Kant on the Impossibility of Psychology as a Proper Science

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In the *Metaphysical Foundations of Natural Science* (MFNS), Kant provides a "[special] metaphysical doctrine of body" (4:473)[1] in order to show the existence and extent of the proper science of matter. In the Preface, however, Kant argues that both chemistry and "the empirical doctrine of the soul" fail to be "a properly so-called natural science" (4:471). The empirical doctrine of the soul falls especially short for two reasons: (1) mathematics is not applicable to its subject matter and (2) unlike chemistry, the empirical doctrine of the soul can never become an "experimental doctrine" because "the manifold of inner observation...cannot be held separate and recombined at will" (4:471). In addition to these remarks in the Preface, I will identify another argument – mostly in the Mechanics chapter – against the possibility of a proper science of the soul: because the soul is not permanent, laws of the kind required by proper science cannot even be formulated. Call the argument in (1) the impossibility argument (following (Sturm 2001)) and this later argument the impermanence argument.

I will analyze both of these arguments. In so doing, I will explicate just what Kant means by proper science and, in particular, the role of the application of mathematics. Although much of the literature on this aspect of MFNS has maintained that the impossibility argument plays a far more pivotal role than the impermanence argument,[2] I will show that a full analysis of the impermanence argument pays dividends. In addition to shedding more light on the impossibility argument, the impermanence argument elucidates the asymmetry between chemistry (which Kant maintains may eventually become a proper science) and the empirical doctrine of the soul (which Kant maintains can never so become), including the remarks mentioned in (2) above. Understanding this argument can also explain the oft-overlooked and seemingly out-of-place

1 MFNS citations use Akademie pagination but are from Michael Friedman's translation. Quotations from CPR are from the Guyer-Wood translation.

2 (Sturm 2001) maintains that only the lack of (sufficient) mathematization prevents empirical psychology from becoming a proper science. (Nayak and Sotnak 1995) do not even discuss the impermanence argument.

assertion in the Remark to Proposition 3 (the Second Law of Mechanics) that "the possibility of a proper natural science rests entirely and completely on the law of inertia (along with that of the persistence of substance)" (4:544).

1. Terminology

I use the terms 'empirical doctrine of the soul' and 'empirical psychology' interchangably. There is some evidence for such a substitution. In the Paralogisms of the CPR, Kant equates rational psychology with "the rational doctrine of the soul" in contrast with "an empirical doctrine of the soul" which is mixed with even "the least bit of anything empirical" (A342/B400). (A342/B400). But in the MFNS, the empirical doctrine of the soul must be grounded by a special metaphysics of nature which concerns itself with "the empirical concept of … a thinking being" (4:470). Kant then refers to this doctrine as "psychology". I will thus adopt the term 'empirical psychology'.[3]

2. The Impossibility Argument

Recall that Kant says that empirical psychology is not "a properly so-called natural science" because "mathematics is not applicable to the phenomena of inner sense and their laws" (4:471). In order to understand this claim, a few questions must be answered. What does Kant mean by a proper science? Why does the inapplicability of mathematics render a doctrine not a proper science? In what sense does mathematics fail to apply to empirical psychology? I turn to the first two of these questions in the next section and then to the third.

2.1 Proper Natural Science and the Applicability of Mathematics

Kant begins the Preface of MFNS by drawing a distinction between nature in its formal and material meaning. In the latter sense, with which MFNS is concerned, nature signifies "the whole of all appearances" (4:467). Nature has two principle parts aligning with the division of

3 For the nuanced relationship between rational and empirical psychology, see (Hatfield 1992).

our senses into inner and outer. A doctrine of nature can therefore be either a doctrine of body (extended nature) or a doctrine of soul (thinking nature). Natural science, in contrast with "systematically ordered facts about natural things" (4:468), consists in rational connection of cognition according to principles. Proper natural science "treats its object wholly according to a priori principles" whereas improper natural science treats its object "according to laws of experience" (4:468).

In other words, for a science to be proper, the certainty found therein must be apodictic. A proper science's "fundamental natural laws" must be "cognized a priori" instead of being mere regularities in experience (4:468). Such a science has a pure part on which is based its apodictic certainty. This pure part "contains the a priori principles of all other natural explanations" (4:469). It also merits the honorific 'proper' since nature contains the concept of laws which involve "the necessity of all determinations of a thing belonging to its existence" (4:468). A proper natural science requires necessary laws, cognizable a priori, in order to ground the apodictic certainty which reason seeks.

Moreover, because these laws concern the necessity of existent things, and "since existence cannot be presented a priori in any intuition" (4:469),[4] proper natural science presupposes what Kant calls metaphysics of nature. This metaphysics, however, can be of two sorts: general or special. General metaphysics of nature would "treat the laws that make possible the concept of a nature in general" (4:469). Special metaphysics of nature, on the other hand, treats a particular empirical concept but relies on no other empirical principles. At this point, Kant considers as examples of such a special metaphysics the doctrines which start with the empirical concept of matter or of a thinking being and seek "that sphere of cognition of which reason is capable a priori concerning these objects" (4:470). It is also here that he refers to the special metaphysics of corporeal nature as physics and that of thinking nature as psychology.

Having laid out this conception of proper science, Kant asserts "that in any special doctrine of nature there can be only as much *proper* science as there is *mathematics* therein" (4:470). Here I quote the complex argument for this proposition in full and offer a detailed reconstruction of it:

4 See also A160/B199.

> For, according to the preceding, proper science, and above all proper natural science, requires a pure part lying at the basis of the empirical part, and resting on a priori cognition of natural things. Now to cognize something a priori means to cognize it from its mere possibility. But the possibility of determinate natural things cannot be cognized from their mere concepts; for from these the possibility of the thought (that it does not contradict itself) can certainly be cognized, but not the possibility of the object, as a natural thing that can be given outside the thought (as existing). Hence, in order to cognize the possibility of determinate natural things, it is still required that the *intuition* corresponding to the concept be given a priori, that is, that the concept be constructed. Now rational cognition through construction of concepts is mathematical. Hence, although a pure philosophy of nature in general, that is, that which investigates only what constitutes the concept of a nature in general, may indeed be possible even without mathematics, a pure doctrine of nature concerning *determinate* natural things (doctrine of body or doctrine of soul) is only possible by means of mathematics. And, since in any doctrine of nature there is only as much proper science as there is a priori knowledge therein, a doctrine of nature will contain only as much proper science as there is mathematics capable of application there. (4:470)

(1) Proper natural science requires a pure part at the basis of the empirical part.

