kant discusses the analogy to causal laws, he considers himself to have established the fact of the good will.

(ii) The Appeal to Unity in Knowledge

Kant succeeds in offering an a priori defense of morality, since he is able to show the existence of critical underpinnings for moral knowledge. The solution Kant discovers for his *Critique of Practical Reason* can be described as an appeal to the unity in knowledge. For Kant expects the formal characteristics of laws prescribed by the understanding such as universality and subsumption to hold of *any* law --whether that law be discovered in the theoretical *or* practical employment of reason. So, it is by this roundabout appeal to a shared formalism conditioning laws that Kant secures a critical starting point for justifying the objectivity in moral knowledge. Buchdahl's work on the connection between reason and unity establishes the importance of such appeals to unity in Kantian thought.

Buchdahl (1992, 1972, 1969) has developed an account of Kant's metaphysics and philosophy of science which emphasizes the role of reason in determining the "order of nature", arguing that the necessitarian status of empirical laws is tied to the scientific systematization of an order of nature by reason. On Buchdahl's view, reason's drive to unify and systematize initiates a "reduction" of nature to a succession of objects. Reason then injects unity into our conception of nature, thereby "realizing" the "order of nature". However, law-like hypotheses in Kant's order of nature depend for their foundation on the real possibility of the objects toward which they are directed. Since Newtonian science is not directed toward "really possible" objects, Buchdahl thinks, Kant fails to establish a tight connection between his order of nature and Newton's science.

Chapter Two of this thesis argues that Kant's difficulty in the special metaphysics stems from a missing law of forces. A law which could relate extensive and intensive magnitude in a manner admitting of mathematical construction. Hence, the problem Kant encountered in the *Metaphysical Foundations* was not generated by Newton's objects; rather, it can be traced to a missing law of mathematical physics. So on this point, Buchdahl's analysis suffers from a lack of attention to detail in Kant's reasoning about constructions.

Buchdahl's exaggeration of the role of reason also obscures some crucial features of Kant's reasoning about the role of concept construction in Kant's foundation for Newton's laws. Admittedly, Kant's own claim in the *Critique of Pure Reason* shows that reason's unifying activity provides an important criterion of empirical truth in critical philosophy. Kant writes:

> For the law of reason which requires us to seek for this unity is a necessary law, inasmuch as without it we should not possess a faculty of reason, nor without reason a consistent and self accordant mode of employing the understanding, nor, in the absence of this, any proper and sufficient criterion of empirical truth. In relation to this criterion, therefore, we must suppose the idea of the systematic unity of nature to possess objective validity and necessity. [A 647/B 675]

However, Kant completes his reasoning in the above passage by explaining that reason's unifying activity is determined by what is given in the understanding -- an important point which Buchdahl virtually ignores. Kant writes that reason's unity

> ...aids us in discovering a principle for the understanding in its manifold and special modes of employment, directing its attention to cases which are not given, and thus rendering it more coherent. [Kant, *Critique of Pure Reason*, A 647/B 675]

Hence, the above passages show that Kant thought the unifying activity of reason functioned in aid of understanding. On Buchdahl's interpretation of Kant's material philosophy, the workload of reason in unifying gaps left in understanding is overstated -- so that reason is thought to compensate in for any failure to demonstrate the critical underpinnings of science.

By emphasizing reason's unifying activity, Buchdahl has highlighted an important facet of Kant's philosophy. However, if Buchdahl's reading were accurate, then Kant's admitted failure to construct the dynamical concept of matter would have been remedied by an appeal to the unifying activity of reason. There is, in fact, little textual support for such a view. The account supported by Kant's text is that in some cases (moral concepts,absolute space), but not others (concepts of quantity), reason's systematic activity and drive to unify justify filling in gaps left in understanding. It seems then, that Kant has a more subtle view of

how constitutive and regulative elements of his a priori foundation for natural science meet than Buchdahl's reading allows for.

(iii) The Role of Unity in Relation to The Concept- Law Axis in Critical Philosophy

There is no doubt that Buchdahl is right to claim that appeals to unity do play a significant role in Kant's reasoning. Hence, it is not surprising to find that Kant's material philosophy contains a strategically similar appeal to the argument from unity found in the practical philosophy. One example of such an appeal in Kant's special metaphysics of nature is made in regard to the concept of absolute space. Because absolute space is not a possible object of experience, it is not a concept which is susceptible to an a priori justification in terms of concept formation. Rather than defend the concept by exhibiting its intuitive content, the concept is described as an assumption needed in order to justify Kant's other representations of concepts and laws of natural science. As Kant writes in the *Metaphysical Foundations*, absolute space is a concept which

> ...signifies merely every other relative space that I can at any time think of outside a given space, and that I merely can extend beyond each given space to infinity as being such a space as includes this given one, and **in which I can assume this given one to be moved**. [IV, 481]

For Kant, absolute space is meaningful because it enables us to justify our representations of relative space, which is the space of experience. In Chapter Two, Friedman is shown to have made sense of the sort of reasoning underlying this appeal to unity. The implications of Friedman's argument are that Kant defends the concept of absolute space in the Phenomenology *only after* the understanding has carefully established the conceptual foundations of a system of Newtonian laws. Absolute space is an "idea of reason" [IV, 559] necessary to justify Kant's a priori foundation for Newtonian laws. It is therefore assumed "for the sake of the possibility of experience" [IV, 481]. Hence, it is in relation to the demand for a unified, coherent system of nature that we are required to think space as absolute.

The parallel between Kant's practical argument and his special metaphysical argument is just this: In both cases, an a priori justification of a concept which is not comprehensible to understanding is provided by appeal to the unity of Kant's a priori foundation of the law-like order of nature. In his ethics, Kant defines an objective basis for critical philosophy by appeal to formal characteristics of laws of nature prescribed by the understanding. It is the shared formalism of laws given through understanding which determines the consistency of maxims with the moral law. Similarly, links to laws grounded a priori in the understanding are appealed to in order to justify the necessity of the concept of absolute space in Kant's natural philosophy. So in both cases, Kant establishes that the concepts are justifiable a priori because they are related to a system of laws which have been otherwise established a priori by the understanding.

A slightly different example of a concept which may only be "possible" in virtue of its connection to a system of laws grounded a priori can also be found in Kant's material philosophy. For instance, in the Mechanics, Kant explains that from the point of view of mechanics, quantity of matter is not an object of intuition --and hence, is not comprehensible. Here we can understand Kant to be referring to the mechanical mode of explicating matter which is assumed in the laws of Newtonian mechanics. Since intuited content cannot be exhibited of this incomprehensible corpuscular view of matter, the mechanical mode of explicating quantity of matter is not constructible. Moreover, since only a construction demonstrates the determinate content of a concept, Kant reasons that "there remains no other universally valid measure of matter than the quantity of its motion" [IV, 538]. Kant says that

> ... the proper motion of matter is a predicate which determines such matter's subject (the moveable) and with regard to matter as a multitude of moveable parts indicates the plurality of the moved subjects ([i.e., the quantity of matter] at equal velocity in the same direction)... [IV, 541]

From the point of view of Kant's a priori formalism, the implication is that the mechanical estimation of quantity of matter is epistemically justifiable only in relation to Kant's laws of mechanics. Although the full meaning of Kant's passage is cryptic, his claims about the

impossibility of a determinate representation of the concept are once again offset by directing us to a unified set of laws which are grounded a priori. Once again, Kant links an incomprehensible concept to a system of laws grounded a priori in understanding.

