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Kant, Newton, and the Conditions of Possible Experience

Linda Cochrane

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of

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ABSTRACT

Kant, Newton, and the Conditions of Possible Experience

Linda Cochrane

Kant limited knowledge to the objects of possible experience "whose objective reality can be proved." To support his position, he sought to demonstrate the principles underlying all theoretical knowledge. He thus sought the *a priori* presuppositions necessary for the possibility of experience. In the *Metaphysical Foundations of Natural Science*, Kant demonstrates that experience includes scientific experience and even seems to imply that the notion of experience is exhausted by scientific experience. Owing to his apparent restriction of experience, and, hence, knowledge, to the objects of Euclidean geometry and Newtonian physics, several philosophers have suggested that developments in non-Euclidean geometries and modern physics have undermined Kant's necessary conditions of possible experience.

In this thesis, I attempt to show that Kant did not contend that Euclidean geometry and Newtonian physics had absolute validity, but limited their applicability to nature "*so far as it can be perceived by our senses.*" Given this limitation, non-Euclidean geometries and the theories of relativity and quantum mechanics cannot be used to undermine Kant's necessary conditions of possible experience. In other words, the infinitesimally small objects and distances of Quantum Mechanics; the extremely large objects, distances, and velocities of Relativity; and the multiple dimensions of String Theory all lie outside the frame of reference of sensible nature. Further, Newtonian physics is not only a useful way of describing and coping with empirical reality, but is a reflection of the way that the human cognitive capacity functions—that is, humans, and perhaps most other beings, synthesise a Newtonian reality.

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ABBREVIATIONS

CJ	–	*Critique of Judgement* by Immanuel Kant
CPuR	–	*Critique of Pure Reason* by Immanuel Kant
GMM	–	*Groundwork of the Metaphysic of Morals* by Immanuel Kant
ID	–	*Inaugural Dissertation* by Immanuel Kant
MFNS	–	*Metaphysical Foundations of Natural Science* by Immanuel Kant
MMRP	–	Massively Modular Reasoning and Processor Model of Cognition
Principia	–	*Philosophiae Naturalis Principia Mathematica* by Sir Isaac Newton
OP	–	*Opus Postumum* by Immanuel Kant
P	–	*Prolegomena* by Immanuel Kant

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CHAPTER 1

1. INTRODUCTION

1.1 BACKGROUND

1.2 In the Preface to the First Edition of the *Critique of Pure Reason*, Kant states that the chief question for his purpose is "what and how much can the understanding and reason know apart from all experience? not:—how is the faculty of thought itself possible?" *(CPuR*, A xvii) He sought to establish the possibility of *a priori* knowledge and, thus, the possibility of a rigorous metaphysical science. In attempting this, Kant was brought to the conclusion that we can never transcend the limits of possible experience *(CPuR*, B xix), that is, that we can never know the world as it is in itself, but he nonetheless contended that although we cannot know the objects of experience as things-in-themselves, "we must yet be in position at least to *think* them as things in themselves; otherwise we should be landed in the absurd conclusion that there can be appearance without anything that appears." *(CPuR*, B xxvi)

1.3 He held that it would be essential to determine if the subjective conditions of thought are objectively valid; that is, if the subjective conditions of thought are conditions of the possibility of knowledge of objects *(CPuR*, B122-3 and B127). Kant contrasted the general truths of mathematics and physics with the claims of traditional metaphysics; Kant claimed that mathematics and physics provide synthetic *a priori* knowledge of the world and that this synthetic *a priori* knowledge is made available through experience of the objects of a shared empirical world. In the *Prolegomena*, Kant states that knowledge of objects "merely from pure understanding or pure reason is nothing but sheer illusion, and only in experience is there truth." (*P*, 123, [374])

1.3.1 During his Critical period, Kant sought to demonstrate the *a priori* presuppositions necessary for the possibility of experience and to link these presuppositions to the sensible intuition to which they must apply. Since he limited knowledge to the objects of possible experience; to the

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objects "whose objective reality can be proved (whether through pure reason or through experience, and, in the first case, from its theoretical or practical data, in all cases by means of a corresponding intuition)" (*CJ*, 5:468), he thus sought to demonstrate the principles underlying all theoretical knowledge.

1.3.2 In the *Metaphysical Foundations of Natural Science*, Kant demonstrates that experience includes scientific experience and even seems to imply that the notion of experience is exhausted by scientific experience. Owing to the significant advances in geometry and physics made since Kant developed his concept of experience, his conditions of possible experience have been subjected to various criticisms based upon his apparent restriction of experience, and, hence, knowledge, to the objects of Euclidean geometry and Newtonian physics.

1.3.3 Developments in non-Euclidean geometries and in modern physics have led many philosophers (*inter alia* R. G. Collingwood, S. Körner) to suggest that Kant's critical work should be thoroughly reconstructed by a philosophical physicist and that Kant was in error by supposing that the scientific assumptions of his time were the necessary assumptions of scientific thinking in general. These philosophers, I wish to propose, are themselves mistaken in presuming that modifications to any specific presuppositions of science need necessarily undermine Kant's identification of the necessary conditions of the possibility of experience—such would only be the case if Kant had held that a *formal* relation existed between them. In addition, I wish to propose that the necessary conditions of experience *are* certain necessary presuppositions of Newtonian science; that we *experience* a Euclidean and Newtonian world, even though, as Kant insisted, we cannot know the world-in-itself. That is, our experiential frame of reference conforms to Newtonian principles because these "concepts of reason are not derived from nature; on the contrary, we interrogate nature in accordance with these ideas, and consider our knowledge as defective so long as it is not adequate to them." *(CPuR*, A 645/B 673)

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1.4 THESIS STRUCTURE

1.4.1 In this thesis, I take a somewhat sympathetic position towards Kant's concepts of possible experience and empirical reality. Although I do not attempt to provide a detailed analysis of Kant's theoretical philosophy, I do spend some time on an analysis of representation and experience in order to ensure that the same premises are being used when advances in physics and mathematics are claimed to undermine Kant's position. This is followed by an examination of some of the aspects of Kant and Newton's theories of space, time, substance, and causality, and, since this is crucial to understanding Kant's position, a discussion of *empirical* as opposed to *absolute* reality. Kant's theories and Newtonian physics are then discussed in light of recent developments in physics and mathematics.

1.4.2 The thesis ends with an examination of some theories on how we experience reality, particularly in respect to the subjectivity of space and time, using, in part, developments in evolutionary psychology. Although Kant had "completely banished [empirical psychology] from the domain of metaphysics", he nevertheless allowed that empirical psychology in his time was "not yet so rich as to be able to form a subject of study by itself, and yet is too important to be entirely excluded and forced to settle elsewhere, in a neighbourhood that might well prove much less congenial than that of metaphysics. Though it is but a stranger it has long been accepted as a member of the household, and we allow it to stay for some time longer, until it is in a position to set up an establishment of its own in a complete anthropology, the pendant to the empirical doctrine of nature." *(CPuR*, A848-849/B 876-877) I feel that rapid advances in evolutionary psychology and especially development of the Massively Modular Mind hypothesis show that empirical psychology "is in a position to set up an establishment of its own" and further can lend some support to my contention that we experience an empirical reality that is consistent with Euclidean geometry and Newtonian physics.

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1.5 THESIS PROPOSAL

1.5.1 I propose that Kant did not contend that Euclidean geometry and Newtonian physics had absolute validity, but limited their applicability to nature "*so far as it can be perceived by our senses* (*ID*, 144). Given this limitation, non-Euclidean geometries and the theories of relativity and quantum mechanics cannot be used to undermine Kant's necessary conditions of possible experience. I propose further that Newtonian physics is not only a useful way of describing and coping with empirical reality, but is a reflection of the way the human cognitive capacity synthesises the manifold of representations — that is, humans, and perhaps most other beings, synthesise a reality for which Newtonian physics provides a mathematical description.

1.6 Newtonian physics and Euclidean geometry help us understand and describe empirical reality — the world of possible experience — and have proven to be extremely successful in so doing. In this thesis, I support the position that, as long as the reality described by Newtonian physics and Euclidean geometry is not taken to be *absolute* reality, then *empirical* reality, the world of possible experience, is not undermined by non-Euclidean Geometry, the theories of Relativity and Quantum Mechanics, nor even by String Theory. The external world of possible experience has four dimensions (three spatial and one temporal) and contains medium sized objects, medium length distances, and medium velocities — in other words, the human cognitive faculties are such that the infinitesimally small objects and distances of Quantum Mechanics; the extremely large objects, distances, and velocities of Special and General Relativity; and the eleven or more dimensions of String Theory, all lie outside their frame of reference.

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CHAPTER 2

2. WHAT IS EXPERIENCE?

2.1 INTRODUCTION

2.2 While it is not the purpose of this thesis to justify Kant's account of possible experience in comparison with other theories, it would be, in my opinion, useful to find grounds of commonality between the different views in answering the question "what is experience?" before attempting to analyse the views of Kant and Newton.

2.3 SENSATIONS AND PERCEPTION

2.3.1 Whether philosophers believe in the existence of an independent external world or not, they can agree that a person must be constituted in a way that makes experience possible, that there must be subjective conditions for possible experience; but they can also agree that having such a constitution is not sufficient for experience. While we can agree that an inanimate object, such as a rock, cannot have experience, we can also agree that, even though having the right constitution would provide the *potential* for experience, something more is required to *have* experience. Stimuli as well as sensitivity to stimuli are both required — a human being raised in a sensory deprivation chamber cannot be said to have any experience. Descartes describes experience as "what we perceive by sense, what we hear from the lips of others, and generally whatever reaches our understanding either from external sources or from that contemplation which our mind directs backwards on itself."[1] Put simply, sensory information is also necessary for experience, whether such information is received through the external senses of sight, hearing, touch, smell, and taste, or through internal sensations within the body. There are, therefore, both subjective and objective conditions for possible experience.