(2) This pure part concerns the a priori cognizable aspects of the science.

  (2.1) Such cognition can be either metaphysical (if proceeding from concepts) or mathematical (if grounded in the construction of concepts).

(3) To cognize something a priori means to cognize from its real possibility.

(4) The real possibility of a determinate natural thing cannot be cognized from its concept.

  (4.1) Only the logical possibility of the thing can be so cognized.

(5) To cognize the real possibility of a determinate natural thing, a corresponding intuition must be given a priori.

(6) The only way to provide a corresponding intuition a priori is via mathematical construction.

(7) Therefore, a pure doctrine of nature is possible only by means of mathematics.

(8) In such a doctrine, the amount of proper science corresponds to the amount of a priori

knowledge.

(9) The amount of a priori knowledge in a proper science corresponds to the amount of mathematics capable of application therein.

In this argument, (1) and (2) are restatements of earlier aspects of Kant's definition of proper science. In (3)-(5), I have tried to clarify Kant's use of logical and real possibility.[5]

The emphasis in (4) and (5) on the real possibility of a determinate natural thing stems from the previously discussed fact that a special doctrine of nature considers "a particular nature of this or that kind of thing" (4:470). That real and not simply logical possibility is at stake can be seen when Kant expresses concern with the possibility of objects "(as existing)". (6) is practically a definition of mathematics for Kant, echoing remarks both in CPR and earlier in MFNS: "that which grounds its cognition only on the *construction* of concepts, by means of the presentation of the object in an a priori intuition, is called mathematics" (4:469). (2) through (6) also clarify the role of metaphysics and mathematics. The pure part of a proper science contains both metaphysical and mathematical cognitions (4:469). Although it may appear that the argument above draws an asymmetry between the two kinds of cognitions, they are in fact interdependent in demonstrating the real possibility of empirical concepts. The parenthetical "(as existing)" hints at this. Although the real possibility of the categories can be demonstrated in general metaphysics (in the Transcendental Deduction), this cannot be done for empirical concepts. Moreover, because existence cannot be constructed, mathematics will be insufficient. What is needed is a metaphysical articulation of the existence of determinate natural things. Because the dynamical categories (relation and modality) are those "directed at the existence of these objects" (B110),[6] such an articulation must run through the categories of relation and in particular the Analogies of Experience. While this point will be elaborated in detail throughout the paper, hints occur in the Preface. At 4:472, we see that "to make possible the application of mathematics to the doctrine of body,… principles for the *construction* of the concepts that belong to the possibility of matter in general must be introduced first." Such principles are characteristically metaphysical. In particular, Kant appears to be alluding to the Analogies of

5 See (Sturm 2001, p.165), (Friedman 2013, pp.27-28), and B194-195.

6 Although this remark about the categories is only in B, the division into mathematical and dynamical has been made in A: see A529/B557.

Experience when he writes just below that metaphysics contains "principles which first bring the manifold of *empirical representation* into the law-governed connection through which it can become *empirical* cognition, that is, experience." This language reflects the B-edition statement of the general principle of the Analogies[7] and the concluding discussion of all three at A216/B263. We will later see that this allusion is not accidental: the Analogies play a central role in securing the applicability of mathematics and thus for establishing a proper science.

A tension, however, arises with (3)-(6). Following the Postulates of Empirical Thought, one must distinguish pure from empirical concepts. The former are a priori conditions on which the possibility of experience rests; the latter are extracted from experience. Consequently, the real possibility of some pure concepts (mathematical ones, in contrast with the categories) can be demonstrated by construction in pure intuition (A720-721/B748-749). By contrast, the real possibility of empirical concepts "can only be gathered from their actuality in experience" (A223/B270). If, then, the relevant "determinate natural thing" in (4) and (5) is an instance of an empirical concept, it seems that its real possibility could not be demonstrated by the construction of an a priori intuition as in (5) and (6). This is especially problematic since Kant appears to be considering the empirical concept of matter as the paradigmatic determinate natural thing. Further confounding this issue, Kant later argues that his dynamical conception of matter cannot be constructed (4:525).

The way out of this impasse, I suggest, is that we understand the correspondence between an intuition and a determinate natural thing in (5) by analogy with representation theorems in measurement theory. Given the undeniable tenets that matter is an empirical concept and that such concepts cannot be constructed in a priori intuition, the argument above cannot be read as Kant trying to 'turn an empirical concept pure'. Rather, he is explaining how mathematical constructions can apply to empirical concepts in order to make experience and necessary laws possible. I will briefly explain how such application works in measurement theory and then analyze the Phoronomy to show that Kant has something similar in mind in the Preface.