The same difficulty faces determinate representations of the a priori content of concepts such as absolute space, the mechanical concept of quantity of matter and the moral concepts of good and evil. None of these concepts can be shown to have a basis in sensible intuition. Consequently, none can be directly explained in relation to the categories, as in the case of concepts which are demonstrably comprehensible in understanding.

The implication for Kant's critical system of representations is that the direct exhibition of any a priori content of these concepts cannot be part of Kant's justification of laws in the preferred, "non-paradoxical" manner of critical philosophy. While Kant's preference in his special metaphysics is to ground his justification of Newton's laws through concept construction, he has and uses an alternative method for justifying concepts and laws. Yet, in certain cases, an appeal to unity within a system of laws grounded a priori is not invoked as a substitute for exhibiting the a priori content of a concept.

One such case is the dynamical concept of matter. The question then, is this: In what respects can Kant's above solution to difficulties in concept formation be compared with his treatment of the dynamical concept of quantity of matter? To begin to compare Kant's treatment of "incomprehensible" concepts and his treatment of the dynamical concept's construction in the *Metaphysical Foundations*, we must take stock of some important differences between the concepts like absolute space, good and evil, and that of quantity of matter.

We have seen that Kant's justifications along the concept-law axis from the direction of concepts in both his moral and natural doctrines, falter for the same reason: the *incomprehensibility* of concepts such as good and evil and absolute space. This particular difficulty does not appear to extend to the case of the construction of a dynamical quantity of

matter. The source of difficulty in the latter case is not that quantity of matter cannot be a possible object of experience. On the contrary, the dynamical quantity of matter can be given to us in sensible intuition and ought to be perfectly "comprehensible" to the understanding.

Another significant disanalogy is the problem of the law of the relation of forces. As Kant sees it, the difficulty in this case is a missing empirical law, a "law of the relation of forces" warranting the representation of matter's specific variety. This, Kant claims, is what inhibits the complete demonstration that concepts of quantity central to the laws of Newtonian science can be represented a priori.

A third point of disanalogy between the rest of the incomprehensible concepts and the concept of quantity of matter is that Kant does not appeal to unity in the latter case. The system of natural laws demonstrated to have an a priori foundation in the *Metaphysical Foundations* is not appealed to as an objective basis for the concept of quantity of matter. There are several places one might expect to find such an appeal to unity: somewhere in the Dynamics; near a discussion of absolute space (perhaps in the Phenomenology); or, in the Preface. There appears to be no appeal to unity in relation to the failed construction at issue.

What can be found instead are several suggestions to the effect that the metaphysical treatment of matter (as described in the Dynamics) may one day be fully subject to a mathematical treatment (as described in the Phoronomy). In the Preface to the *Metaphysical Foundations* [478,479] Kant expresses the hope that his union of metaphysics and mathematics may be completed. At the end of the Dynamics [534], Kant suggests that natural science look to the requirements of a dynamical mode of explication of matter for clues to determinate laws, since such laws would aid in the mathematical construction of matter. In addition, Kant's 1792 letters to Beck (Forster and Rosen 1993: xxxvi) indicate that this search for laws, and clues to the relationship between attraction and density still hold an interest for him.

So instead of objectively grounding quantity of matter by appeal to the unity between laws discovered by reason, we find the hope of a solution in the union of mathematical and metaphysical treatments of matter. That Kant envisioned such a union is of considerable significance. What emerges is that Kant saw an important relationship between the Phoronomy and the Dynamics in the special metaphysics. The weight Kant places on this connection suggests that, for him, a specific manner of representing matter a priori was at least as vital as locating matter theory within an intelligible ontology.

Since Kant restricts his appeals to unity in relation to justifications along the concept-law axis, reason does not have carte blanche for filling in gaps left in understanding, contra Buchdahl. But if reason is not able to fix every gap in understanding by an appeal to unity, we require an explanation of why Kant thinks that some concepts need only be linked to a system of laws and others seem to require constructions. It seems unlikely that the difference in approach is ad hoc. It may be that Kant respects a very specific set of restrictions in his critical justification of concepts and laws in moral and natural knowledge. If so, the principles underlying his a priori foundation for natural science will become more apparent if these restrictions can be made explicit. The aim of the next section is to characterize Kant's notion of epistemic warrant along the concept-law axis.

Conclusion: Toward a Comprehensive Account of the Sense of Epistemic Warrant Along the Concept-Law Axis

That Kant considered the representation of matter to be an important part of his special metaphysics is a point worth emphasizing. In Chapters Two and Three, I have endeavoured to defend my reading of how Kant's view of matter theory in the *Metaphysical Foundations* unfolds. My exegesis suggests that Kant held very specific notions of epistemic warrant; notions which differ for constructible concepts, non-constructible concepts, empirical laws invoking quantitative features of empirical concepts, and laws which can be grounded only through the systematic requirements of reason. These distinctions concerning epistemic

justifications along the concept-law axis have been described in various places in Chapters Two and Three. Summarized, they are as follows.

In the *Metaphysical Foundations*, epistemic warrant for constructions appears to be determined by at least three factors: 1) The concept constructed is a quantitative feature of the empirical concept of matter required by Newton's system of laws in natural science; 2) The concept constructed must be represented according to the general criteria of geometrical construction described in the Phoronomy, as listed in Chapter Two of this thesis; 3) The concept to be constructed must be contained in an empirical law which is part of an empirically successful system of laws.

By way of contrast, non-constructible concepts such as absolute impenetrability are "possible" explications of matter since they are linked to laws grounded a priori. However, such concepts, since they have not been exhibited a priori in relation to mathematical categories, are not definitive of matter as it is determined through cognition. In addition, a non-constructible concept such as absolute space is "necessary" as an idea of reason since the necessity Kant establishes for his other representations of concepts and laws in Newtonian Science depend on this concept.

At the other end of the axis on which we envision a constructed concept, is a law which is grounded a priori. The successful representation of an empirical law in Kant's critical system seems to depend on the following circumstances: 1) Empirical laws which are grounded a priori are contained in a system of empirical laws; 2) Empirical laws which are based on principles which regulate how we judge objects in relation to one another are successfully grounded not only because they instantiate general metaphysical principles but also because the quantitative features of the empirical concepts they contain are mathematically constructible according to the criteria of construction outlined in Chapter Two. Finally, empirical laws may in some sense be justifiable in light of the systematic requirements of reason, although for any empirical law which contains quantitative features of the empirical

concept of matter, the sense of a priori necessity attached to the law is only proven if the latter's construction is also justified.[43]

We have discovered that Kant's treatment of "incomprehensible" concepts, where he claims success, differs from his treatment of the failure of concept construction in the special metaphysics. The difference can be traced to a fundamental disanalogy between these examples of difficulty in concept formation. In those cases where Kant appeals to unity in justifying a concept, the concept is incomprehensible to understanding. An example of such an appeal in Kant's special metaphysics is the concept of absolute space. However, in the case of the failure to construct the dynamical quantity of matter, the difficulty runs in the other direction.