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[1] R, Descartes, *Rules for the Direction of the Mind*, pp. 43-44.

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2.3.2 Sensation is the process of sensing the environment through the senses; it is usually considered to be a *passive* process in that no conscious effort is involved — Kant denotes *sensation* as "that which is really empirical in our cognition" *(CPuR*, A143/B182) and *sensibility* as the "capacity (receptivity) to acquire representations through the way in which we are affected by objects" *(CPuR*, A19/B33). Perception, on the other hand, can be defined as the *active* process of selecting, organizing, and interpreting sensory information; it is the method by which sensations (sensory information, sense-data[2]) are interpreted. As Wolfgang Kohler has pointed out, there is an all-important distinction between sensations and perceptions, "between the bare sensory material as such and the host of other ingredients with which this material has become imbued by process of learning."[3] A physical account[4] would be that sense organs absorb energy from stimuli in the environment; sensory receptors convert this energy into neural impulses and transmit them to the brain. Perception is the result of the brain's organizing the sensory information and translating it into something meaningful, however "meaningful" may be defined. It must be emphasised that the preceding is a description of *sense* or *object* perception. There is a difference between perception of an object and perception of a fact. *Fact* perception involves knowledge and beliefs, and therefore involves the whole cognitive apparatus, whereas *object* perception does not. Philosophical theories vary on whether we apprehend, in object perception, external objects or internal objects (representations of the objects, ideas in the mind).

2.3.3 Not all theories of perception hold that the sense organs are purely receptive, if receptivity implies passivity. Sense organs can be used actively to seek out objects such as in the case of a visual search. In this respect, according to some theories of perception and of mental imagery, the senses are *systems* that respond to particular classes of inputs; rather than being

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[2] In representationalist theories of perception, "sense-data" are the immediate objects of sensation. C/f, J. L. Austin's *Sense and Sensibilia*, ed. by Geoffrey J. Warlock, Oxford, 1962; and B. Russell's *The Problems of Philosophy*

[3] W. Kohler, *Gestalt Psychology*, pp. 68-69.

[4] Such as that proposed by Hermann Ludwig Ferdinand von Helmholtz: in his *On the Sensations of Tone*, (1870; English 1875)

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passive or impenetrable, the senses are dedicated input systems which "consist of their own sets of operations and representations, housed in separate neural pathways"[5] or they are domain-specific Darwinian/Chomsky modules[6]. Whether or not the senses are input systems or input modules, it is doubtful that any theory of perception proposes that inputs (such as photons) are directly sent to the mind without some form of pre-processing. How the sensory information "reaches our understanding" and is used as an external source of experience is not answered by treating the senses as separate systems.

2.3.3.1 Most philosophical discussions of sensation and perception privilege the visual — *inter alia* in the examination of how we experience colour in the writings of Descartes, Locke, Berkeley, and Hume. This is understandable as sight is the pre-eminent sense for human survival, but an examination of the physical structure of the visual apparatus will not provide all the information necessary to explain visual perceptions. The physical structure of the visual apparatus would not explain the ability to have different visual perceptions through conscious effort in ambiguous figures such as Edgar Rubin's example of visual reversal. Visual stimuli appear to under-determine perception; for Gestalt psychologists, the *Gestalt* or pattern is under-determined. Photons are the only means of communication between the objects around us and our visual apparatus; but, while there seems to be no organisation in the retinal stimulation, perceptions are organised. Gestalt psychologists hold that even though local stimuli are mutually independent, they nevertheless exhibit formal relations of proximity, similarity, et cetera.[7]

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[5] Jesse J. Prinz, *Furnishing the Mind*, p. 115

[6] In 1994, L. Cosmides and J. Tooby argued that selection pressures to solve adaptive problems that humans faced in the Pleistocene era can be expected to produce highly specialized cognitive mechanisms since different adaptive problems often require different solutions and "different solutions can, in most cases, be implemented only by different, functionally distinct mechanisms. Speed, reliability and efficiency can be engineered into specialized mechanisms because there is no need to engineer a compromise between different task demands.". L. Cosmides and J. Tooby, "Origins of Domain Specificity: The Evolution of Functional Organization", in *Mapping the Mind*, p. 89

[7] Kohler, Op. Cit., p.167

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2.3.3.2 Furthermore, while the curved physical structure of the retina would seem to provide some explanation of the ability to locate objects in space[8], experiments have shown that humans are able to adapt to visual distortions caused, for example, by wearing prism glasses[9] and that the initial efforts to adapt to the distortions are conscious. Such adaptation to distortions of sensory information demonstrates that additional conditions are required for a coherent and complete account of experience.

2.3.3.3 There is a notion of an experiential "frame of reference" in Gestalt psychology, and also in other disciplines such as the psychology of perception and developmental psychology. According to the definition given in the Fontana Dictionary of Modern Thought (2nd edition, 1988), a "frame of reference" is the "context, viewpoint, or set of presuppositions or of evaluative criteria within which a person's perception and thinking seem always to occur, and which constrains selectively the course and outcome of these activities". This sounds very much in accord with Kant's account which postulates that the mind applies concepts or "categories" to experiences, thereby rendering them understandable and giving them meaning, and that these categories are pre-conditions for anything to be an experience. For Kant, the "possibility of an experience in general and cognition of its objects rest on three subjective sources of cognition: **sense**, **imagination**, and **apperception**" *(CPuR*, A115), Following is a brief overview of Kant's account of experience, several aspects of which (such as his account of space, time, substance, causality, and empirical reality) are treated in more detail in subsequent chapters.

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[8] The visual system seems to be such that photons hitting the left side of the retina would indicate that there is an object on the right side; those hitting the centre of the retina, that there is an object directly in front, et cetera.

[9] Cognitive Daily: October 20, 2005 *How our vision system adapts to a crooked world* — Dave Munger

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2.4 KANT'S CONCEPT OF EXPERIENCE

2.4.1 Kant's concept of experience is that of an empirical realist: all knowledge "of things out of pure understanding or pure reason is nothing but mere illusion, and truth lies only in experience." (*P*, §374) Kant rejected the "problematic" idealism of René Descartes and the "dogmatic" idealism of George Berkeley *(CPuR*, B274-275). Kant agreed with Hume's statement that: "all the laws of nature, and all the operations of bodies without exception, are known only by experience"[10], but he rejected Hume's skepticism; Kant held that "inner experience in general is possible only through outer experience in general"; that "we have **experience** and not merely **imagination** of outer things"; and that "our **inner experience**, undoubted by Descartes, is possible only under the presupposition of outer experience" *(CPuR*, B278-279). Kant was not, however, a "common-sense" realist for whom concepts of objects correspond to, or label objects that actually exist in the world. Kant claims that he had proved in the "Transcendental Aesthetic" that "everything intuited in space or in time, hence all objects of an experience possible for us, are nothing but appearances, i.e., mere representations, which, as they are represented, as extended beings or series of alterations, have outside our thoughts no existence grounded in itself". He was, in his terminology, a "transcendental idealist" rather than the type of realist for whom "in the transcendental signification, makes these modifications of our sensibility into things subsisting in themselves, and hence makes **mere representations** into things in themselves." *(CPuR*, A491/B519). For Kant, experience is the "reflex knowledge originating from several appearances compared by the intellect" and that "there is no way from appearance to experience except by reflection according to the logical use of the intellect." (*ID* §5) Further, experience "consists in the synthetical connection of phenomena (perceptions) in consciousness, so far as this connection is necessary" (*P* §20, 304-305). By labelling his idealism "transcendental", Kant emphasised that it allowed for the existence of synthetic *a priori* knowledge of objects in space and time and for there being no knowledge of things in themselves.

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[10] David Hume, *An Enquiry Concerning Human Understanding: And Selections from a Treatise of Human Nature* (Chicago: Open Court Publishing, 1921) P. 27, Questia, 10 Dec. 2005 <http://www.questia.com/PM.qst?a=o&d=101949879>.

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2.4.2 Kant limited knowledge to the bounds of experience, as did John Locke before him, but Kant's definition of experience differs considerably from that of Locke who held that concepts and intuitions (ideas) could be derived only through sensation and reflection; that objects of knowledge, with their primary qualities, have objective existence. While Kant maintained that knowledge is impossible prior to experience, he also maintained that not all knowledge arises directly from experience. In the *Critique of Pure Reason*, Kant seeks to establish the possibility of *a priori* knowledge and, thus, the possibility of a rigorous metaphysical science. In attempting this, Kant recognised that it would be essential to determine if the subjective conditions of thought are objectively valid; if the subjective conditions of thought are conditions of the possibility of knowledge of objects *(CPuR*, B122-3 and B127).

2.4.3 In response to the various positions expostulated by Locke, Gottfried Wilhelm Leibniz, and others, Kant instituted a "Copernican Revolution" which reversed the relationship between the knowing subject and the possible objects of knowledge. Until this point, Kant claimed, philosophers had assumed that knowledge could be achieved only by matching mental concepts to a world of independent, objective facts, that "all our knowledge must conform to objects". Kant's view that knowledge is only of the world as it appears in experience is contrary to the skepticism of Descartes and is in direct opposition to Leibniz' position which, according to Kant, claimed *a priori* knowledge of the world as it is in itself — that is, that human understanding contains within it certain principles that enable formation of a complete and accurate description of the world. Kant held that, if we are to make claims to knowledge of the external world, our experience must be structured in accordance with our understanding: "objects must conform to our knowledge" *(CPuR*, Bxvi) and he maintains, in the *Critique of Pure Reason*, that this will be proved "apodeictically not hypothetically, from the nature of our representations of space and time and from the elementary concepts of the understanding." *(CPuR*, Bxxiii) Such proofs will require an explanation of how the faculties of understanding, sensibility, and imagination are able to represent empirical objects by means of intuitions, concepts, and syntheses.