Consider the paradigm example of measurement theory: the measurement of length. Suppose that we have a bunch of rods. These can be ordered as follows: *r1* is (strictly) longer than *r2* iff when *r1* and *r2* are placed side-by-side with one end of each agreeing, *r1* extends

7 B218: "Experience is possible only through the representation of a necessary connection of perceptions."

beyond *r2*. There is a binary operation on rods – concatenation, a kind of mereological sum – that generates a rod longer than the length of either individual rod. We can model this as an empirical structure $<A,R,*>$ where A is the set of rods, R the comparison relation and * the concatenation operation. By considering the empirical meaning of this structure, we can verify certain basic facts about it. For instance: * is commutative, $a*aRa$ (concatenating a rod with itself produces a longer rod) holds for all a, and so on. Measurement theory delivers representation theorems of the following kind: if an empirical structure $<A,R,*>$ satisfies certain conditions (call them S), there is a homomorphism (structure-preserving function) from $<A,R,*>$ to $<\mathbf{R},<,+>$, where **R** is the real numbers, < the strictly-less-than relation, and + the addition operation.[8] In light of this representation theorem, if we can check that our empirical structure satisfies the axioms in S, then we can represent the lengths of rods as real numbers. When we find an empirical structure with a binary concatenation operation which is representable as addition in some number system, we call the structure *additively measurable*.[9] In other words, a representation theorem of the kind mentioned above shows that quantities can be ascribed to entities in such a way that empirical compositions can be represented by numerical sums. For present purposes, it's worth noting that all standard axiomatizations of additively measurable empirical structures require an axiom to the effect that any two elements in the structure can be combined via the * operator, i.e. that it is total. Accordingly, a key step in demonstrating that a certain quantity is additively measurable is exhibiting a binary operation that can combine any two of the relevant set of elements.

The Phoronomy can be understood in these terms as demonstrating that motions are additively measurable by exhibiting an appropriate composition operation. Recall that the Phoronomy lines up with the determination of matter with respect to the categories of quantity. Because Kant argues in the Preface that natural science is a "pure or applied doctrine of motion" (4:477), the Phoronomy is "the pure theory of quantity (mathesis) of motions" (4:489). The Phoronomy itself contains a sole Proposition (4:490) which, via a case-by-case argument,

8 The precise details need not concern us. For surveys, see (Suppes and Zinnes 1963; Luce and Suppes 2004). The first set of axioms for this particular representation theorem are due to Hölder; see the translation of his 1901 paper: (Michell and Ernst 1996).

9 Although the measurement theory literature usually uses *extensively measurable*, I avoid that term because of Kant's subtly different use of the term extensive magnitude. These differences will become apparent later. See (Sturm 2006) for details on the history of the distinction between extensive and intensive magnitudes.

demonstrates how to compose two motions. Explication 5 (4:489) tells us that "[t]he *composition of motion* is the representation of the motion of a point as the same as two or more motions of [this point] combined together." In other words, the Proposition exhibits a binary operation on motions of a similar kind as concatenation of rods in length measurement. Now, because Kant takes the concept of quantity to be the representation of an object via composition of the homogeneous, "the doctrine of the composition of motion is, at the same time, the pure doctrine of the quantity of motion" (4:495).

Returning to the puzzle raised by (3)-(6), I claim that the way of giving a corresponding intuition a priori for a determinate natural thing that Kant has in mind consists in showing that aspects of the relevant empirical concept are measurable. In other words, Kant seeks to secure the applicability of mathematics in natural science via measurement. One aspect of the analogy to measurement theory that might mislead should be avoided: in measurement theory, the relevant empirical structure is taken as given and we simply ask whether certain axioms hold of it. In Kant's case, however, the main task is exhibiting how certain appearances can have the relevant structure in the first place. Doing so involves characteristically metaphysical tools: in the Phoronomy, the categories of quantity; in the Mechanics, as we will see, the categories of relation (and substance in particular). Even so, the Phoronomy example does not tell the full story of how measurement works for Kant. Although the construction in the Phoronomy makes the emphasis on the addition operation clear, the relevant construction takes place in pure intuition. We will later see how the exhibition of such an operation in the case of measuring quantity of matter requires an even stronger interaction between the metaphysical and mathematical parts of the pure part of a proper science.

2.2 The Inapplicability of Mathematics to Empirical Psychology

Kant's first argument against the status of empirical psychology as a proper science now seems straightforward: because mathematics is not applicable to the objects of empirical psychology, there is no proper science to be found. Immediately following this statement, however, Kant writes that

> the only option one would have would be to take the *law of continuity* in the flux of inner changes into account – which, however, would be an extension of cognition standing to that which mathematics provides for the doctrine of body approximately as the doctrine of the properties of the straight line stands to the whole of geometry. For the pure inner intuition in which the appearances of the soul are supposed to be constructed is *time*, which has only one dimension. (4:471)

In particular, Kant seems to be saying that we could apply the mathematics of a one-dimensional continuous line in the empirical doctrine of the soul.[10] Kant echoes this exact view in *What real progress has metaphysics made in Germany since the time of Leibniz and Wolff?*:

> In both [the doctrine of body and the doctrine of soul] there can be [proper] science only insofar as mathematics, i.e., the construction of concepts, can be applied therein, and hence the spatiality of objects can do more a priori for physics, than the form of time which underlies intuition through inner sense, since the latter has only one dimension. (20:286)

Note that when Kant says that time has one dimension, he alludes to the Aesthetic, where he argues that we must "represent the temporal sequence through a line progressing to infinity" (A33). In other words, to mathematically construct time, which is a necessary step in potentially rendering the empirical doctrine of the soul a proper science, we must appeal to space, the form of outer sense.

Nevertheless, the question arises: if Kant grants that a small amount of mathematics is applicable in empirical psychology, why does he so flatly reject its status as proper science simpliciter? Why is it not just a proper science to a lesser degree than, say, physics? After all, using the language of the previously outlined argument, it could just be that the amount of proper science in the doctrine of the soul is much smaller than in the doctrine of body. In fact, the amount of mathematics applicable by the above argument is quite small: for reasons that will be given later, the mathematics of the one-dimensional line that Kant here refers to does not include its additive or multiplicative structure but is simply the mathematics of a continuous linear order.

10 Friedman (2013, p.6) and Sturm (2001, p.168).

Still, that is some non-trivial mathematics, so the question above remains. Other commentators have pointed out this difficulty and responded in ways that are ultimately unsatisfactory.