A determinate quantity of matter filling space due to forces is, ostensibly, a possible object of experience. But quantities which are objects of experience and which determine the a priori foundation of an empirical law can be justified only if they are constructible. However, a quantity cannot be constructed unless it is warranted by an appropriate scientific law. But the law of gravity does not warrant the geometric construction of the intuited content of quantity of matter in relation to the symbolic construction of force -- that is, the law itself does not justify the mathematical constructing quantity of matter. Nevertheless, the Dynamics suggests that the role of forces needs to be more fully described if quantity of matter is to be constructed. Hence, Kant explores the possibility of constructing the specific variety of

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43 As Friedman argues in Chapter 4 of *Kant and the Exact Sciences* (Friedman 1992), it is not that the laws of nature discovered by physics, for example the law of gravity, derive a priori from the understanding entirely independently of experience. Physics is not, for Kant, an a priori science; he allows that laws of physics depend essentially on experience. On the other hand, Kant also wishes to hold that such laws depend essentially on a priori laws of the understanding (the analogies of experience). It is in virtue of their dependence on laws of this latter sort that laws of nature enjoy a kind of "empirical" or "material" necessity, possession of which makes laws of nature more firmly established relative to the a posteriori data than mere inductive generalizations, but still allows that the laws are in an important sense a posteriori.

Friedman's account is attractive in that it allows the necessity which Kant wishes to attach to laws of nature to derive from the understanding, and hence the first *Critique*'s central positive results in the Analytic. Buchdahl's ascription to Kant of the view that the necessity attaching to laws of nature is imposed from above by Reason seems not only to circumvent the process of construction that Kant appears to extol so highly in the *Metaphysical Foundations*, but also makes Kant's claims to be providing epistemological warrant for Newton's laws even less credible.

matter. While the absence of a law of the relation of forces inhibits the justification of such a construction, Kant ponders the suitability of this concept of quantity of matter according to the requirements of concept construction.

Hence, it seems that problems associated with concept formation run along an axis between concepts and laws, but that difficulties can stem from opposite poles of the axis. For there will be no objective basis for quantity of matter if there is no law to license its construction. In this situation, an appeal to the unity of laws grounded a priori by the understanding would violate epistemic principles of critical philosophy: The critical philosophy is devoted to demonstrating the a priori foundation of knowledge, and not to inventing a priori justifications for concepts in relation to imagined laws of nature.

On this reading, Kant's continued interest in the concept of matter, an interest which is foreshadowed in the Preface to the *Metaphysical Foundations* and blossoms in the Opus Postumum, is not wholly perplexing. For Kant 's special metaphysics aims to exhibit the concepts and principles provided by general metaphysics and described in the *Critique of Pure Reason* [IV, 473]. Natural philosophy is best suited to such a demonstration, since the schematization of moral and aesthetic concepts (although presumed by Kant), cannot be directly or precisely described. Therefore, Newtonian science offered what was perhaps the only opportunity for a complete exhibition of the concepts and principles laid out in the general metaphysics. Hence, the a priori representation of the concept of quantity of matter would have enabled Kant to fulfil the stated goal of the *Metaphysical Foundations*.

Notwithstanding any remaining "gap" left with respect to the concept of quantity of matter in the critical system, Kant's attempt at a critical foundation for natural science should not be regarded as a complete failure. Kant encounters a multitude of obstacles in his attempt to fully demonstrate the critical underpinnings of natural, moral and aesthetic knowledge. Given the extent to which Kant does manage to provide the critical groundwork in his *Metaphysical Foundations*, we should regard this work as a near perfect victory, both for Kant and the critical philosophy.

Chapter 4

Introduction

Kant claims that his special metaphysics serves the following purposes: It supplies an a priori foundation for Newtonian science [IV,473] and it provides a case *in concreto* for his own general metaphysics [IV,478]. Typically opaque, these statements of mission have been a subject of debate and a source of frustration for Kant's readers. No less controversial has been Kant's attempt to carry through the mission; the *Metaphysical Foundations of Natural Science* had engendered some strongly divergent readings. Chapter 4 situates the present work in relation to some of the more prominent of these.

I have attempted to take Kant's statement of mission quite seriously. Others have not. Based on his reading of the *Metaphysical Foundations* Gordon Brittan believes that the objective of providing a foundation for Newtonian science should be taken with a grain of salt. There is no shortage of apparently fundamental disagreements between Kant and Newton to provide fodder for Brittan's stance. However, Michael Friedman's (1986, 1992) reading of Kant's philosophy of science goes some distance towards recovering Kant's claim to provide a foundation for Newtonian science. His brilliant reconstruction of the argument in the *Metaphysical Foundations* shows Kant's attempt to give an appropriately critical grounding for the concept of an absolute reference frame, a notion which Kant otherwise profoundly disagrees with.

On the other hand, as Brittan (1992: 75n 19) has pointed out, absolute space is not the only apparent bone of contention between Kant and Newton. There is also, for example, matter theory. Brittan is certainly correct in thinking matter theory to be of central concern to Kant in the *Metaphysical Foundations*; however, there is also certainly much to object to in his interpretation of the nature of Kant's matter theory. We shall return to the grounds for disagreement shortly.

Apart from the exegetical constraint of taking seriously what Kant said in the *Metaphysical Foundations* -- whether concerning his aims, or on the particular issue of matter theory -- I have also emphasized the role of construction in Kant's special metaphysics. Chapter Four highlights distinctive features of my reading of the *Metaphysical Foundations*, by critically evaluating and contrasting it with specific claims about construction made in several influential works on Kant's material philosophy: Against Brittan, I argue that Kant did not intend a geometrical construction of force to take the place of the mechanistic concept of matter in Newtonian science. Friedman's (1992) portrayal of Kant's "imitation of a mathematical method" as an homage to Newton's reasoning from phenomena also needs qualification; a complete description of the mathematical method in Kant's natural philosophy requires an account of how Kant's special metaphysical constructions of concepts of quantity are instrumental in his defense of Newtonian concepts. Finally, the extent to which mathematical construction constrains Kant's a priori philosophy of nature is not comprehended in Buchdahl's influential work on the regulative activity of reason. As I will show, each of these views is importantly connected with my own work on Kant. Their appraisal in Chapter Four leads in a natural way to a summary of the results of this dissertation on concept construction in special metaphysics.

(i) Against Brittan's "Realist" Reading of the *Metaphysical Foundations*.

In this dissertation, I have followed Friedman in assuming that construction in pure intuition is primarily intended to explain mathematical proof or reasoning. On my reading, since Newton's laws describe mathematical properties of objects, concepts of quantity of

motion and matter must be constructible a priori. For Kant, such reasoning is not equivalent to logical or analytic reasoning. Gordon Brittan has forcefully and clearly articulated a contrary view. According to Brittan, Kant did not deny that mathematical reasoning is analytic; his primary concern, rather, is with the status of the premises of such inferences, for example, the propositions of Euclidean geometry. Brittan holds that for Kant, construction aims to guarantee the meaningfulness, the truth value, of the propositions of Euclidean geometry:

> ...if a proposition has a truth value, then its corresponding "existential proposition" must be satisfied. That is, an object corresponding to the subject term of the proposition must be capable of being given, the proposition must describe a "really possible" state of affairs. The only guarantee of "real possibility" in the case of pure concepts such as those of mathematical geometry is an a priori "construction"; and the only concepts capable of being constructed are those of Euclidean geometry. (Brittan 1978: 82)

Geometry is synthetic because its basic propositions are synthetic; these propositions are synthetic because they involve an "existential assumption" (Brittan 1978: 56-7); but the theorems of geometry follow purely logically.