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2.4.4 For Kant, there are two sources of human knowledge, namely, sensibility and understanding, and the way in which objects of experience are perceived, identified, and reflected upon may have a form or structure which shapes or contributes to experience. This view of the mind as *active* is contrary to both the Rationalist and Empiricist traditions according to which the mind is passive: the former maintaining that the mind possesses innate, well-formed ideas; and the latter maintaining that it receives ideas of objects into a *tabula rasa* through experience. For Kant, experience of a world is possible only if the mind is capable of structuring representations systematically. In other words, the human cognitive apparatus shapes all sensory experience and thought. Kant's position is that objective reality is made possible by the form of its representations; that the nature of objective reality depends upon the human cognitive apparatus.

2.5 CONDITIONS OF EXPERIENCE

2.5.1 In the *Inaugural Dissertation*, Kant distinguishes between the immediate knowledge of intuition and the mediated knowledge of the understanding; he claims that, to man, " no intuition of intellectual concepts is given, only *symbolical cognition*, and intellection is granted us only by universal concepts in the abstract, not by the concrete singular. For all intuition is restricted by some principle of form under which alone anything can be *discerned* by the mind immediately or as *singular*, and not merely conceived discursively by general concepts." (*ID*, §10) Hence, for Kant, intuition is a faculty of knowledge which is restricted by some principle of form which is the condition under which something can be a sense object and which is, hence, a (subjective) condition of sensuous knowledge. This notion of intuition is continued in the *Critique of Pure Reason*: objects are *given* by means of sensibility, and sensibility alone yields intuitions; objects are *thought* through the understanding from which *concepts* arise. "But all thought must, directly or indirectly, by way of certain characters, relate ultimately to intuitions, and therefore, with us, to sensibility, because in no other way can an object be given to us." *(CPuR*, A19)

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2.5.2 Without sensibility there can be no intuition, but, apart from intuition, the only other mode of knowledge is by means of concepts. The knowledge yielded by understanding must, therefore, be by means of concepts, but no concept is ever related to an object immediately; it is related to some other representation of it, where the representation is either an intuition or is, itself, a concept. Judgement is, in consequence, a mediated knowledge of an object; it is a relation combining both intuitions and concepts. Kant argues that a judgment requires both an intuition and a concept and hence that we can have no knowledge of something of which we have no concept, nor can we have knowledge of something that cannot be intuited in a possible experience. "Accordingly, all judgments are functions of unity among our representations." *(CPuR*, A69/B94). Most concepts are empirical; that is, they are obtained by observing similarities and differences in what we perceive. Kant is not concerned, however, with empirical concepts but with those that Hume observed are not obtained in the normal way by examining the contents of experience. Substance and causation are obvious examples. To move from a simple observation of similarities and differences to a knowledge of empirical laws, depends upon certain assumptions or principles which are assumed in the mathematical sciences but not proved. At least some of these assumptions or principles are also, according to Kant, necessary conditions for possible experience.

2.5.3 By abstracting the mere form of understanding from the content of a judgement, Kant found that the function of thought in judgement "can be brought under four headings, each of which contains three moments." These are:

I. Quantity (Universal, Particular, Singular)

II. Quality (Affirmative, Negative, Infinite)

III. Relation (Categorical, Hypothetical, Disjunctive)

IV. Modality (Problematic, Assertoric, Apodeictic)

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2.5.4 The same function which gives unity to the various representations *in a judgment*, however, also gives unity to the "mere synthesis of various representations *in an intuition*"; and this unity, in its most general expression, Kant entitles the "pure concept of the understanding." *(CPuR*, A 79, B 105) Kant follows Aristotle in naming his pure concepts of the understanding "categories". In the *Categories*, Aristotle provided a schema of the ten categories, but Kant distinguishes his from the Aristotelian categories which he held to be arbitrary classifications derived from "ordinary knowledge". Kant held that his own categories are the forms according to which objects of experience are structured; he sought the concepts which do not "rest upon particular experience, and yet occur in all knowledge from experience" and to explain why knowledge "has just this and no other formal constitution" and why "just so many, neither more nor less, can constitute this kind of cognition" (*P*, §39, 322-323).

2.5.5 Kant claims that, after "long reflection on the pure elements of human knowledge (those which contain nothing empirical)", he succeeded in "distinguishing with certainty and in separating the pure elementary notions of the sensibility (space and time) from those of the understanding." He was thus able to exclude the spatio-temporal categories: "the seventh, eighth, and ninth categories had to be excluded from the old list." (*P*, §39, 322-323) In order to develop his own list of categories, Kant "looked about for an act of the understanding which comprises all the rest and is distinguished only by various modifications or phases, in reducing the multiplicity of representation to the unity of thinking in general" and found this "act of the understanding to consist in judging." (*P*, §39, 323-324) Kant further develops this in his *metaphysical deduction (CPuR*, A70ff/B95ff) where he argues that the synthesis of representations requires the synthesis of the manifold according to the forms of intuition, namely space and time, but also requires the synthesis of the intuitions in a judgement. Judgement is, for Kant, the unification of the manifold, and the pure concepts refer to ways in which manifolds may be unified. There are fixed forms or "functions" of judgement and , hence, all synthesis will proceed in accord with these functions. Kant, therefore,

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derives his (ten) categories from the various modes of the act of judgement. These Categories are intended to define every possible form of predication.:

I. Quantity (Unity, Plurality, Totality)

II. Quality (Reality, Negation, Limitation)

III. Relation (Inherence and Subsistence, Causality and Dependence—cause and effect, Community—reciprocity between agent and patient)

IV. Modality (Possibility–Impossibility, Existence–Nonexistence, Necessity–Contingency)

2.5.6 The *Analytic of Concepts* (*CPuR*, A 66-130/B 91-169) provides justifications for synthetic *a priori* judgements. In the *Analytic of Principles* (*CPuR*, A 130-292/B 169-349) these judgements are justified individually and "schematised". The *Analytic of Principles* is the exposition and establishment of the principles of the pure understanding in detail. It is the attempt to solve the problem of how any concept is applied to its instances. It is also a more detailed justification of how synthetic *a priori* judgements are possible and is concerned, in particular, with the synthetic *a priori* judgements of Newtonian physics.

2.5.7 In the chapter "The Schematism of the Pure Concepts of Understanding" *(CPuR*, A137-147/B176-187), Kant presents a general theory of how a concept is applied with the aid of its *schema* which is a 'representation of a universal procedure of imagination in providing an image for a concept' *(CPuR*, A140/B170-180)[11]. Despite being a "universal procedure", however, this "schematism of our understanding. . . is an art concealed in the depths of the human soul, whose real modes of activity nature is hardly likely ever to allow us to discover." (*CPuR*, A141, B180-181).

[11] For example, the schema of the concept of a dog is "a rule according to which my imagination can delineate the figure of a four-footed animal in a general manner, without limitation to any single determinate figure such as experience... actually presents." (*CPuR*, A 141/B 180).

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2.5.8 The metaphysical deduction of the categories *(CPuR*, B159) derived a list of categories from the twelve concepts of logic through an examination of the connection between the general work of understanding in inference and its specific work in making judgements about objects. In order for the categories to be applicable to objects of temporal intuition, they need to be "schematised". The metaphysical deduction supposed that the function of judgement provides a "clue to the discovery of all pure concepts of the understanding", namely, that it is in judgement that the employment of concepts consists. Kant begins with determining the basic forms of judgement. He then proceeds to demonstrating that a specific concept corresponds to each basic form of judgement.

2.5.9 A judgement is "the faculty of subsuming under rules" *(CPuR*, A132/B171) but, whenever an object is subsumed under a concept, the object, according to Kant, must be "*homogenous* with the concept" (*CPuR*, A137/B176), that is, it must be possible for intuitions to conform to concepts. The categories, as previously derived, are "quite heterogenous" from sensible intuition (*CPuR*, A137/B176) and, as such, are too abstract for the purpose. To resolve this problem, Kant proposes "some third thing" which is homogenous with both the categories and intuition *(CPuR*, A138/B177).

2.5.10 In the deduction of the categories, it was shown that pure concepts of the understanding (the categories) are of empirical as well as transcendental use; as conditions of a possible experience, pure concepts of the understanding relate *a priori* to appearances, but, as conditions of the possibility of things in general, they can also be extended to objects in themselves. Concepts have meaning only if they have instances or, at least, have instances for "the elements of which they are composed." In other words, concepts are not applicable to things in themselves independently of how or whether the objects are presented to the subject. *(CPuR*, A139/B178) "These conditions of sensibility constitute the universal condition under which alone the category can be applied to any object. This formal and pure condition of sensibility to which the employment of the concept of understanding is restricted, we shall entitle the *schema* of the concept. The procedure of

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understanding in these schemata we shall entitle the *schematism* of pure understanding." *(CPuR*, A140/B179) No experiential judgement would be possible without the schematism of judgement which schematises concepts and applies the resulting schemata to each empirical synthesis. Schemata and schematism thus constitute the "third thing" which is homogenous with both the categories and intuition and mediates between the otherwise heterogenous concept and intuition, thereby transforming the unschematised categories of the metaphysical deduction into the schematised categories (or principles) of the *Analytic of Principles.*

2.5.11 Schemata, rather than images of objects, underlie pure sensible concepts. For example, an image could never be adequate to the concept of a triangle in general since "it would never attain that universality of the concept which renders it valid of all triangles, whether right-angled, obtuse-angled, or acute-angled; it would always be limited to a part only of this thought." Moreover, an object of experience or its image can never be adequate to the empirical concept;"for this latter always stands in immediate relation to the schema of imagination, as a rule for the determination of our intuition, in accordance with some specific universal concept." *(CPuR*, A141)

2.5.12 The schemas of the categories ("pure concepts of the understanding") are explicated in terms of the table of categories:

a) The schema of the quantitative categories is number, while those of the categories of quality are being in time (reality), not being in time (negation), and the same time both filled and empty (limitation) (*CPuR*, A143/B182);

b) The schemas of relation are "permanence of the real in time" (substance), "the real upon , something else always follows" (Causality), and the "co-existence, according to a universal rule, of the determinations of the one substance with those of the other" (community) (*CPuR*, A144/B83);

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c) The schemas of modality are "the determination of the representation of a thing at some time or other" (possibility), "existence in some determinate time" (actuality), and "existence of an object at all times" (necessity).