Nayak and Sotnak (1995, pp.147-149) argue that natural science studies fundamental metaphysical properties of objects of outer sense and that among these properties are attractive and repulsive forces. They attribute to Kant the view that for a doctrine to become a proper science, what is needed "is not simply mathematization of the subject matter, but a particular sort of mathematization, viz., a mathematical expression of laws of attractive and repulsive forces". They also maintain that such laws can only be expressed for objects of outer sense. Psychology, then, can never become a proper natural science because its object of study is restricted to purely inner sense. While they are right in the light of our previous discussion to try and restrict the applicability claim, doing so in this manner inverts the order of explanation in Kant's text. They overlook the fact that in Kant's primary argument for the claim that there is only as much proper science as mathematics capable of application, he does not yet eliminate the possibility of mathematizing empirical psychology. The doctrine of soul is directly mentioned in the argument itself: "a pure doctrine of nature concerning determinate natural things (doctrine of body or doctrine of soul) is only possible by means of mathematics" (4:470). If Nayak and Sotnak were correct in arguing that the kind of mathematization that Kant has in mind in the Preface involves laws of attractive and repulsive forces which cannot be formulated for the object of inner sense, it would remain wholly mysterious why Kant does not rule out the doctrine of soul as a candidate pure special doctrine of nature at this point. Moreover, at this point in MFNS, Kant has not established the fundamentality of attractive and repulsive forces. Although the General Remark to Dynamics (4:534) does make some suggestive remarks about reduction to fundamental forces, it is an error to argue that these ideas are in play in Kant's argument in the Preface.

On my reading, this impossibility argument is of secondary importance. While the inability to apply more than the mathematics of a continuous linear order to the phenomena of inner sense certainly seems limiting, it alone cannot account for the strength of Kant's claims concerning the doctrine of the soul. In order to fully understand why this doctrine will never attain the status of a proper science, we must look at the impermanence argument and its connections to more fundamental tenets of Kant's distinction between corporeal and thinking nature.

3. The Impermanence Argument

The second argument against the possibility of empirical psychology as a proper science – the impermanence argument – runs roughly as follows: because the soul cannot be permanent, it cannot realize the schematized category of substance and thus cannot be a substratum of time determination. Because of this, the Analogies of Experience fail to apply to the phenomena of inner sense. This means that the kind of laws that Kant requires in the pure part of a proper science cannot be formulated for inner sense. In order to elucidate all of these points, I will analyze some of Kant's arguments in the Mechanics and relevant sections of CPR in order to draw out the distinction between objects of outer sense and of inner sense with respect to permanence. First, I will explain how a quantitative conservation law like one has in the doctrine of body cannot be formulated in the doctrine of soul because of the soul's impermanence. Then, I will explain how this lack of a quantitative conservation law renders the doctrine of soul incapable of being a proper science.

3.1 Conservation of Quantity and Divisibility of Substance

Proposition 2 of the Mechanics (the First Law of Mechanics) states that "In all changes of corporeal nature the total quantity of matter remains the same, neither increased nor diminished" (4:541). This is a quantitative conservation law. The proof of Proposition 2 appeals to the First Analogy of Experience, which states a qualitative conservation law:

> (From general metaphysics we take as basis the proposition that in all changes of nature no substance either arises or perishes, and here it is only shown what substance shall be in matter.) In every matter the movable in space is the ultimate subject of all accidents inhering in matter, and the aggregate of these movables, external to one another, is the quantity of substance. Hence the quantity of matter, with respect to its substance, is nothing else but the aggregate of substances of which it consists.[11] Therefore, the

11 Kant earlier introduced quantity of matter as "the aggregate of the movable in a determinate space" (4:537).

> quantity of matter cannot be increased or diminished except in such a way that new substance arises or perishes. Now substance never arises or perishes in any change of matter; so the quantity of matter is also neither increased nor diminished thereby.... (4:541-542)

In other words, the quantity of matter is an aggregate of movables which are themselves substances. Then the conservation of this quantity follows relatively straightforwardly from the conservation of substance stated in the First Analogy. This is because the quantity of matter cannot change "without substance arising or perishing" (4:542).

In the Remark immediately following this proof, Kant draws a fundamental asymmetry between outer sense and inner sense on precisely this point. The quantity of an object in outer sense can be linked to the quantity of substance therein because the object "must consist of *parts external to one another*" (4:542) which must be substances since they are themselves movable. The purported object of inner sense, by contrast, "*does not consist of parts external to one another*". This means that the parts of the object of inner sense are therefore not themselves substances and so they can arise or perish without substance arising or perishing. In other words, this object can have a magnitude which varies while the amount of substance contained therein does not. Although there may be an intensive magnitude (A168/B210) providing a quantity to the object of inner sense, the conservation of this magnitude cannot be inferred from the conservation of substance more generally. Only when an object is spatially extended, when it has 'parts external to one another' can this inference be made because then the relevant magnitude is extensive.[12] For Kant, a magnitude is extensive when it is the sum of its parts, which necessarily precede it (A162/B203). In other words, when the quantitative sum can be read directly off of the mereological sum. This contrasts with the modern use of extensive magnitudes which normally refers to those magnitudes measurable on a ratio scale (essentially what I have called additively measurable magnitudes). As an example, velocity or quantity of motion for Kant is an intensive magnitude. The earlier discussion of the Phoronomy shows, however, that it can still be additive because an appropriate composition operation can be exhibited. But the existence of this composition operation does not make velocity an extensive

12 See (Friedman 2013, pp. 311-335). The inference alluded to resembles what Michell (2006) calls 'the psychometrician's fallacy'.

magnitude for Kant because the composed velocity does not arise as the composition of homogeneous parts.