On Brittan's conception of pure intuition, its role is to provide a model or structure that distinguishes the one true geometry from a wider class of geometries. In fact, Brittan claims that "[it] was Kant's appreciation of the fact that non-Euclidean geometries are consistent...that, among several different considerations, led him to say that Euclidean geometry is synthetic," (Brittan 1978: 70n). Pure intuition just happens to pick out, from a wider class of possible structures, a structure for space that makes Euclidean geometry true.

To be sure, Brittan is on firm ground in holding Kant to deny that non-Euclidean geometry is "really possible". But the absence of contradiction, for example, in "the concept of a figure which is enclosed in two straight lines" [A 220/B 268] does not amount to the concession of the real possibility of non-Euclidean geometries on Kant's part. Similarly, the representation of a body in absolute motion does not confirm the Euclidean structure of space for Kant; in Kant's view, such a representation is empty and tells us nothing about the objects represented. Brittan's extensive use of contemporary "possible worlds" jargon suggests that

he assimilates Kant's notion of real possibility to our own; if so, he is mistaken. Kant does distinguish the conditions of thought alone and the conditions of cognition: thought plus intuition. The former yield the "empty" idea of the "thing-in-itself" -- not real possibility. What best approximates a notion of real possibility for Kant is thought plus intuition. Considered apart from our (Euclidean) intuition, then, the concept of a non-Euclidean figure or the representation of a body's motion in absolute space remains "empty" and lacks both "sense and meaning" [B 149]. Brittan's analysis that constructions yield a model of the structure of space which makes Euclidean geometry true does not truly take into account how the constructive procedure in intuition is carried out, and hence, it is not representative of Kant's view of how constructions demonstrate "real possibility".

The flaws in Brittan's reading of Kant on geometry infect his reading of Kant on physics. Citing the first of the three notes to #13 of the *Prolegomena*, he notes that

> The same dual problem arises in the case of physics, unsurprisingly, since for Kant physics is no more than applied mathematics: to say what the conditions are that must be satisfied if the propositions of physics are to have objective reality and to show that those conditions are satisfied. (Brittan 1978: 127)

He then proceeds to construe the *Metaphysical Foundations* as an attempt to provide a "realist" response to formalistic interpretations of Newtonian physics. In essence, Brittan's account merely applies a contemporary notion of logical possibility to Kant's special metaphysical reasoning in order to defend the view that Kant is grounding Newtonian science with a coherent form of realism.

Applying this framework to his understanding of Kant's constructive method, and following in the tradition of Kant interpretation in which Kant is thought to reject Newton's ontological commitments, Brittan translates Kant's use of a mathematical method of construction as an attempt to evaluate the inherent conflict between the two traditional forms of realism about properties of matter and space. The "two grand hypotheses" to which Brittan refers are the mathematical-mechanical and metaphysical-dynamical hypotheses about matter. On the mathematical-mechanical hypothesis, physical objects are viewed as

"composed of particles and empty space, and the density and cohesion of these objects is explained in a derivative way as resulting from impact forces and varying mixtures of particles and empty space," (Brittan 1986: 74). The metaphysical-dynamical hypothesis is essentially the Leibnizean one that matter must be further explained as essentially composed of attractive and repulsive forces through which it can be thought as filling space; on this picture, "physical objects are fields of force" (Brittan 1986: 74). These two grand hypotheses were held to represent incompatible views of matter and its filling of space.

As has been noted above, Kant deviates from a number of Newton's metaphysical assumptions -- or, more properly, those of the Newtonians, given Newton's notorious hesitancy and equivocation over just what he was committed to. Brittan diagnoses the differences as the result of Newtonian science lying on one side of the divide -- the mathematical-mechanical one -- and Kant's sympathies lying on the other. Brittan views the *Metaphysical Foundations* as primarily an attempt to replace the mechanistic concepts in Newtonian science with dynamical ones consistent with the "actual" (i.e. dynamical) concept of matter which is given in appearance. Now to return to the issue of construction: on Brittan's reading, constructing the dynamical concept of matter would involve constructing matter in relative motion. In such a dynamical construction, the motion of one object is determined relative to other objects in space, and the object constructed must be conceived of as composed of forces. A successful dynamical construction of matter, Brittan thinks, would provide an empirical determination of space and time consistent with Leibnizean dynamism, and hence, confirm that a force based ontology and a relativistic determination of space exhibit a structure which makes Euclidean geometry true, (Brittan 1978: 137).

Conceived as such, Brittan argues, Kant's dynamical construction could not succeed. The specific difficulty Brittan describes for constructions relating to the dynamical view of matter stem from the dynamical view of motion in space. If a body's motion is relative, then a determinate direction cannot be assigned to a force -- and, consequently, forces are not constructible:

> These forces are determined for any individual body as a function of its relation to other bodies. But we still face the problem of dividing up the accelerations; if we refer the motion to one frame of reference, we assign a particular value to the postulated forces; if we refer it to another frame, then the forces receive another value. In either case, the notion of a postulated dynamical force is fundamentally indeterminate. It is in this sense that the dynamical forces are not "constructible". (Brittan 1986: 90)

Brittan notes that Kant actually prefers the dynamical concept of matter because it has application to objects of experience -- a characteristic which defines a minimal constraint on its "real possibility" (Brittan 1986: 62). Nevertheless, Brittan argues that Kant's critical defense of the dynamical concept of matter is doomed to fail: For the construction of the dynamical concept of matter is also necessary in order to adequately establish its "real possibility", and its construction is, in principle, impossible. Since Brittan maintains that Kant was ontologically committed to a dynamical view of matter, Kant's failure to construct the dynamical concept of matter results in a failure to provide a critical basis for Leibnizean dynamism.

The irony in Kant's inability to construct a dynamical concept, Brittan thinks, is that the mechanical view of matter *is* perfectly constructible:

> In one way, Kant comes to a rather paradoxical conclusion. The mechanical hypothesis is "constructible", but there are no empirical conditions for the application of several of its key concepts. It is not "really possible". The corresponding concepts of the dynamical hypothesis are in the same sense "really possible", but they are not "constructible". (Brittan 1986: 90)

Brittan links the constructibility of the mechanical concept to its characterization of matter as a stuff existing in absolute space. Here Brittan envisions the mechanical construction of matter as providing an empirical determination of absolute space. According to Brittan, the assumption that motion takes place in absolute space justifies the attribution of relational properties to matter, as well as its construction. On the mechanical view, matter's motion is capable of determinate quantitative measurement and representation a priori in construction, and hence, provides a structure which makes Euclidean geometry true.

Brittan's reading of Kant's doctrine of construction as an attempt to address the ontological conundrum presented by the two grand hypotheses of metaphysics places Kant's reasoning within a well accepted framework for understanding debates in early modern philosophy. However, Brittan's reading of Kant's doctrine of construction as involving representations of objects which determine that space is either relative or absolute is not consistent with Kant's description of construction. What Brittan seems to hold is that constructions of matter provide empirical determinations of space and time, and that the successful construction of a dynamical or mechanical concept of matter would show that Euclidean geometry is made true by either the dynamical or mechanical model of the structure of space.