2.5.13 Schematism and the schemas thus have the property of "realising" the categories while simultaneously restricting their scope to appearances. They play an essential role in bringing together the otherwise empty "thoughts without content" and blind "intuitions without concepts" (*CPuR*, A51/B75). It is through schematism and the schemas that concepts, which are "merely functions of the understanding", are given meaning in relation to sensibility "which realises the understanding in the very process of restricting it." (*CPuR*, A147/ B187)[12]

2.5.14 Each category is "capable of representation only as a determination of time" (*CPuR*, A145/B184) – the transcendental schema of time mediates between category and object[13], thereby allowing concepts to be applicable to experience:

a) "The schema of substance is permanence of the real in time, that is, the representation of the real as a substrate of empirical determination of time in general, and so as abiding while all else changes."

b) "The schema of cause, and of the causality of a thing in general, is the real upon which, whenever posited, something else always follows. It consists, therefore, in the succession of the manifold, in so far that succession is subject to a rule."

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[12] In the "Architectonic of Pure Reason", Kant describes schematism as a way of realising the idea of a systematic unity of reason. The schema is defined as a "constituent manifold and an order of its parts, both of which must be determined *a priori* from the principle defined by its end" (A 833, B 861) A schema which unifies empirically according to "purposes that are contingently occasioned" is technical, while a schema that is derived from an idea of reason is architectonic.

[13] The transcendental schema, time, mediates between category and object because it is both "intellectual" and "sensible"; that is, it is both similar to the categories and to the intuitions which are to be conceptualised. (A 139, B 178)

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c) "The schema of community or reciprocity, the reciprocal causality of substances in respect of their accidents, is the co-existence according to a universal rule, of the determinations of the one substance with those of the other."

d) "The schema of possibility is the agreement of the synthesis of different representations with the conditions of time in general."

e) "The schema of actuality is existence in some determinate time."

f) "The schema of necessity is existence of an object at all times." (*CPuR*, A144-145/B184)

2.5.15 It should be noted that Kant distinguishes between an image of an object; the concept of an object; and the schema of the concept (*CPuR*, A14/B179). The schema is a product of the imagination which synthesises the different perceptions making up an appearance to produce an image. The action which the imagination exercises directly upon perceptions is "apprehension". There are, according to Kant, two faculties of the imagination: the "reproductive" faculty which associates objects and is subjective and empirical; and the "productive" faculty of a synthesis *a priori* which unites all empirical consciousness in one consciousness, which constitutes objects in conformity to the schemata, and which is objectively necessary. (*CPuR*, A121-123) The productive imagination is a pure imagination which "grounds all cognition *a priori*" and thus mediates between sensibility and understanding both of which are necessary, otherwise, although sensibility would still yield appearances, it would yield "no objects of an empirical cognition, hence there would be no experience." (*CPuR*, A124)

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2.6 SPACE AND TIME

2.6.1 The attempt to determine how internal objects are related to external objects (the "Mind-Body" problem) led Descartes to propose that there are two quite different sorts of substances in the universe: a physical substance which is located in space and time, and a mental substance which is located in time but not in space. According to Descartes, internal objects (phenomena) are events or states occurring in a mental substance, while external objects (phenomena) are events or states occurring in a physical substance, with a two-way causal interaction between the mental and the physical. If one type of object is in space and the other is not, this interaction seems problematic. Kant had already identified in his Pre-Critical phase (in *Thoughts on the True Estimation of Living Forces*) a number of several false assumptions in the "Mind/Body" problem which created difficulties with understanding mind/body interaction.

2.6.2 Kant wished to show that knowledge claims can be made only about spatio-temporal objects that obey causal laws. To this end, he introduces, in the *Inaugural Dissertation*, several ideas which are developed and expanded in his later work. Chief among these ideas are: that a subject can have *a priori* knowledge of space and time **only** because they are forms imposed by the subject's mind on experience – that is, that the schema of space and time have a subjective origin; that there is a disjunction between things-as-they-are-in-themselves and things-as-they-appear; and that there is a distinction between experience and thought. In the *Inaugural Dissertation*, Kant defines experience as "the reflex knowledge originating from several appearances compared by the intellect", and, by holding that "there is no way from appearance to experience except by reflection according to the logical use of the intellect" (*ID*, §5), he rejects John Locke's contention that simple ideas may be derived directly from outer experience. In fact, at this stage, his position appears to be closer to that of Gottfried Wilhelm Leibniz who held that ideas are presupposed by experience. As is made clear later in the *Critique of Pure Reason*, however, Kant's view that knowledge is only of the world as it appears in experience is in direct opposition to Leibniz' position which, according to Kant, claimed *a priori* knowledge of the world as it is in itself — that is, that human understanding contains

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within it certain principles that enable formation of a complete and accurate description of the world. In the *Inaugural Dissertation,* Kant introduced his theory that space and time constitute necessary conditions for experience[14]. The formal principle of intuition are space and time, which are the conditions "under which something can be an object of our senses." (*ID*, §10) Intuitions of present things are not possible without "a ground of relation between my representation and the object" which "*precedes all the actual impressions through which I am affected by objects.*" (*ID,* §9) Experience of objects would be impossible without the *a priori* forms of intuition to relate the subject (the "I") and it objects.

2.6.3 In the *Transcendental Aesthetic* (*CPuR*, A 19-45/B 33-73), Kant is concerned with sensibility or sensible intuition. Sensibility is, for Kant, a passive means for receiving data and he proposes first to "*isolate* sensibility, by taking away from it everything which the understanding thinks through its concepts" (*CPuR*, A 22, B 36). Kant claims that, in the course of his investigation, it will be found that there are two pure forms of sensible, space and time, and that these serve as principles of *a priori* knowledge. The pure *a priori* forms of intuition, time and space, are "two sources of knowledge from which bodies of *a priori* synthetic knowledge can be derived' (*CPuR*, A38/B55). It must therefore be proved:

a) that space and time originally belong to the subject as forms of its sense perception; and that they are not introduced *through* experience; and

b) that they are two sources of knowledge from which bodies of *a priori* knowledge can be derived (Kant points to pure mathematics as a "brilliant example").

2.6.4 Space and time are *pure,* not empirical, intuitions. Only space and time qualify as pure forms of intuition. All concepts except space and time presuppose "something empirical": for

[14] In the *Inaugural Dissertation* (ID, §10), he states that the "formal principle of our intuition" is space and time.

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instance, "motion presupposes the perception of something moveable; consequently the moveable must be something that is found *in space only through experience* and must therefore be an empirical datum". Space and time are pure and *a priori*: space does not occupy space and time itself does not alter. (*CPuR*, A 41, B 58) For Kant, space is a shared system of representation, an *a priori* unity of which *spaces* are limitation, and the unity of nature in time and space is identical to the unity of possible experience (*CJ*, 20:209).

2.6.5 That space and time are pure intuitions is insufficient, according to Kant, for *knowledge* of space and time. Space and time are not merely "*forms* of sensible intuitions", but also are, themselves, *objects* of cognition; they are "themselves *intuitions* which contain a manifold [of their own] and therefore are represented with the determination of the *unity* of this manifold" (*CPuR*, B160). By saying that space and time can be objects of *cognition*, Kant is not saying that they can be empirical objects which are apprehended. He denies that space and time are objects of *perception*, and, by doing so, rejects both the Newtonian doctrine that absolute space and time are "real entities" and the Leibnizian ideas of space as merely the order of co-existing things and their states and of time as the order of successive things and their states.

2.6.6 For space and time to be objects of cognition requires a procedure that sensibility alone cannot provide. "Space and time contain a manifold of pure *a priori* intuition. But at the same time are conditions of the receptivity of our mind — conditions under which alone it can receive representations of objects. And which therefore must also always affect the concept of these objects. But if this manifold is to be known, the spontaneity of our thought requires that it be gone through in a certain way, taken up, and connected. This act I name *synthesis*." (*CPuR*, A77/B102)

2.6.7 Now, all synthesis , "even that which renders perception possible, is subject to the categories; and since experience is knowledge by means of connected perceptions, the categories are conditions of the possibility of experience, and are therefore valid *a priori* for all objects of

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experience." (*CPuR*, B161) When, for example, by apprehension of its manifold, the empirical intuition of a house is made into a perception, the "*necessary unity* of space and of outer sensible intuition" lies at the basis of the apprehension, but "this same synthetic unity has its seat in the understanding, and it is the category of the synthesis of the homogenous in an intuition in general, that is, the category of *quantity*." (*CPuR*, B162) But "the categories, as yielding knowledge of *things*, have no kind of application, save only in regard to things which may be objects of possible experience"; the categories "serve only for the possibility of *empirical knowledge*; and such knowledge is what we entitle experience." (*CPuR*, B147-148). In order that the categories be more than "mere forms of thought, without objective reality", they must, according to Kant, be connected with the imagination by first linking the unity of apperception to time as the form of inner sense, and then relating the categories to perception.