3.2 Lifelessness and Empirical Time-determination

The contrast between objects of inner sense and of outer sense with respect to permanence does not alone, however, explain why there can be no proper science of the soul. What about the permanence of objects renders them amenable to proper scientific treatment? The answer to this question involves a detour through the schematized concept of substance. Recall that the Second Law of Mechanics realizes in the special metaphysics of corporeal nature the First Analogy of Experience in general metaphysics. In the proof of this First Analogy, it becomes clear that the operant notion of substance is the schematized concept. Compare in the proof that substance is referred to as "the substratum of everything real, i.e., everything that belongs to the existence of things" (B225) with "the schema of substance is the persistence of the real in time, i.e. the representation of the real as a substratum of empirical time-determination in general, which therefore endures while everything else changes" (A144/B183). More general architectonic considerations also make this clear. The four groups of Principles of Pure Understanding break into two groups: mathematical (Axioms of Intuition and Anticipations of Perception) and dynamical (Analogies of Experience and Postulates of Empirical Thinking in General). The latter two pertain "to the existence of an appearance in general" (A160/B199). Because the Analogies are rules for the empirical use of the understanding, however, their proofs show not how to subsume appearances under the pure categories, but only under their schemata (A181/B223). As Kant concludes the introduction to the Analogies, in the execution of an analogy corresponding to a category of relation, "we set its schema in its place" (B224).

It follows that a necessary condition for empirical time-determination is an instance of the schematized category of substance. Proposition 2 of the Mechanics, as well as the Proof and Remark following it, show that such an instance can only be an object of outer sense. These conclusions also echo remarks from the A Paralogisms relating the doctrines of soul and body. Kant maintains that "much can be cognized *a priori* from the mere concept of an extended impenetrable being" (A381) but that nothing can be so cognized from the concept of a thinking

being. Most critically, this asymmetry arises because the object of outer sense "has something standing and abiding in it, which supplies a substratum of transitory determinations" whereas "that which we call the soul...has nothing abiding" (A381). In other words, it is because only objects of outer sense can be substrata for time-determination that anything about them can be cognized a priori.

In the context of MFNS, we can elaborate this thought and relate it to proper science because the a priori laws that form the pure part of a proper science for Kant can only be formulated in terms of time-determination and therefore by reference to objects of outer sense. Recall that the concept of these laws "carries with it the concept of the *necessity* of all determinations of a thing belonging to existence" (4:468). This, again, echoes the proof of the First Analogy which states that "everything that belongs to existence can be thought only as a determination" of substance (B225). As Friedman (2013, p. 328) puts it, "All such a priori laws of nature, in the critical period, are ultimately based on the necessary conditions of empirical time determination, and what Kant calls the substratum of time determination is an instantiation of the schematized category of substance." Because these instantiations can only be objects of outer sense, a priori natural laws of inner sense alone cannot even be formulated. A fortiori, there is no proper science thereof.

This connection with the First Analogy can also shed light on the impossibility argument. This is because "only in that which persists, therefore, are temporal relations possible" (B226). In particular, duration, that is the existence of an object at different parts of time, becomes a mathematical magnitude only through the persistent substratum of time-determination (see A215). Thus, when in the Preface Kant refers to time as one-dimensional, he still does not mean that it has the full structure of the continuum. We know the law of continuity applies to the flux of inner changes, but this does not mean that one-dimensional time has, for instance, additive structure. In order for time to have such a structure, parts of the temporal sequence must be able to be related to each other, compared, and composed. This, however, is possible only via time-determination which is mediated by objects of outer sense.

In fact, the Second Law of Mechanics (Proposition 3) also plays a pivotal role in making time-determination possible. This law, Kant's version of the law of inertia, states that "Every

change in matter has an external cause" (4:543).[13] The structure of the proof resembles that of the First Law: from "general metaphysics" (CPR), the Second Analogy (that every change has a cause) is borrowed and it is shown that in the case of matter this cause must be *external*. For our present purposes, the Remark plays a more pivotal role than the proof. I quote a large chunk:

> *Life* is the faculty of a *substance* to determine itself to act from an *internal principle*, of a *finite substance* to change, and of a *material substance* [to determine itself] to motion or rest, as change of its state. Now we know no other principle in a substance for changing its state except *desiring*, and no other internal activity at all except *thinking*, together which that which depends on it, the *feeling* of pleasure or displeasure, and *desire* or willing. But these actions and grounds of determination in no way belong to representations of the outer senses, and so neither [do they belong] to the determinations of matter as matter. Hence all matter, as such, is *lifeless*. The principle of inertia says this, and nothing more. (4:544)

Later in the Remark, Kant concludes that "The possibility of a proper natural science rests entirely and completely on the law of inertia (along with that of the persistence of substance)" (4:544).

On my reading, when Kant in the Preface says that "even observation by itself already changes and displaces the state of the observed object" (4:471), he contrasts this change of state with the lifelessness of matter. In other words, the soul can internally cause a change of its own state. But Kant seems to hold that the possibility of a proper natural science depends essentially on the lifelessness of the object of study. Why, however, does the lifelessness of matter play such a pivotal role?

The answer to this question, I believe, is that even though the First Law of Mechanics shows that only objects of outer sense can serve as substrata of time-determination, it is not until this Second Law that Kant shows how time-determination may actually be carried out. This can be seen by noting that in the General Remark to Mechanics, Kant argues that "the possibility of

13 Kant continues with a more traditional formulation: "(Every body persists in its state of rest or motion, in the same direction, and with the same speed, if it is not compelled by an external cause to leave this state.)" See (Friedman, 2013, pp.335-347) and (Buchdahl 1969, ch VIII, S9) for the relationship between these formulations.

acceleration in general, by means of a continued moment thereof, rests on the law of inertia" (4:551). Moreover, the application of the Second Analogy of Experience to matter specifically can only occur through acceleration. This is because Kant takes alteration to mean change of state of an object; while traveling at uniform velocity would involve change of place, it does not constitute change of state (of motion) of the object. In a footnote at A207/B252 Kant says roughly that: "Note well that I am not talking about the alteration of certain relations in general, but rather of the alteration of the state. Hence if a body is moved uniformly, then it does not alter its state (of motion) at all, although it does if its motion increases or diminishes." Now, the application of the Second Analogy makes time-determination possible because through it we subject the succession of the manifold of appearance to a necessary order. So Kant says at the beginning of the Second Analogy in B that "it is only because we subject the sequence of the appearances and thus all alteration to the law of causality that experience itself … is possible" (B234).