But Kant never says that constructions establish empirical determinations of space and time. What he does say is that constructions given a priori in pure intuition create objects as quanta [A 722]. Such constructions do not represent bodies in either relative or absolute motion; for the pure part of the empirical concept of matter which can be exhibited a priori in intuition is exhibited in a space which is itself neither absolute nor relative. Constructions are not empirical representations of motions in relative or absolute space, but idealizations of concepts of quantity created a priori in intuition. Hence, it is difficult to see how motions in absolute space -- or relative space for that matter -- could be represented by this procedure. While the idea of situating Kant squarely within the Leibniz-Newton controversy is an attractive one, it is difficult to make sense of Kant's doctrine of the method of construction and his claim to defend Newton's results on Brittan's reading.

Hence Brittan's analysis of the criteria of concept construction and the subject of Kant's constructions in the *Metaphysical Foundations* is not beyond reproach. On Brittan's hypothesis, it is the measurability of motion in absolute space which exhibits the Euclidean structure of space, and hence, licenses the mechanical construction of matter. However, to my knowledge, Kant nowhere cites absolute space as a criterion of constructibility. Brittan himself provides no adequate textual support for this claim, and his interpretation of Kant's criteria of construction is not sufficiently textually motivated. In addition, there are also

conceptual reasons for rejecting Brittan's criteria of construction. Specifically, the different ideas of motion in space which are linked to the two grand hypotheses about matter need have no bearing on Kant's doctrine of mathematical construction. On my reading, Kant's justification of constructions makes no appeal to an "actual" concept of space. In the *Metaphysical Foundations*, constructions are achieved along lines similar to these: 1) The empirical concept of matter featured in Newtonian laws is "given" by science, and is a product of empirical intuition, 2) The given concept is *critically* analyzed, and definitions corresponding to the concept as it is given to philosophy are generated (per categories), 3) Concepts of quantity featured in the empirical concept of matter are constructed a priori in intuition.

Indeed, it seems that the impact of Kant's critical turn on the constructions in the *Metaphysical Foundations* is omitted from Brittan's interpretation. As many commentators have noted, construction is defined as a method for exhibiting a pure concept or the pure part of a concept capable of mathematical treatment a priori in intuition.44 What Kant claims to construct are mathematical parts of concepts, i.e., concepts of quantity -- not "really possible" states of affairs, as Brittan suggests. Brittan himself neglects Kant's positive argument for a dynamical conception of matter's capacity to fill space and Kant's discussion of the construction of this concept, saying that the positive argument for the dynamical hypothesis is "difficult to comprehend" and that its details "are unimportant for my purposes" (Brittan 1978: 152).

However, it is here that Kant's argument in the Dynamics makes clear that construction is a procedure which is necessary to exhibit the mathematical part of a concept. The problem, as Kant sees it, is neither mathematicians nor metaphysicians had shown why mathematics applies to matter:

> For although matter is infinitely divisible from a mathematical point of view, it does not necessarily follow that matter is physically divisible to infinity, even if every part of

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44 See, for example, (Butts 1984, 1986b), Friedman (1985, 1990b, 1992), and (Winterbourne 1988).

> space is again a space and consequently always includes within itself parts external to one another... Therefore, something was lacking heretofore in the mathematical proof; without this something, such a proof could have no sure application to natural science.[*Metaphysical Foundations*, 505]

"Something", Kant says, "was lacking heretofore in the mathematical proof" that mathematics applies to matter. This "something", Kant maintains, is a constructive procedure which can be infinitely continued, and in terms of which matter can be represented as infinitely divisible. In the Dynamics, Kant's preference for a dynamical concept of matter is explained in light of the constructive procedure [533-534], which requires that the iteration of an operation be possible indefinitely.45

The constructive procedure ensures the applicability of mathematics to matter in relation to a third thing; the representation of the object. As Kant writes, "it is not the division of the thing but only the division of its representation that can be infinitely continued." [IV, 507]. Indeed, he objects to other grounds for attributing mathematical properties to matter, which he takes to involve a misreading of mathematicians:

> One completely mistakes their meaning and misinterprets their language when he attributes to the object of the concept what necessarily belongs to the process of the construction of the concept. [*Metaphysical Foundations*, 505]

Hence, for Kant, only the indefiniteness of our capacity to repeat iterations in construction can justify our application of mathematical concepts such as "infinity" to matter. Moreover, it is the constructibility of the dynamical concept which shows that mathematics applies to bodies:

> For according to this process, all contact can be represented as an infinitely small distance; moreover, this must necessarily happen in those cases where a larger or smaller space is to be represented as completely filled by the same quantity of matter, i.e., by one and the same quantum of repulsive force. Consequently, as regards something infinitely divisible, there can be assumed no actual distance of parts, which always constitutes a continuum as regards all expansion of the space of the whole... [*Metaphysical Foundations*, 505]

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45 See also the *Physical Monadology* and the Second Antinomy of the *Critique of Pure Reason*.

Thus the dynamical concept is "really possible" because it reflects the applicability of mathematics to bodies in a way that the mechanical concept cannot; for the mechanical hypothesis is not consistent with an indefinite repetition of the iterative procedure in construction; it views matter's fundamental particles as indivisible. Here Kant associates his preference for a dynamical conception of matter with its mathematizability or constructibility.

Kant's reasoning in the Dynamics regarding matter's divisibility, and his preference for a dynamical concept of matter are related to the iterative procedure fundamental to construction. What is at stake regarding the construction of the dynamical concept of matter is not the proof that the structure of space is Euclidean, but the proof that mathematics applies to matter. Kant not only takes it for granted that the geometry of perception is Euclidean [*Prolegomena*, 38], but he denies knowledge of space as a thing in itself. Hence, Brittan's depiction of the purpose of constructions is mystifying. Moreover, his claim that a dynamical or mechanical concept of matter is constructed indirectly in relation to the measurability of motion in relative or absolute space and a defense of Euclidean geometry is not and could not be textually grounded. In the *Metaphysical Foundations*, Kant does not claim to be trying to show that the correct metric for space is given by motion in absolute space, but only that mathematics applies to the same quantitative features of objects which are attributed mathematical properties in Newtonian science.

Contra Brittan, I maintain that it is in fact possible to read Kant's strategy in the special metaphysics as negotiating a "middle ground" for Newton's dynamical and mechanical views of matter -- an epistemic middle ground which is defined in relation to mathematical construction. On the alternative reading suggested in this dissertation, Kant is neither constructing a purely "mechanical" nor a purely "dynamical" concept of matter. Rather, his aim is to construct pure concepts of quantity corresponding to Newton's descriptions of "quantity of matter" and "quantity of motion", in order to show that concepts of quantity featured in the empirical concept of matter employed in Newtonian science can be exhibited a priori in intuition. Moreover, Kant's aim to construct a dynamical concept is motivated by his view that only a dynamical concept of matter is constructible, and hence, mathematizable.

Since it is possible to give a coherent explanation of Kant's reasoning about the construction of the dynamical and mechanical concepts of matter from a purely epistemological point of view, Brittan's initial assumption that Kant thought constructions could prove either a Leibizean or mechanistic hypothesis to describe the structure of Euclidean space is not one we must accept.