2.7 Inner and Outer Senses

2.7.1 Kant has shown that space and time are the pure forms of intuition and therefore constitute the forms of sense experience, but time "cannot be outwardly intuited, any more than space can be intuited as something in us." (*CPuR*, A23/B37). Instead, space is the form of *outer sense* by means of which "we represent to ourselves objects as outside us", and time is the form of *inner sense* "by means of which the mind intuits itself or its inner state." Outer sense is the experience of outer, non-mental objects which are all represented "without exception in space"; inner sense is the experience of "everything which belongs to inner determinations" and for which there is "a determinate form [namely, time] in which alone the intuition of inner states is possible." (*CPuR*, A22-3/B37) It should be noted, however, that Kant is not denying the temporality of outer objects; he is saying, instead, that outer objects derive their temporality from being represented by inner mental states which *are* temporal. Inner sense thus has primacy over outer sense: "representations of the *outer sense* constitute the proper material with which we occupy our minds", but these representations are set is time which is an "*a priori* condition of all appearances whatever." (*CPuR*, A34/B50). Time is thus

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"antecedent to [representations of the *outer sense*] in experience" and "underlies them as the formal condition of the mode in which we posit them in the mind." (*CPuR*, B67)

2.7.2 Unlike Descartes, who held inner sense to be the source for the certainty of the subject's existence in the *cogito*, Kant distinguishes between inner sense and the faculty of apperception. (*CPuR*, B153). For Kant, inner sense is determined by the understanding and its power of combining the manifold of intuition. With the outer sense "we represent to ourselves objects as outside us"(*CPuR*, A22/B37), while, with the inner sense, "the mind intuits itself or its inner state" not as an object but as the determinate form "in which alone the intuition of inner states is possible." (*CPuR*, A23/B37) The inner "objects" of experience are the contents of consciousness, not the thinking subject. While endurance of the subject follows from the endurance of the manifold of inner representations over time, it cannot be extended to the intuition of the subject as a "fixed and abiding self." (*CPuR*, A107) The contents of consciousness are not "objects" per se; they are not sensuous objects — sensations belong to outer sense only — nor do they conform to the Categories which can only apply to enduring objects.

2.8 POSSIBLE EXPERIENCE

2.8.1 Both intuitions and concepts are required for experience or knowledge. Just as the "Transcendental Aesthetic" examines the faculty of intuitions, the "Transcendental Analytic" examines the faculty of concepts. Just as the "Aesthetic" furnished pure intuitions, so the "Analytic" justifies pure concepts or categories. The "Analytic" also provides an explanation of how the conceptual and the sensible components are connected in the structure of experience. Knowledge of the objective world requires, in addition to the space and time relations, other formal elements which, amid all the differences of content, remain the same. The task in the "Analytic", as in the "Aesthetic", is:

a) to set these elements forth and to establish their *a priori* nature (or "ideality" in the sense in which it is used in the "Aesthetic"); and

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b) to show that by means of them, objective *a priori* knowledge is possible.

2.8.2 Categories alone are insufficient for pure understanding to prescribe to appearances "any *a priori* laws other than those which are involved in a *nature in general*". Special laws concerning empirically determined appearances "cannot in their specific character be *derived* from the categories, although they are one and all subject to them." Experience is required in order to obtain any knowledge whatever of these special laws; but it is "the *a priori* laws that alone can instruct us in regard to experience in general, and as to what it is that can be known as an object of experience." (*CPuR*, B165) The conditions of the *possibility of experience* in general are also the conditions of the *possibility of the objects of experience* and thereby they have objective validity in a synthetic *a priori* judgement. (*CPuR*, A156/B195)

2.8.3 In the *Critique of Judgement*, Kant is concerned, in part, with finding a solution to the problem that sole reliance on the principles of pure understanding plus an unlimited number of empirical laws would be insufficient for a unified and systematically organised knowledge of nature, and would render impossible a unified knowledge of the world of experience:

> The problem, which lies *a priori* in our understanding, is to make a connected experience out of given perceptions of a nature containing at all events an infinite variety of empirical laws. The understanding is, no doubt, in possession *a priori* of universal laws of nature, without which nature could not be an object of experience, but it needs in addition a certain order of nature in its particular rules, which can only be empirically known and which are, as regards the understanding, contingent. These rules, without which we could not proceed from the universal analogy of a possible experience in general to the particular, must be thought by it as laws (i.e. as necessary), for otherwise they would not constitute an order of nature, although their necessity can never be cognized or comprehended by it. Although, therefore, the understanding can determine nothing *a priori* in respect of objects, it must, in order to trace out these empirical so-called laws, place at the basis of all reflection upon objects an *a priori* principle, viz. that a cognizable order of nature is possible in accordance with these laws. (*CJ*, 5:184-185)

2.8.4 The solution is to assume that there is a "*law of the specification of nature* in respect of its empirical laws" (*CJ*, 5:186) and that the universal laws of nature correspond to the conditions

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of possible experience. Kant is not concerned with the conditions for the existence of purposive structures in nature; rather, he is concerned with the particular orientation of knowledge when it judges something as purposive. He is, however, proposing that nature meets conditions of regularity; that there are *objective* conditions for the possibility of experience, and that subjective conditions alone would be insufficient to enable one to have experience. As he states in the *Critique of Pure Reason*, purposive unity must be in the "essence of the things" which constitute all objectively valid knowledge. (*CPuR*, A694/B722) The laws of nature order reality in such a way as to render its representation possible. In other words, nature is organised purposively: "nature specifies its universal laws according to the principles of purposiveness for our cognitive faculty" (*CJ*, 5:186)

2.8.5 In the *Opus Postumum*, Kant treats attraction and repulsion as modifications of the internal vibrations of a "universally and uniformly distributed world-material", a *caloric*, which is the "universal basis of the moving forces of matter affecting the senses" and without whose presupposition an outer object of the senses [cannot] have an empirically possible object." Moreover, this "radical world-material is not problematic and merely assertoric, but apodictically certain. Its existence belongs to the transition from the metaphysical foundations of natural science to physics; and its recognition (according to *a priori* concepts of objects in appearance in general ... makes physics initially possible." (*OP*, 22:476) Kant deduces the existence of this world-material from the conditions of possible experience: "For just as there is only one space and only one time (as objects of pure intuition), there is likewise only one object of possible outer experience in the field of the causality of perception of outer things. For all so-called *experiences* are always only parts of *one* experience, in virtue of the universally distributed, unbounded caloric which connects all celestial bodies in one system and sets them into a unbounded caloric which connects all celestial bodies in one system and sets them into a community of reciprocity." (*OP*, 22:554n)

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2.9 SCIENCE AND EXPERIENCE

2.9.1 Following the success of the techniques of mathematics—that is, deduction from "self-evident" axioms according to fixed rules , *a priori* methods, *et cetera*— philosophy and natural science were both strongly influenced in the seventeenth century by the mathematical model. In the eighteenth century, the mechanical model, particularly that of the Newtonian system, came to dominate. As Ernst Cassirer noted[15], Kant believed that Newton's system provided him with a fixed code of physical "truth" and that philosophical knowledge could be definitively grounded on the "*factum*" of mathematical natural science; that metaphysical speculations could be guided by data arising from "the mathematical consideration of motion in connection with knowledge of space"[16].

2.9.2 In his *Metaphysical Foundations of Natural Science*, Kant appears to hold that the notion of experience must include scientific experience; he also held that his table of categories were a "clue" to the division of the laws of motion, and that, ordering the elementary concepts of the moving forces and laws of motion of matter under the category headings of quantity, quality, relation, and modality, constitutes "the stages of the transition from the metaphysics of corporeal nature to physics." (*OP*, 22:135) In this transition from the transcendental principles (of the *Critique of Pure Reason*) to empirical science, Kant attempted to show that, in order to qualify as a science, cognition must be systematically ordered according to rational principles and known with "consciousness of their necessity" (*MFNS*, 4:468); that such cognition is scientific only in as far as it contains mathematics (*MFNS*, 4:470); and that substance can be experienced only through principles, such as the laws of mechanics, which involve the categories (*MFNS*, 4:472-475).

2.9.3 Kant contended that subjective conditions alone would be insufficient to enable one to have experience. Just as appearances must agree with the form of *a priori* sensible intuition, so must the *laws* of appearances in nature agree with the understanding and *it's a priori* form. (*CPuR*,

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[15] Ernst Cassirer, *Substance and Function. Einstein's Theory of Relativity*, pp. 352-353.

[16] Immanuel Kant, *Attempt to Introduce the Concept of Negative Magnitudes into Philosophy*, quoted Ibid, p. 351

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B163) In the *Critique of Judgement*, Kant is concerned with discovering subjective principles which are basic to the search for systematic explanations of natural phenomena. As stated previously, Kant proposes that nature meets conditions of regularity, and the laws of nature order reality in such a way as to render its representation possible. In other words, nature is organised purposively: "nature specifies its universal laws according to the principles of purposiveness for our cognitive faculty" (*CJ*, 5:186) There are, therefore, *objective* conditions for the possibility of experience. The notion of purpose is involved in any scientific explanation. In the *Metaphysical Foundations of Natural Science*, Kant suggests that the idea of experience must include scientific experience; further, the structure of science *is* the structure of objective knowledge, the foundation of which is expressed in synthetic *a priori* judgements.