In other words, the Second Law of Mechanics provides the means by which we can actually place appearances in time and relate them to one another. Kant concludes the Second Analogy by noting that through this analogy arises "the possibility of a continuous determination of all positions for the appearances in this time, through the series of causes and effects" (B256). Although I argued that a priori natural laws cannot even be formulated without a substratum of time-determination (thus not without reference to objects of outer sense), the relationship between such laws and inertia seems even stronger in light of the present discussion. Recall that such laws will exhibit necessary connections of perceptions. In other words, they will be instantiations of the Second Analogy to particular changes of state of objects. Thus, while the Second Analogy shows "the possibility of cognizing *a priori* a law concerning the form of alteration" (B255-256), a priori laws of nature would provide the content of some particular alterations. The arguments of the first two Laws of Mechanics show that these laws can only be formulated as laws of alterations of objects of outer sense. Such objects, in the first place, are the only ones which can be substrata of time-determination; in the second place, alterations of such objects are the only way that particular time-determination becomes possible. This intimate relationship also explains why Kant connects both inertia and permanence of substance with the possibility of proper natural science in the Remark to the Second Law of Mechanics. Because

the soul does not meet these conditions, there can be no proper science thereof.

3.3 Separability in the Preface

In the Preface to MFNS, after the impossibility argument discussed earlier, Kant continues his discussion of psychology:

> … the empirical doctrine of the soul can also never approach chemistry even as a systematic art of analysis or experimental doctrine, for in it the manifold of inner observation can be separated only by mere division in thought, and cannot then be held separate and recombined at will (but still less does another thinking subject suffer himself to be experimented upon to suit our purpose), and even observation by itself already changes and displaces the state of the observed object. (4:471)

At first glance, these remarks appear just to point to some methodological limitations on our ability to 'experiment' on the soul. The parenthetical remark, for instance, seems simply to state that we have no access to the inner sense of another person. The end of the quoted remark indicates that observation changes the object observed and so cannot be reliable. These seem to indicate that Kant has introspectionist psychology in mind and intends here only to point out the limitations of introspection as a scientific method.[14] Nevertheless, there are interesting parallels between these remarks and the impermanence argument that we find in the Mechanics.

In the context of the above remark that "the manifold of inner observation can be separated only by mere division in thought" (4:471), it is interesting to note that Kant frames the distinction between outer and inner sense discussed in section 3.1 in terms of division. The quantity of matter can be diminished only by division "(separation of substance from a composite)" whereas the "very substance of the soul would still be subject to a gradual perishing", i.e. "a gradual waning of its degree" that would result "not by division" (4:542). In other words, the objects of outer sense can be divided into sub-substances while the alleged object of inner sense cannot. It seems then, that the "mere division in thought" mentioned in the

14 See (Sturm 2001) and (Sturm 2006) for historical details on the introspectionist school in psychology and Kant's reaction thereto.

Preface could correspond to this expiration of the intensive magnitude of the soul, in contrast to the substantial division of an object of outer sense. This terminology also alludes to the "Refutation of Mendelssohn's proof of the permanence of the soul" at B413-415. While the details need not concern us presently, Kant there concludes that the soul cannot be permanent.

This remark about division in thought is immediately followed by the further statement that the manifold of inner observation "cannot then be held separate and recombined at will" (4:471). This becomes especially pertinent when one observes that measuring weight by an equal-arm balance is another example *par excellence* of the kind of additive measurement discussed earlier. In this case, the binary operation consists just in placing two objects on the same pan of the balance and the ordering relation is just given by the relative heights of the two pans. In fact, just this kind of measurement serves as Kant's departure point in Proposition 1 of the Mechanics, which states that quantity of matter can only be measured via quantity of motion. Thus, in the Remark to Proposition 1, he writes that "this quantity of matter (the aggregate of the movable) *manifests itself* in experience only by the quantity of motion at equal speed (for example, by equilibrium)" (4:540). This emphasis on measurement of quantity of matter by the balance appears heavily in the *Opus Postunum* as well (21:408, 22:206-208). While Proposition 1 primarily shows how to extend this kind of measurement can be extended to compare different kinds of matter,[15] the relevant point for the present discussion is that the reason this kind of measurement works for quantity of matter is that this quantity for a body is the aggregate of the quantities of matter in the subparts of the body. This provides a link between mereological and numerical sums of the kind captured by representation theorems in formal measurement. The equal-arm balance and the details in Proposition 1 show how to give a binary combination operation for quantity of matter measurement; Kant's remark in the Preface about the inability to recombine inner observation at will can be read as alluding to the futility of seeking such a combination operation for the purported object of inner sense.