Brittan's version of the ontological reading of Kant's difficulties regarding concept construction also inhibits our understanding of which features of the empirical concept of matter Kant intended to geometrically construct. When Kant refers to the construction of the dynamical concept of matter, Brittan understands this as part of a defence of a force ontology; hence, he takes Kant's goal to be the *geometrical* construction of force. But as Kant's Anticipations of Perception makes clear, the "degree" which is given in appearance is not itself determinable as an extended magnitude in intuition -- it can only be associated with what is determinable in appearance [A 168/B 210]. So, in his discussion of intensive magnitude, Kant makes it very clear that the degree of force cannot itself be geometrically constructed. Brittan's suggestion is that Kant is simply confused about the issue, but in light of what Kant says in the Anticipations, this reading is both absurd and uncharitable.

A more coherent picture emerges when we consider that Kant may have thought of the issues surrounding construction only a little differently. If Kant envisioned a symbolic construction of force in agreement with a rule of geometrical construction of quantity of matter, then he would not have set himself the sort of paradoxical task Brittan envisions for him. Rather, the constructed dynamical concept of matter represents quantity in relation to quality; and the quantity which is *geometrically* constructed is not the intensive magnitude of force -- it is quantity of matter. On this reading, there are *two* types of mathematical constructions of quantity which concern Kant in the special metaphysics; they are the geometrical constructions of quantity of motion and quantity of matter, and the symbolic construction of forces following the rule of the procedure for the geometrical construction of quantity of matter.

My account underwrites a reading of the direction of dependency in the *Metaphysical Foundations* running from constructed concepts to a priori laws of nature; and finally, to ontology. By way of contrast, the strong ontological reading attempts to reconstruct the special metaphysics as driven initially in relation to ontological commitments rather then epistemological ones. This section has attempted to show that Brittan does not make a case for his reading sufficient to force us to accept it. At the least, it still remains open to question which of the two readings of Kant's matter theory should stand as an inference to the best explanation: The reading which has Kant motivated for ontological reasons to replace empty Newtonian concepts or the reading which has Kant bringing the "metaphysical portion" in the Dynamics into unison with Newtonian physics via construction.

(ii) Kant's Constructions: the Imitation of a Mathematical Method

It is well understood by Kant scholars that the special metaphysics instantiates the general metaphysics: Each chapter in the *Metaphysical Foundations* falls under one of four sets of categories in the first *Critique*; the Mechanics instantiates the Analogies of Experience; and reason's regulative activity plays a role in ascribing the sort of unity to nature which makes possible both science and the systematic presentation of the a priori foundations of science. None the less, there are important aspects of Kant's extended application of the critical system of space/time and the categories in special metaphysics which are less well known.

Less well documented, for example, is the sense in which spatial and temporal forms of intuition supply criteria for constructions of quantitative features of physical concepts given in Newtonian science. Indeed, most of the literature on Kant's doctrine of construction fails to draw the distinction between Kant's discussion of constructions of pure mathematical concepts in the first *Critique* (objects of pure geometry) and the construction of features of empirical concepts by *imitation* of a mathematical method in special metaphysical contexts.

On my reading, Kant's claim to devote a considerable effort to following a mathematical method in his a priori foundation for Newtonian science is accorded considerable significance. Indeed, the main goal of this dissertation is to characterize the sense in which the mathematical method brings the metaphysical portion of his treatise "into unison with the mathematical doctrine of motion". In the Preface to the *Metaphysical Foundations*, Kant writes:

> I have in this treatise followed the mathematical method, if not with all strictness (for which more time would be required than I had to devote to it), at least imitatively. I have done this not in order to get a better reception of it through a display of profundity, but because I believe that such a system is quite capable of mathematical treatment, and that perfection may in time be attained through a cleverer hand, when stimulated by this sketch, mathematical investigators of nature may find it not unimportant to treat the metaphysical portion--which cannot be gotten rid of anyway -- as a special fundamental part of general physics, and to bring it into unison with the mathematical doctrine of motion. [*Metaphysical Foundations*, 478]

Kant notes in the above passage that his system has not been fully mathematized; the most striking such gap is the incompleteness of his exhibition of the mathematical constructibility of the dynamical concept of quantity of matter under categories of quality. Because it is incomplete, it leaves an uninstantiated metaphysical portion in his foundation of natural science. The general metaphysical arguments of the first *Critique* establish only that intensive magnitude is thought as a quality associated with what is given in appearance; they do not show that a specific relationship between intensive magnitude and extensive quantity of matter is the basis for Newton's concept of density. Hence, as the above passage indicates, Kant's special metaphysics does not entirely succeed in strictly following a mathematical method.

Furthermore, on my account, Kant's claim to follow a mathematical method in the special metaphysics involves an attempt to establish the constructibility of quantitative features of the empirical concept of matter contained in Newton's laws. These mathematical constructions are necessary to show that one and the same set of a priori representations can justify our finding necessity in the concepts and laws discovered in natural science. Hence the preceding chapters of this thesis defend the view that mathematical constructions of concepts of quantity play an important role in the special metaphysics -- a role which involves

bringing constitutive and regulative aspects of knowledge described by empirical laws together under the categorical structure.

As such, the dissertation aims to follow Friedman's (1985, 1992) interpretation of the constructive procedure of the *Metaphysical Foundations*. Friedman suggests that the central concern of the *Metaphysical Foundations* is to address issues arising from the argument of Book III of Newton's *Principia*. Absolute motion with respect to absolute space is at the very basis of Newtonian physics, but absolute motions and absolute space are not given in our experience of nature. However, Newton holds that it is possible to infer the true motions from the observable effects. The central aim of the *Principia* is to carry out such an inference, which is finally explicitly carried out in Book III. There, Newton applies his laws of motion to empirically given "phenomena" so as to derive first the inverse-square law and then the law of universal gravitation. The argument culminates in Proposition XI: "That the common centre of gravity of the earth, the sun, and all the planets, is immovable" (Cajori 1945: 419).

On Friedman's account, Kant is to be understood as "attempting to turn Newton's argument of Book III of *Principia* on its head," (Friedman 1992: 142). Newton begins with the ideas of absolute space and absolute time, formulates his laws of motion with respect to this pre-existing spatio-temporal framework, and finally uses the laws of motion to determine the true motions in the solar system from the observable, merely apparent motions in the solar system. "Kant, on the other hand, conceives this very same Newtonian argument as a *constructive procedure for first defining the concept of true motion*. This procedure does not find, discover, or infer the true motion; rather it alone makes an objective concept of true motion possible in the first place," (Friedman 1992: 143). For example, where Newton conceives of his laws of motion as asserting facts about antecedently defined true motions, Kant employs the same laws of motion in the *Metaphysical Foundations* to show the conditions under which the concept of true motion has meaning. That is, the true motions are just those that satisfy the laws of motion.

Friedman goes on to present a detailed reconstruction of the line of reasoning in the *Metaphysical Foundations* based on this interpretation of Kant's constructive procedure. For present purposes, I do not propose to seriously question -- nor, for that matter, to regurgitate -- the specifics of Friedman's reconstruction. Rather, I shall assume that Friedman's interpretation gives an adequate account of Kant's attempt at grounding the concept of absolute motion.