2.10 SYNTHETIC *A PRIORI* JUDGEMENTS

2.10.1 Kant departed from the position, held by both the rationalist and empiricist philosophers of his time, that there are only two kinds of truth: namely, analytical *a priori* and synthetic *a posteriori*. He proposed instead that there are not one, but two forms of synthetic judgements: synthetic *a posteriori* and synthetic *a priori* (*CPuR*, A8/B12ff; *P*, §5). Analytic judgements are governed by the principle of contradiction (*CPuR*, A150/B190), whereas synthetic judgements are governed by the principle that "every object stands under the necessary conditions of synthetic unity of the manifold of intuition in a possible experience."(*CPuR*, A158/B197) All empirical judgements, judgements of experience, are synthetic — "an experience is itself a synthetic combination if intuitions." (*CPuR*, A8/B12)

2.10.2 Kant held that synthetic *a priori* judgments are the fundamental principles that determine the structure of science. According to Kant, synthetic *a priori* judgements are also those that define the structure of experience, this structure being manifest in, and identifiable through, our acceptance of certain judgements as non-logically necessary; to say how synthetic *a priori*

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judgements are possible is to account for the structure of experience[17]. Consequently, Kant must seek a "solution of the general problem of transcendental philosophy: *how are synthetic a priori judgements possible*?" (*CPuR*, B73)

2.10.3 Kant held, synthetic *a priori* judgments provide the necessary foundations for knowledge in both natural science and mathematics . Experience cannot justify the most general laws of nature, nor the truths of mathematics, but they must apply universally to experience. Kant offers a transcendental argument from the knowledge of the natural world to the truth of synthetic *a priori* propositions about the structure of experience of it. The application of the forms of sensible intuition — space (the outer form comprising the spatial relations of geometry) and time (the inner form comprising the linear succession of arithmetic) — is a necessary condition for any perception. The possibility of scientific knowledge requires that experience of the world be not only perceivable but also thinkable. According to Kant, this requirement is met by the synthetic unity of the sensory manifold and the transcendental unity of apperception (the transcendental unit of self-consciousness[18]), whereby concepts and intuitions are united in judgements.

2.10.4 The pure concepts of the Understanding, the Categories, especially the Category of Relation — namely, of Inherence and Subsistence (*substantia et accidens*); of Causality and Dependence (cause and effect); and of Community (reciprocity between agent and patient)— are the necessary preconditions for scientific knowledge as exemplified by Newtonian mechanics. Synthetic *a priori* judgements consist in applying the Categories to sensory data, to the "perceptual manifold", in space and time. Through application of the Categories physical objects may be realised as capable of causal relations and of interactions with other objects. Synthetic *a priori* judgements thus express

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[17] For empiricism and rationalism, synthetic *a priori* is not possible. According to Kant, this is because these philosophical traditions either fail to recognise that experience must have a structure (empiricism) or falsely suppose it to derive from logical principles (rationalism).

[18] *Transcendental apperception* is distinguished from intuitions and is disposed according to the categories of the understanding. An intuition is that "representation which can be given prior to all thought" and has a "necessary relation to the 'I think' in which the manifold is found." (*CPuR*, B 132) That is, Kant argued that we are only conscious of ourselves through knowledge of something which is not ourselves.

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the conditions under which objective experience is possible, and are the presuppositions of the apprehension of objects of science and common sense. They permit valid empirical knowledge and cognition *a priori* of the universal conditions which make possible nature itself and a science of nature. Kant held that Newton had proved beyond any possibility of doubt that what happens within the empirical world is governed entirely by scientific laws, but that without experience there can be no empirical world.

2.11 CONCLUSIONS

2.11.1 According to Kant, "it is possible to show that pure *a priori* principles are indispensable for the possibility of experience, and so to prove their existence *a priori*. For whence could experience derive its certainty, if all the rules, according to which it proceeds, were always themselves empirical, and therefore contingent?" (*CPuR*, B5) Certainty is important for Kant in establishing the limits of knowledge. He argues that it must be possible for reason to attain to *subjective* certainty, "that is, to come to a decision either in regard to the objects of its enquiries or in regard to the capacity or incapacity of reason to pass any judgements upon them." (*CpuR*, B 22) Subjective certainty, for Kant, cannot serve as a criterion for truth, but only as a mark of the subjective experience of the truth of a judgement. Experience derives its certainty from the fact that the objects of experience conform to the general truths of mathematics and physics which are synthetic and *a priori*.

2.11.2 Kant does place some limits on the applicability of Euclidean geometry and Newtonian science: "pure speculative reason has this peculiarity about it, that it can and should measure its own capacity according to the different ways for choosing objects of its thinking, and also completely enumerate the manifold ways of putting problems before itself" (*CPuR*, xxiii) He does, however, use the Newtonian ideas of substance, force, and reciprocity, in the "Analogies of Experience", to argue, albeit implicitly, that conceptualization of matter itself is possible only by means of the mathematical exact sciences. Whatever is connected with a perception in the understanding

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in accordance with empirical laws is actual and Kant treats the whole of nature as "a single all-encompassing experience" (*CPuR*, A232/ B284) This view is extended in the *Critique of Judgment*:

> We have seen in the critique of pure reason that the whole of nature as the totality of all objects of experience constitutes a system in accordance with transcendental laws, namely those that the understanding itself gives *a priori* (for appearances, namely, insofar as they, combined in one consciousness, are to constitute experience). For that very reason, experience, in accordance with general as well as particular laws, insofar as it is considered objectively to be possible in general, must also constitute (in the idea) a system of possible empirical cognition. For that is required by the unity of nature, in accordance with a principle of the thoroughgoing connection of everything contained in this totality of all appearances. To this extent experience in general in accordance with transcendental laws of the understanding is to be regarded as a system and not as a mere aggregate. (CJ, 20:208-9)

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CHAPTER 3

3. KANT ON SPACE, TIME, SUBSTANCE, AND CAUSALITY

3.1 INTRODUCTION

3.2 In his search for the necessary conditions for possible experience, Kant discussed some philosophical problems which are still of importance to modern philosophers, among them, the problems concerned with space and time; with substance; with causality; and with the general truths of mathematics and physics (that is, of Euclidean geometry and arithmetic, and of Newtonian science). According to P. F. Strawson, Kant "believed without question in the finality of Euclidean geometry, Newtonian physics, and Aristotelian logic."[19] But is this the case? Did Kant accept the tenets of Euclidean geometry and Newtonian physics "without question"? Further, did he believe that Euclidean geometry provides a unique body of necessary truths about the structure of physical space? I postulate that the answer to these questions is "No". I will attempt in this chapter to provide a more detailed examination of Kant's views on space, time, substance, and causality, and their relationships to Euclidean geometry and Newtonian physics, as a preparation for conducting, in Chapter 4, an analysis of these views in light of recent advances in mathematics and physics.

3.3 BACKGROUND ON KANT'S VIEW OF THE SPATIO-TEMPORAL WORLD

3.3.1 In the *Inaugural Dissertation*, Kant introduced his theory that space and time constitute necessary conditions for experience[20]. "This formal principle of our intuition—space and time—is the condition under which something can be an object of our senses." (*ID*, §10, 2:134) Intuitions of present things are not possible without "a ground of relation between my representation and the object" which "precedes all the actual impressions through which I am affected by objects." (*ID*, §9, 2:133) As discussed in Chapter 2, Kant held that intuition is a faculty of knowledge which is

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[19] P. F. Strawson, *The Bounds of Sense: An Essay on Kant's Critique of Pure Reason* , London: Routledge, 1989, p.16, Questia, 28 Dec. 2005 <http://www.questia.com/PM.qst?a=o&d=103651436>.

[20] In the *Inaugural Dissertation* (ID, §10), he states that the "formal principle of our intuition" is space and time.

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restricted by some principle of form which is the condition under which something can be a sense object and which is, hence, a (subjective) condition of sensuous knowledge. Experience of objects would be impossible without the *a priori* forms of intuition to relate the subject (the "I") and its objects. In the *Critique of Pure Reason*, Kant states that appearances are nothing but "sensible representations" which must not be taken as objects capable of existing independently of our power of representation, but he questioned what it means to be an object of representations; what is to be understood by an object corresponding to and, hence, also distinct from knowledge (*CPuR*, A 104). Objects are given by means of sensibility, and sensibility alone yields intuitions. In no other way can an object be given to us. (*CPuR*, A 19)

3.3.2 In the Preface to the Second Edition of the *Critique of Pure Reason*, Kant outlines his critical philosophy by which he considers that the problems of metaphysics could be better resolved by replacing the previous metaphysical assumption that our cognition conforms to objects with his supposition that objects must conform to our cognition (*CPuR*, B xvi)—this reversal of previously held assumptions are "just like the first thoughts of Copernicus" who considered that he might have better success in explaining celestial motions were he to assume that the observer revolves around the stars rather than the other way around. Hence, Kant's conception of subjectivity is often called his "Copernican Revolution" but he goes further than Copernicus by maintaining that, while Copernicus merely presented an hypothesis, he will prove his transformation in our way of thinking "apodictically from the constitution of our representation of space and time and from the elementary concepts of the understanding" (*CPuR*, B xxii).

3.4 Absolutist and Relativist Theories of Space

3.4.1 At the time of Kant, there were two main contending views on space: Absolutism (represented by Newton) and Relativism (represented by Leibniz). Newton defined an absolute and real space, a metaphysical reality. According to Newton space is a self-subsisting reality, a uniform and infinite three-dimensioned space in which objects can be located but which is independent of

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objects. This is often considered to be the "common-sense" view of space. In addition, Newton held that properties of bodies, such as extension, figure, motion and rest, depend on their being in space. Newton did not, however, hold that there is only absolute space: in the Scholium to the *Principia*[21], he defines *absolute space* as that space which "in its own nature, without relation to anything external, remains always similar and immovable." Whereas, *relative space* "is some movable dimension or measure of the absolute spaces, which our senses determine by its position to bodies and which is commonly taken for immovable space." He goes on to say that absolute and relative space "are the same in figure and magnitude, but they do not remain always numerically the same."