This kind of measurement of quantity of matter does have a fundamental difference with the measurement of quantity of motion in the Phoronomy even though both are examples of additive measurement: whereas the construction of the operation on motions in the Phoronomy takes place in pure intuition, the operation in the Mechanics requires metaphysical in addition to

15 See (Friedman 2012) for details of the extension to celestial bodies.

mathematical principles. To see this, two aspects must be distinguished: (i) how balance measurement works and (ii) why Kant thinks that quantity of matter must be estimated mechanically via the balance. First, one must distinguish between what we now call inertial mass and weight.[16] The former, resistance to acceleration, equals the force applied divided by acceleration. This is a property of bodies[17] which does not depend on the particular forces acting on a body. The latter – weight – is, however, what is measured in the balance. The balance measures the gravitational force on the respective pans which corresponds to the sum of the weights of the bodies in the pan. When the balance is in equilibrium, we know therefore that the forces acting on each pan are equal. To infer from this that the masses of the bodies in each pan are equal, one must use Galileo's result that all bodies experience uniform acceleration due to gravitation.[18]

For the second issue, the relevant discussion occurs in Explication 2 and Proposition 1 of the Mechanics and the ensuing Note and Remark. The Explication states that "the *quantity of matter* is the aggregate of the movable in a determinate space" (4:537); Proposition 1 states that this quantity can only be estimated (that is, measured) by quantity of motion at a given speed. The proof of the Proposition is illuminating. It begins: "Matter is infinitely divisible." This is a restatement of Proposition 4 of the Dynamics (4:503). This appeal makes sense in the context of the Remark to Explication 1 that "all mechanical laws presuppose dynamical laws" (4:537) because matter is explicated as being the movable insofar as it has moving force. Moreover, although quantity of matter can be measured by volume if two matters of the same kind need to be compared, this does not yield a universal measure for the purpose of comparing matters of potentially different kinds. This follows from Kant's rejection of hard-body atomism (the "mechanical mode of explanation") in the General Remark to the Dynamics. That "quantity of motion at a given speed" will suffice follows from the later part of Explication 2 where Kant

16 In general, to measure quantity of matter of celestial bodies, we must also consider gravitational mass. Kant first indicates this much in the Remark to Proposition 1: "*original attraction*, as the cause of universal gravitation, can still yield a measure of the quantity of matter" which Kant says will be "indirectly" mechanical measurement (4:541). Again, see Friedman (ibid.) for details on this extension.

17 Recall that the Phoronomy considers point-masses and not empirical bodies.

18 In more modern terms, we have that F1=m1*a1 and F2=m2*a2, where F1 and F2 are the forces exerted on each pan. In equilibrium, we know that these two quantities are equal: m1*a1 = m2*a2. By Galileo's result, a1=a2, and so m1=m2 where m1 and m2 are the total mass of the bodies in each pan. The status of this result for Kant is an interesting topic lying beyond the present scope.

states that quantity of motion can be estimated mechanically as quantity of matter and speed together. If we want a difference in quantity of motion to yield a difference in quantity of matter, we need the speed to be the same. This occurs, for instance, in a balance in equilibrium.

To see the Kantian metaphysics at play in all of this, in the Remark to Proposition 1, Kant writes that "the quantity of matter is *the quantity of substance* in the movable" (4:540). It becomes clear in the subsequent discussion that the relevant concept of substance here is the unschematized category. This remark also alludes to the Remark to Explication 5 and the proof of Proposition 4 in the Dynamics where matter is considered as "material substance". In light of the remarks in the Preface about separability by mere division in thought, it is worth noting that these passages in the Dynamics are also couched in terms of separability and (physical) division. Most importantly, while the proof of Proposition 1 ruled out volume as a general measure of quantity of matter, this identification with quantity of substance helps explain why the measurement of quantity of matter via motion must proceed mechanically and not dynamically. This is because the inherent motion of a matter is a predicate which indicates an aggregate of moved matters (via Explication 2); this contrasts with dynamical properties which can have varying magnitudes as the result of a single subject (4:541). In other words, Kant's conception of substance plays an ineliminable role in singling out the mechanical measurement of quantity of motion at a given speed – paradigmatically, by a balance in equilibrium – as the unique general measure of quantity of matter.

By the previous discussion, I do not mean to suggest that this ability to separate and recombine at will suffices to get conservation of quantity of matter. For one thing, in measurement theory, the totality axiom is one amongst many. The ability to form arbitrary compositions is necessary, but not sufficient, for additive measurement. Moreover, if this separability and recombinability were sufficient, this would deliver a conservation law for chemical reactions which was not yet known. Nevertheless, it's worth noting that as early as the 1781 A edition of CPR, Kant appears open to the idea of the conservation of quantity of matter in chemical reactions. In the First Analogy, he writes (A185/B228): "A philosopher was asked: How much does the smoke weigh? He replied: If you take away from the weight of the wood that was burnt the weight of the ashes that are left over, you will have the weight of the smoke." Kant contends that this answer presupposes what is shown in the First Analogy, i.e. that in fire

substance only changes but does not disappear. As he writes in a margin note to his copy of A (23:47): "Whence does he know this? Not from experience." Once we have the First Analogy, we know that the above must give the weight of the smoke even in the absence of a method for directly measuring said weight. This is because although the wood has been separated into two components – ash and smoke – by combustion, no substance has arisen or perished. One must also note that this smoke passage remains in the B edition, in which the First Analogy has changed from a qualitative persistence law to a quantitative conservation law. Thus, although Kant does not at this point have an implementation of conservation of quantity of matter in chemical reactions, he does hint that such conservation should hold. We will soon see how Kant's attitude towards conservation of quantity of matter in chemical reactions shifts in response to Lavoisier's work. For now, it has been shown that the manifold of inner observation is not permanent enough to be amenable to additive measurement. Although it has not been shown that the manifold of chemical observation is so amenable, there are indications that Kant thinks it may be.

4. Chemistry and Conservation

One last virtue of my reading is that a fundamental asymmetry between chemistry and psychology becomes apparent. Although chemistry also does not constitute a proper science, this is because "its principles are merely empirical" (4:471). In other words, the laws of chemistry are mere laws of experience, not laws of nature cognizable a priori as required for proper natural science. Kant leaves it open that chemistry may one day become a proper science, though psychology can never so become. Consider, for instance, how the argument against a science of the soul concludes:

> Therefore, the empirical doctrine of the soul can never become anything more than an historical doctrine of nature, and, as such, a natural doctrine of inner sense which is as systematic as possible, that is, a natural description of the soul, but never a science of the soul, nor even, indeed, an experimental psychological doctrine. (4:471)

The fundamental differences between the soul and objects of outer sense discussed above provide the reason why there will *never* be a proper science of the soul. These fundamental differences do not exist, however, between the object of chemical study and the more fundamental objects of physics treated in MFNS. In principle, a priori laws of chemical actions may be discovered in the future (whereas such laws of the soul could not even be formulated). Thus, at 4:470-471, Kant refers to the discovery of a "law of the approach or withdrawal of the parts of matter" to explain the motions of chemical actions as "a demand that will only with great difficulty ever be fulfilled". But it could possibly be fulfilled since the object of chemical study satisfies the conditions required to formulate such a law.