Friedman also gives a brief presentation of the way in which, on his construal, Kant's reinterpretation of the *Principia* in the *Metaphysical Foundations* is to serve as an "example *in concreto* of the abstract transcendental principles of the first *Critique*. Friedman gives a relatively detailed description of the way in which the Phenomenology, which depicts a constructive procedure whose goal is a description of all true motion in the universe, realizes the procedure of the Postulates of Empirical Thought in the first *Critique* (Friedman 1992: 159-161). Immediately following this discussion, Friedman makes a concession, of one paragraph in length, to the importance of matter theory in the *Metaphysical Foundations*:

> [The] abstract principles of the first *Critique* --in particular, the analogies of experience -- are to be further specified by means of Kant's articulation of the concept of matter in the *Metaphysical Foundations*, which renders this concept a priori suitable for application to outer experience. The result is a realization or instantiation of the analogies of experience according to which the conservation of mass realizes the first analogy (Prop. 2 of the Mechanics), the law of inertia realizes the second analogy (Prop. 3 of the Mechanics), and the equality of action and reaction realizes the third analogy (Prop. 4 of the Mechanics). Inertial motion, then, realizes (provides an example for) the category of causality [B 292]; matter, and quantity thereof, realizes the category of substantiality [B 278, B 291]; mutual interaction in space with respect to a common centre of mass frame realizes the category of community or simultaneity. (Friedman 1992: 162)

Note that what precedes this paragraph is a description of the procedure by which inertial motion is constructed.

There is little in Friedman's book that acknowledges the extent of the discussion of matter and quantity thereof in the *Metaphysical Foundations*, let alone a parallel to the discussion of inertial motion; that is, a discussion of Kant's procedure for the construction of matter, and its attendant complications. While I do not intend to challenge Friedman's

reconstruction of Kant's constructive procedure, I depart from Friedman when he pays attention to matter theory in the *Metaphysical Foundations* only in order to set it aside. I have attempted to show that matter theory is important to Kant; that Kant envisioned a construction of this basic concept of Newtonian science (or rather, *his conception* of this basic concept); and that an account of the steps Kant takes toward this goal, consistent with Friedman's reconstruction of Kant's procedure with respect to absolute motion, can be given. Hence, my dissertation is at least an extension of Friedman's work.

(iii) Mathematical and Metaphysical Arguments in Kant's Reasoning

In his influential and extensive work on Kant's critical methodology, Gerd Buchdahl has stressed the importance of reason's unifying activity in Kant's a priori foundation for science. With sensitivity to the complexity of Kant's methodology, Buchdahl urges us, on the one hand, to take note of the sense in which Kant envisions a transition from the level of understanding to that of reason, and, on the other hand, to see a "looseness of fit" between the fields of understanding and reason.

According to Buchdahl, Kant's natural philosophy contains an essential distinction between "nature" and the "order of nature". In the *Metaphysical Foundations*, the categorical principles are developed into specific laws in understanding, and these define the possibilities for "nature". However, it is reason which requires us to seek unity in science, and which ultimately secures the sort of necessity for the lawlikeness which we find in the "order of nature" (Buchdahl 1969: 497). Hence, empirical lawlikeness is a result of the regulative function of reason, although there is also a sense in which the necessitarian character of laws emerges from understanding:

> The lawlikeness of the empirical laws of Newtonian science (e.g. of Kepler's laws, Galileo's laws) has now been seen to be a function of the architectonic of reason; it is injected, so to speak, "from above". There are, however, certain privileged principles whose necessitarian character is established "from below". They are part of Kant's "special metaphysics of nature", being contrasted with his "general metaphysics" (i.e. the doctrine of the Transcendental Analytic) where the former, instead of being occupied only with the concept of nature in general, involves the introduction of a

> *specific* aspect of nature, viz. nature qua "matter" -- a concept which Kant declares to be "empirical". (Buchdahl 1992: 231)

As Buchdahl sees it, there is a link -- a "transition" -- between "nature" as it is prescribed at the level of the understanding, and the "order of nature" due to reason in Kant's natural philosophy. Buchdahl cites Kant as giving a number of reasons for taking such a transition to be possible (Buchdahl 1992: 177-9).46 Buchdahl summarizes these reasons as follows:

> The concept of the understanding, qua phenomenon, is incomplete, though as such alone it can be "known". Yet that which would complete it (the noumenon), is quite *indeterminate*, and in order at least to make it *determinable*, i.e. intelligible, an advance towards the field of reason must be undertaken. In this way, whilst from one point of view the understanding is cut off from reason, from another, though in a highly speculative fashion, it requires to advance towards, and to be linked with the latter. (Buchdahl 1992: 179)

Buchdahl argues that it is a methodological goal of unifying and systematizing nature which drives reason to complete the plan of nature undertaken in understanding, and it is through this activity of reason that the relevant sort of necessity is provided for the "order of nature" which underlies Newtonian science.

Ultimately then, it is a "need of reason" which requires a transition from understanding to reason, and the necessity which is generated in understanding must be seen as "highly speculative". It is reason which secures necessity for science, and reason which gives import to the categorical structure.

Despite his acknowledgement of a "transition" from understanding to reason, Buchdahl depicts the understanding as "cut off from reason" and as advancing toward reason "in a highly speculative fashion". Buchdahl holds that the level of reason, which is the level of the "order of nature", must be accorded a greater degree of "logical strength" than the level of understanding or "particular nature" (Buchdahl 1992: 191). Thus there is a "looseness of fit" between the fields of understanding and reason for Buchdahl. And this is a tacit

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46 According to Buchdahl, the reasons Kant gives for a transition from understanding to reason are these: 1) There is a methodological requirement to relate phenomena given in appearance in theory construction; 2) We must regard the understanding as holding up a mirror to reason; and 3) We tend to think of our representations of objects as being grounded in the noumenal world.

recommendation to view the role of understanding in Kant's philosophy of nature as a surprisingly limited one, and a portrayal of the transition from understanding as motivated and regulated "from above".

The source of the depiction is quite different in the two cases, but Buchdahl's Kant, like Brittan's, has more of the rationalist in his theoretical philosophy than the text gives explicit admission to. There is, however, a way of reading the transition from understanding to reason which gives more weight to the constraints the understanding places upon empirical knowledge. Consider what Kant says in the Doctrine of Method:

> Reason is never in immediate relation to an object, but only to the understanding, and it is only through the understanding that it has its own [specific] empirical employment. It does not, therefore *create* concepts (of objects) but only *orders* them...[A 643/B 672]

The role of reason in natural philosophy, Kant goes on to say, is to "assist the understanding by means of ideas, in those cases where the understanding cannot by itself establish rules, and at the same time to give to the numerous and diverse rules of understanding unity..." [A 648/B 676]. What Kant indicates then, is that understanding plays an important role as a mediator, and this suggests that the need for a transition to reason is constrained as it were, "from below", rather than "from above".

Consequently, Buchdahl's reading of the role of reason as the significant source of necessity for empirical lawlikeness may be too strong. While reason systematizes Kant's transcendental concepts and principles by projecting a "synthetic unity objectively", and thereby yields an "order of nature", the elements in this order are strictly constrained by understanding, which alone has the capacity to prescribe concepts of objects (Buchdahl 1992: 157). In Kant's *Metaphysical Foundations*, an appeal to unity is not an adequate substitute for exhibiting the a priori content of constructible concepts, since reason cannot *create* concepts of empirical objects. So there is a very real sense in which understanding places constraints on the necessity we find in empirical laws, for the concepts of objects they describe, and hence their necessity, must originate in understanding.