3.4.2 The Relativist position, represented by Leibniz, is that there is only relative space; that absolute space does not exist. Leibniz did not accept the "common-sense" view of space which he held to be an illusion. He held that space is merely an abstracted relationship, dependent as such upon real objects, upon things-in-themselves; it is the order of non-co-existing objects and their states, mere *entia rationis*, like mathematical entities. Leibniz rejects Newton's position that space has metaphysical reality; for Leibniz, space has no reality of its own but is, instead, relative to bodies in it— space is ideal, a fiction. Leibniz also rejects the Newtonian position that the properties of bodies rest on their being in space, but held that the properties of bodies are complete without any reference to space—bodies have relational properties, their location, but location is not a relation of a body to space. In his correspondence with Clarke, Leibniz wrote "that space denotes, in terms of possibility, an order of things which exist at the same time, considered as existing together, without entering into their manner of existing."[22]

3.4.3 In the First Section of the "Transcendental Aesthetic", Kant asks "what are space and time? Are they actual entities? Are they only determinations or relations of things, yet ones that would pertain to them even if they were not intuited?" (*CPuR*, A 23/ B 37) Kant contrasts his theory

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[21] Isaac Newton, *Newton's Philosophy of Nature: Selections from His Writings*, pp. 17-18

[22] Quoted in: Ezio Vailati, *Leibniz and Clarke: A Study of Their Correspondence*, p. 113

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of space with both the Newtonian and the Leibnizian concepts: the view that space is an"actual entity" and the view that space is a "relations of things". Kant states that in order for certain "sensible representations" to be taken as representing something external to ourselves, then we must already have a representation of space which is not obtained through experience (*CPuR*, A 23/B 38). For Kant, space is not an empirical concept drawn from outer experiences but, rather, outer experiences are only possible through the representation of space . This representation of space is not only prior to experience, but is also necessary—it is the ground of all outer intuitions. While we can never represent there being no space, we can represent there being a space empty of objects. Space is, therefore, a condition of the possibility of appearances. Also, according to Kant, space is not a general concept of relations of objects but an *a priori* intuition. We can represent to ourselves only a single space and if we talk of many spaces, then we understand by that only parts of the one, all-encompassing space. In addition, space is represented as infinite and no concept of relations could bring with it a principle of their infinity. (*CPuR*, A24-25/B 39)

3.4.4 Kant argues that both the absolutist and relativist theories of space are incorrect but for different reasons: the Newtonian view is metaphysically incorrect; while the Leibnizian view is epistemically untenable. Newton's concept of space is unintelligible since he would have to "assume two eternal and infinite self-subsisting non-entities (space and time), which exist (yet without there being anything real) only in order to comprehend everything real within themselves" (*CPuR*, A 39/B 56). Leibniz' concept is faulty since, if space is derived from the relations of appearances, then it can be known only through these appearances which are abstracted from experience, and therefore space can be known only through experience. Thus, any *a priori* concepts of space (and time) are only "creatures of the imagination" and would lead to the position that disputes the "validity or at least the apodictic certainty of a priori mathematical doctrines in regard to real things (e.g., in space), since this certainty does not occur a posteriori." Newton's concept of space avoids this epistemic fault: according to his view, space subsists in its own right and, hence, there is no absolute necessity that it be known through experience.

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3.4.5 The Newtonian conceptions of space and time are defended in a famous exchange of letters between Samuel Clarke and Leibniz[23]. Kant agreed with Leibniz' argument against Newton's idea of space as a "sensorium of the Omnipresent Being" (from "Dr Clarke's First Reply"). Leibniz argues that, since "the word sensorium hath always signified the organ of sensation", this gives the impression of space as an organ of perception, but God does not need an "organ of sensation" to perceive objects; nor can space be an absolute reality since this would imply that it possesses a greater reality than the substances themselves[24]. Kant does not, however, agree with Leibniz' argument (in his "Answer to Mr Clarke's Second Reply") that "'tis impossible there should be a reason, why God, preserving the same situations of bodies among themselves, should have placed them in space after one certain particular manner, and not otherwise; why every thing was not placed the quite contrary way, for instance, by changing East into West." Kant argues that, although it is true that plane figures in geometry that are "quite equal in all respects" are congruent, this is not true of all figures: left and right-handed gloves, for example, may be equal and similar but are incongruent—"one cannot be enclosed in the same bounds as the other." The gloves differ only in their spatial relationship and thus demonstrate that space itself is real and independent of the objects. (*P* , §13, 285-286)

3.4.6 In "The fourth paralogism of the ideality (of outer relations)" (*CPuR*, A 367-A 380), Kant states that all appearances are to be regarded as mere representations, not as things-in-themselves, and that, accordingly, space is only a sensible form of our intuition, but is not a determination given for itself nor a condition of objects as things in themselves. This position he calls *transcendental idealism*. Absolutism and Relationism, on the other hand, are positions that both belong to *transcendental realism* which Kant defines to be the doctrine that space is something given in itself (independent of our sensibility). The "transcendental realist" represents "outer appearances

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[23] E. Vailati, *Leibniz and Clarke: A Study of Their Correspondence*

[24] Clarke replies that: "The word sensory does not properly signify the organ, but the place of sensation. The eye, the ear, etc., are organs, but not sensoria. Besides, Sir Isaac Newton does not say, that space is the sensory; but that it is, by way of similitude only, as it were the sensory, &c.", *Ibid* , p. 21

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(if their reality is conceded) as things-in-themselves, which would exist independently of us and our sensibility and thus would also be outside us according to pure concepts of the understanding." Transcendental realism leads, Kant maintains, to empirical idealism because, by holding that objects exist as things-in-themselves independent of our sensibility, the transcendental realist is lead to the position that our sense representations are insufficient to make certain the reality of these objects. (*CPuR*, A 369)

3.5 SPACE AND THE "ARGUMENT FROM GEOMETRY"

3.5.1 Advances in mathematics and physics since Kant's time have led many commentators to question his theory of space, some of them postulating that Kant's "argument from geometry" has been thereby rendered untenable[25] or, at least, irrelevant[26]. According to P. F. Strawson, Kant "believed that Euclidean geometry provided a unique body, not only of truths, but of necessary truths, about the structure of physical space"[27] and that, "as far as the Transcendental Aesthetic is concerned, the doctrine of the transcendental subjectivity of space rests on no other discernible support that that [sic] provided by the argument from geometry."[28] I believe that neither the view that Kant accepted Euclidean geometry uncritically as a unique body of necessary truths about physical space, nor the view that Kant presents Euclidean geometry as proof of his theory of space, is consistent with Kant's later writings.

3.5.2 The idea that Kant accepted Euclidean geometry uncritically and the idea that Kant presents Euclidean geometry as proof of his theory of space both seem to rest on the assumption that Kant contended that Euclidean geometry is necessarily true of physical space, of the space of the real world. In fact, Kant was concerned to prove that space is an *a priori* intuition. Space, for Kant, is

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[25] Paul Guyer, *Kant and the Claims of Knowledge*, Cambridge University Press, 1987, p. 367

[26] Henry Allison, *Kant's Transcendental Idealism*, Yale University Press, 1983, p. 99

[27] P. F. Strawson, *Op. Cit.*

[28] P. F. Strawson, *Op. Cit.*, p. 277

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not physical, but is transcendentally ideal and transcendental idealism does not require that physical space be necessarily Euclidean. On the contrary, "the apodictic certainty of all geometrical principles and the possibility of their a priori construction are grounded in this a priori necessity." Space, for Kant, is "to be regarded as the condition of the possibility of appearances, not as a determination dependent on them". Geometry is concerned with the properties of empirical space which is known *a posteriori* and as Kant states, what is borrowed from experience "always has only comparative universality, namely through induction." (*CPuR*, A 24/B 39) Kant does not appear to preclude the possibility of a geometry other than the Euclidean when he states that "in the concept of a figure that is enclosed between two straight lines there is no contradiction" (*CPuR*, A 220/B 268); that "the straight line between two points is the shortest, is a synthetic proposition" which cannot be derived through any process of analysis from the concept of the straight line (*CPuR*, B 16); and that, in plane geometry, two triangles equal in all respects are congruent, whereas, this is not always true of triangles on the surface of a sphere (*P* , §13, 285-286).

3.5.3 As Michael Friedman has pointed out[29], there is a standard modern complaint that Kant does not distinguish between pure and applied geometry, where pure geometry is defined as the study of the formal or logical relations between propositions in a particular axiomatic system and where applied geometry is concerned with the truth or falsity of a system of axioms under a particular interpretation in the real world. An axiomatic system, such as Euclidean geometry is *a priori* and certain but makes no appeal to experience. Whereas, applied geometry is a matter for empirical investigation. In this regard, Friedman quotes Einstein: "As far as the laws of geometry refer to reality, they are not certain; and as far as they are certain, they do not refer to reality."[30] It should be noted, however, that Euclid's system of geometry consists of both axioms and postulates where an axiom is considered to be, in some measure, self-evident, whereas a postulate is an assumption that is

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[29] Michael Friedman, "Kant's Theory of Geometry", in *The Philosophical Review*, Vol. 94, No.4 (Oct., 1985), pp. 455-456

[30] Albert Einstein, *Geometrie und Erfahrung* (Berlin: Springer, 1921). English translation by G. Jeffrey and W. Perrett in *Sidelights on Relativity* (London: Methuen, 1922).

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necessary for derivation of the truths of geometry. In Kantian terms, axioms may be viewed as analytic propositions and postulates as synthetic.

3.5.4 Friedman states that Kant's "conception of logic is not that of modern quantification theory" and that "the confusion here is the idea that Kant is operating with two notions of possibility: 'logical possibility,' given by the conditions of thought alone; and 'real possibility,' given by the conditions of thought plus intuition."[31] Friedman appears to be basing his discussion of Kant's notions of possibility on his "postulates of empirical thinking in general" (*CPuR*, A 218/B 266) where Kant states that "whatever agrees with the formal conditions of experience (in accordance with intuition and concepts) is possible". Kant is here referring to possible objects of experience; *real* possibility refers not to what is *physically* possible, but to what can be constructed or represented by the human perceiver. As noted in paragraph 3.5.2 above, Kant clearly felt that non-Euclidean geometries are logically possible. Mere logical possibility is not, however, of prime importance in Kant's theories.