While Kant in MFNS leaves open the possibility of chemistry becoming a proper science, his attitudes toward chemistry in fact change dramatically in the post-critical period during which the Chemical Revolution took place.[19] In both editions of CPR and in MFNS, chemistry refers to traditional Stahlian chemistry with its crucial use of phlogiston in explaining combustion. Approximately a decade after the publication of the B edition, however, Kant enthusiastically supports in print the chemistry of Lavoisier. In the 1797 Preface to the First Part of *The Metaphysics of Morals*:

> So the *moralist* correctly says: there is only one virtue and doctrine thereof, i.e., one unique system that combines all duties of virtue through a single principle; the *chemist*: that there is only one chemistry (that according to *Lavoisier*); …. (6:207)

Even more tellingly, in the 1798 *Anthropology From a Pragmatic Point of View*, Kant mentions Lavoisier in the same light as Archimedes and Newton:

> What amount of knowledge, what discovery of new methods would now lie already in store, if an Archimedes, a Newton, or a Lavoisier had, with their industry and talent, been favored by nature with a lifetime lasting through a century of undiminished vitality? (7:326)

19 For the relevant changes in chemistry and Kant's evolving attitude towards chemistry, see (Friedman 1992), chapter 5, section III. Friedman concludes that Kant had officially adopted Lavoisier's chemistry by 1795. (Partington 1962) contains relevant portions of the history of chemistry.

These passages appear to mark an implicit attribution by Kant of the honorific proper science to the new anti-phlogistic chemistry of Lavoisier.

In light of the earlier discussion, I conjecture that one source of Kant's late attitude toward chemistry and admiration of Lavoisier consists in Lavoisier's ingenious experimental demonstration of the conservation of quantity of matter for gases in chemical reactions. Central to these experiments was Lavoisier's use of the equal-arm balance in gaseous reactions; in fact, Guerlac (1961) refers to the use of the balance as "the key to the [Chemical] Revolution" (xviii). In the present context, this emphasis gains importance when combined with Carrier's (2001) argument that the procedure for measuring quantity of matter in terms of quantity of motion that Kant has in mind in Proposition 1 of the Mechanics is terresterial weighing in an equal-arm balance.[20] That the quantity of matter in chemical reactions can be measured in the same way as in physical reactions likely made Kant more confident in conservation in chemical reactions. Because, as we have seen in section 3, the kind of laws which lie in the pure part of a proper science can only be formulated for objects for which a quantitative conservation law can be demonstrated, confidence in this conservation could yield confidence in discovery of the right kind of laws which would move chemistry from an experimental doctrine to a proper science. Therefore, the present interpretation of the impermanence argument not only explains the difference in attitude towards chemistry and psychology in MFNS but can also help explain Kant's subsequent shift in attitude towards the new science of chemistry.

We also have evidence that there were intermediate steps in Kant's evolving attitude towards chemistry. The following sentence from the 1788 *Critique of Practical Reason* is telling (5:26): "Even the rules of uniform appearances are called laws of nature (e.g., mechanical laws) only when they are cognized really a priori or (as in the case of chemical laws) when it is assumed that they would be cognized a priori from objective grounds if our insight went deeper."[21] Two things must be noted. First, it reflects a stronger endorsement of the possibility of chemistry becoming a proper science (which, recall, will happen when its laws are cognized a

20 Recall the passages in the *Opus Postunum* (21:408, 22:206-208) where Kant emphasizes measuring quantity of matter via equal-arm balance.

21 Thanks to Meica Magnani for bringing this quotation to my attention.

priori) than we find in the MFNS. In the latter, while it is left open that chemistry may become a proper science, there exists no assurance that the only stumbling block is our current lack of insight. He there speaks of the "dissatisfaction" left by chemical principles which are contingent empirical laws for which "one can adduce no a priori grounds" (4:469).[22] Second, and more importantly, the conservation of quantity of matter stands as the most significant of the mechanical laws to which Kant alludes in the first part of this sentence. Of course, that this conservation law is a law in the strict Kantian sense can be seen from it being named the First Law of Mechanics. Moreover, just before the earlier discussed smoke passage in the First Analogy, Kant writes that the law of persistence of substance[23] "deserves to [stand] at the head of the pure and completely *a priori* laws of nature" (A184/B227). While the discussion in section 3 helps to elaborate this claim, the present sentence from the second Critique links Kant's shifting attitudes towards chemistry with the importance for him of quantitative conservation laws.

While a complete discussion of Kant's views of chemistry and their evolution lies beyond the present scope, this discussion adds one more dimension in which Nayak and Sotnak's reading falls short. On my present reading, Kant's attitudes towards chemistry change not because the appropriate kind of laws alluded to in the Preface of the MFNS have been found but because of the discovery of a quantitative conservation law. But on the Nayak and Sotnak view, mathematization for Kant requires laws of attractive and repulsive forces. On my interpretation, additive measurement of magnitudes plays the critical role. While we earlier argued that their view gets the order of explanation wrong in MFNS, this new understanding also provides a more satisfying diagnosis of Kant's evolving views towards chemistry.

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22 We speculate that the development of pneumatic chemistry in 1781-1788 contributed to this change in attitude.

23 The present quotation comes from A, at which point the First Analogy has not yet been formulated as a quantitative conservation law.

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