One of the chief aims of this dissertation has been to emphasize the role of constructions in providing an a priori foundation for Newtonian science. And construction is a function of the understanding, par excellence. The role construction plays exhibits a meaningful sense in which a priori constraints on conceptual and lawlike representations in understanding determine the a priori necessity which can be attached to Newtonian laws: Kant's laws of mechanics, for example, follow a priori if concepts of quantity of motion and quantity of matter are constructible. Similarly, the construction of the dynamical quantity of matter is required in order to establish that a priori constraints underlie the dynamical quantity of matter expressed in Newton's law of gravity. This procedure of construction is required to show that there is a sense of necessity attached to the concept; where necessity is existence (the science discovered through empirical synthesis) given through possibility (the forms of intuition and the categorical structure and related cognitive processes). On this reading, there is an important sense in which the necessity of concepts of quantity is determined at the level of understanding, and since understanding must provide concepts to reason, the necessity in any science which purports to describe constitutive features of our knowledge, i.e., quantitative and qualitative features of objects, must be a necessity which derives from understanding.

In addition to careful study of Kant's doctrine of construction as it applies in special metaphysics, attention must also be paid to the relationship between schematized concepts and principles, and the instantiation of this relationship in the *Metaphysical Foundations*.47 In the first *Critique*, Kant claims that "the highest principle of understanding" is that "every object stands under the necessary conditions of the synthetic unity of the manifold in intuition in a possible experience" [A 158/B 197]. According to this principle, the understanding specifies how objects are to stand under rules of synthesis, i.e., to be schematized. The main task of the transcendental doctrine of judgment is to show how synthetic judgments (principles) follow a priori given that the conditions of schematism, i.e., that the conditions of the possibility of objects of experience are met [A 136/B 175]. In this sense, Kant's doctrine of motion and

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47 Paul Guyer does explore this point; see (Guyer 1987), Chapter 6.

matter bring constitutive and regulative aspects of the concepts and principles thought in understanding together through mathematical constructions.

This relationship between schematized concepts and principles holds important clues about the service mathematical constructions render in securing an a priori foundation for Newtonian laws. For it is this relationship which defines a concept-law axis in the critical philosophy, and it is the existence of such an axis which suggests that Kant's a priori foundation for Newtonian science involves more than the mere piecemeal instantiation of categories: Rather, it seems that only the constructibility of extensive magnitudes representing concepts of motion and matter (as they are given empirically) enables Kant to say that the foundation for laws of nature containing such given concepts "follows *a priori* according to principles". Hence, Kant's justification of concepts and laws has its own epistemic restrictions requiring that constitutive and regulative elements within the categorical structure meet in licensing an a priori and necessary foundation for Newtonian science.

The relationship between concepts and principles, or constitutive and regulative elements of our cognition is both more specific and more detailed than Buchdahl claims. The link between concepts and principles, which is the highest principle of understanding, indicates that at least in understanding, there are constraints on how constitutive and regulative elements can meet. Indeed, the understanding does not aim at reason in a highly speculative fashion when it grounds empirical knowledge, it follows a clearly prescribed set of rules and restrictions through which the understanding "originally makes experience, as regards its form, possible":

> But all empirical laws are only special determinations of the pure laws of understanding, under which, and according to the norm of which, they first become possible. Through them appearances take on an orderly character, just as these same appearances, despite the differences of their empirical form, must none the less always be in harmony with the pure form of sensibility. [A 127-128]

Buchdahl's reading of the role of reason does not take sufficiently seriously Kant's actual restraint from an appeal to unity in a law-like system in justifying quantitative and qualitative concepts of matter as the moveable filling space. If Kant refrains from such an

appeal because of the sense of epistemic warrant running along the concept-law axis, then it is not always possible to save the transcendental apparatus by appeal to reason. Butts (1991) and Friedman (1991) are right then, to criticize Buchdahl's inference that "the system of space/time and the categorical structure plays no crucial role in determining the character of matter and its motion in the a priori foundation of natural science" (Butts 1991: 104). Indeed, Buchdahl's view seems to contradict Kant's claim that the categories "supply the complete plan of a whole science... according to determinate principles" [B 109-110]. If we take Kant's claim that the understanding provides the complete plan of science, and attend to Kant's doctrine of construction and his linking of concepts and principles, then we must conclude that Buchdahl's analysis of the transition from understanding to reason is both an understatement of the importance of the role of understanding in natural philosophy, and an overstatement of the role of reason.

Conclusion

In the *Metaphysical Foundations*, Kant's project is to establish the sense of *a priori necessity* underlying concepts and rules of Newtonian science; this is to be accomplished via mathematical construction. The a priori necessity the understanding provides for Newtonian science is proven in two stages. First of all, determinable features of matter expressed in Newtonian laws are mathematically constructed. Secondly, constructions are linked to Kant's a priori foundation of empirical laws given through regulative principles. For Kant, this procedure shows that "necessity is existence given through possibility itself" [B 111]. The mathematical construction of concepts of quantity, then, is the crucial component in Kant's demonstration of the a priori necessity in Newtonian science.

For Kant, the successful exhibition of a priori constraints on constitutive and regulative elements of empirical cognition is of considerable importance in two respects. At issue is the critical foundation for physics -- that is, a demonstration of the source of universality and necessity underlying Newtonian science. There is also the issue of

Newtonian physics as an "example *in concreto*" that confers sense and meaning on the concepts and principles of the transcendental philosophy set forth in the *Critique of Pure Reason*. As such, the *Metaphysical Foundations* is of considerable importance as a test of the correctness of the exceedingly abstract and general program of the first *Critique*. Given that these are Kant's goals, a reading of the *Metaphysical Foundations* as a substantial extension or revision of Newtonian science amounts to reading the work as a tacit admission of failure on both counts. To my knowledge, there is no evidence Kant thought of the *Metaphysical Foundations* in this way. Hence, my guiding principle has been to read the work as an attempt to display, so far as possible, the coherence of Newtonian physics and the critical philosophy.

Ultimately, the mathematical treatment of features of the empirical concept of matter presents Kant with a most formidable challenge. Kant rejects the atomistic conception of the ultimate constituents of matter, arguing that "the dynamical style of explanation" is "far more suitable and favourable to experimental philosophy..." [IV, 533]. So a mathematical construction of the dynamical concept of matter is required.

Kant favours exhibiting the geometrical constructibility of concepts, since these are directly associated with what is given in appearance. But Kant finds himself unable to construct the dynamical concept of matter by this procedure. This shortcoming in the *Metaphysical Foundations* tempers the success of both the a priori foundation for physics and the exhibition *in concreto* of transcendental philosophy.

One of the chief goals of this dissertation has been to show Kant thought of this failure as local and curable, and not a failure in principle requiring ad hoc measures to repair the damage. My suggestion is that Kant believed a remedy to be achievable by "a cleverer hand", and that aspects of his theory of mathematical construction provided the materials for such a remedy. I make no pretence here at being the cleverer hand; nor am I so complacent as Kant concerning the attainability of the resolution he envisions. Examining Kant's suggestion concerning the construction of the concept of matter will be a project of

considerable interest, both from the point of view of his philosophy of nature and of his notion of mathematical construction. But such a project is beyond the scope of this dissertation. What this dissertation does attempt is a reading of Kant's *Metaphysical Foundations of Natural Science* consistent with its stated goals and its place in the critical philosophy.

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