3.5.5 Since an *a priori* judgment cannot be falsified by experience, application of an *a priori* judgment to objects of experience, entails that the judgement is necessarily true with respect to those objects. It should be emphasised, however, that Kant does not propose that such a judgement is necessarily true in an absolute sense but only that it is necessarily true with respect to the objects of possible experience[32]. Thus an *a priori* judgment could be false for objects in the "real" world which is outside the realm of possible experience. Space in the real world could, for instance, have more than three dimensions (*CPuR*, A 24/B 39), while it remains necessarily true that *empirical* space is three-dimensional relative to the objects of experience. As Kant says, we can "speak of space, extended beings, and so on, only from the human standpoint. If we depart from the subjective condition under which alone we can acquire outer intuition, namely that through which we may be

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[31] Friedman, *Op. Cit.*, p. 503

[32] As stated previously, rather than holding the prevalent view that the truth of metaphysical judgments required that they conform to objects, Kant held that objects conform to the way we represent them.

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affected by objects, then the representation of space signifies nothing at all." (*CPuR*, A 27/B 43) In the paper quoted by Friedman and referred to above, Einstein ends by saying that: "My only aim to-day has been to show that the human faculty of visualisation is by no means bound to capitulate to non-Euclidean geometry."[33] I discuss this further in Chapter 4 below.

3.6 KANT'S THEORY OF TIME

3.6.1 As he did with his theory of space, Kant contrasts his theory of time with both that of Newton and that of Leibniz but is more dismissive of the other theories of time than he was with the other theories of space. In the *Inaugural Dissertation*, he calls the objective reality of time conceived as "a continuous flow in what exists, without, however, any existing thing, as is done especially by the English philosophers" an absurd fiction, and calls the objective reality of time conceived as "something real abstracted from the succession of inner states, as it has been put by Leibniz and his followers" a false opinion. (*ID*, §14, 2:139)

3.6.2 Following from his theory of space as an outer intuition, Kant holds that objects that are in different positions in space are represented differently; that is, there is a succession of mental states of representations of the objects which we represent as in time. In so doing, we indirectly subject the outer objects to time— succession and, also, simultaneity would not be perceived if they were not grounded *a priori* by representations of time (*CPuR*, A 30/B 46). "But since all representations, whether they have for their objects outer things or not, belong, in themselves, as determinations of the mind themselves, to our inner state; and since this inner state stands under the formal condition of inner intuition, and so belongs to time, time is an *a priori* condition of all appearance whatsoever." (*CpuR*, A 34/B 50). Therefore, unlike space which is limited as an *a priori* condition to outer intuitions only, time is a necessary condition which grounds all intuitions (*CPuR*, A 34/B 50).

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[33] Friedman, *Op. Cit.*

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3.7 MATHEMATICS AND KANT'S THEORIES OF SPACE AND TIME

3.7.1 In the *Opus Postumum*, Kant contrasts physics with mathematics: physics "is a philosophical, not merely empirical, not mathematical [discipline] (although to use mathematics in physics is philosophical)"; in contrast with mathematics, physics is a special subject of philosophy. Both physics and mathematics have *a priori* principles; "both have their fixed limits" which should not be transgressed. If, then, physics is termed *philosophia naturalis*, the title of Newton's "immortal work philosophiae naturalis principia mathematica ... creates a bastard (conceptus hybridus) which is neither purely one nor the other." (OP, 22:488-489) For Kant, there are both mathematical and metaphysical foundations of natural science, "but not mathematical foundations of philosophy, for they are incompatible." (OP, 22:490) For Kant, "[P]hilosophical cognition is rational cognition from concepts, mathematical cognition that from the construction of concepts ." (*CPuR*, A 713/B 741)

3.7.2 In his earlier work, *Physical Monadology*, Kant had attempted to reconcile the unity demanded in metaphysics with the infinite divisibility of space needed by geometry. In the *Critique of Pure Reason*, Kant states that pure mathematics, as it regards conditions of space and its relations, is a "splendid example" of a synthetic cognition which can be drawn *a priori* from time and space. (*CPuR*, A 39/B 56) For Kant, the validity and apodictic certainty of *a priori* mathematics rest on these pure forms of all sensible intuition (namely space and time) but are problematic for both the Newtonian and Leibnizian concepts of space and time:

— those who support the view that space and time subsist ("which is generally the position of the mathematical investigators of nature", such as Newton) are successful in "opening the field of appearances to mathematical assertions" but at the expense of assuming that time and space are eternal and infinite, self-subsisting non-entities "which are there (yet without there being anything real) only in order to contain in themselves all that is real" (*CPuR*, A 39/B 56);

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— those who support the view that space and time are relations of appearances that are extracted from experience (which is the position of "some metaphysicians of nature", such as Leibniz) are able to avoid the confusion of the former group, but at the expense of questioning the validity "or at least the apodictic certainty of *a priori* mathematical doctrines in regard to real things (e.g., in space). (*CPuR*, A 40/B 57)

3.7.3 In the *Fifth Meditation* (7:64-65), Descartes notes that the essence of bodies is manifested in Euclidean geometry, which determines *a priori* the structure of the spatial world. Objects must be regarded as being uniquely located in space and time in order to be perceived. In contrast, Kant argues, in the "Transcendental Aesthetic", that space and time are the "pure forms of sensible intuition" required for perception.

3.8 KANT ON SUBSTANCE, ACCIDENTS, AND MOTION

3.8.1 In Kant's "Table of Categories" (*CPuR*, A 80/B 106), "substance and accidents" (substantia et accidens) is the first of the categories of relation but this category is "more as their condition than as itself containing a relation" (*CPuR*, A 187/B 230). The schema of substance is "the persistence of the real in time ... as a substratum ... which endures while everything else changes." (*CPuR*, A 144/B 183) In the "First Analogy", Kant defines his principle of the persistence of substance: "In all change of appearances substance persists, and its quantum is neither increased nor diminished in nature." (*CPuR*, A 182/B 224). Accidents are "the determinations of a substance that are nothing other than particular ways for it to exist" and, since they concern the existence of the substance, are always real; while persistence, is "nothing more than the way in which we represent the existence of things (in appearances)" (*CPuR*, A 186/B 229) Kant attempts to prove the commonly-accepted, proposition that "in all alterations in the world, the substance remains and only the accidents change", but this proposition, being synthetic *a priori*, can only be proved through a deduction of the possibility of experience (*CPuR*, A 184/B 228) For Kant, therefore, the philosophical concept of substance is an *a priori* condition for possible experience.

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3.8.2 In the *Physical Monadology*, Kant had introduced his argument for the necessity of the Newtonian forces of attraction and repulsion. In his correspondence with Clarke, Leibniz argued that motion, as well as position, is only detectable in relation to other objects. Neither motion nor position can be detected in relation to space itself. Clarke replied that motion is detectable in relation to space itself, for an object accelerating or rotating alone in a void betrays the effect of forces that exist in relation to no other object—this follows from Newton's analysis in the *Principia* (Book III, Proposition 19) of the effect of rotation on the water in a bucket.[34] Given his rejection of Newton's absolute space and time, Kant must, as Friedman points out, develop some way of providing an appropriate meaning for absolute motion, that is, he must account for the real, as opposed to merely apparent, relative motion of bodies. Kant, accordingly, "views the laws of motion as definitive or constitutive of the spatio-temporal framework of Newtonian theory, and this, in the end, is why they count as *a priori* for him."[35]. In particular, "[W]e need to presuppose the immediacy and universality of gravitational attraction in order to develop a rigorous method for comparing the masses of the primary bodies in the solar system. We need such a method, in turn, in order rigorously to determine the center of mass of the solar system. This, in turn, is necessary for rigorously determining a privileged frame of reference and thus for giving objective meaning, in experience, to the distinction between true and apparent (absolute and relative) motion."[36] If matter, as the movable in space (Definition 1 of the *Phoronomy*: 480.5-10), is to be itself possible as an object of experience, then absolute and relative motion must be distinguished. Further, immediate and universal attraction is also necessary for matter to be an object of experience. The laws of motion must, therefore, be in some manner *a priori*.

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[34] Newton deduced that the shape of the rotating water in the bucket results from the particles' attempting to recede from the axis of rotation. Ernst Mach postulated that inertia is the result of an interaction with all the rest of the mass of the universe.

[35] Friedman, *Kant and the Exact Sciences*, p. 143

[36] *Ibid*, pp. 157-158

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3.9 KANT ON CAUSALITY

3.9.1 Kant agreed with Hume who "quite rightly remarked about that [the principle of causality] that one could not base its truth (indeed not even the objective validity of the concept of an efficient cause in general) on any insights at all, i.e., a priori cognition, and thus that the authority of this law is not constituted in the least by its necessity, but only by its merely general usefulness in the course of experience, and a subjective necessity arising therefrom, which he calls custom." (*CPuR*, A 760/B 788) But, as Kant points out in the *Prolegomena*, Hume was presented with a problem: that is, whether the concept of cause could be "thought by reason a priori, and consequently whether it possessed an inner truth, independent of all experience, implying a perhaps more extended use not restricted merely to objects of experience." (*P*, Introduction, 259)

3.9.2 Kant claims that opponents of the Humean position appealed to common sense to resolve the problem but, for Kant, such an appeal is acceptable only when insight and science fail. His own solution was to find a critical position that could confirm the objective validity of such a concept, noting that either the concept of cause is grounded in the understanding completely *a priori* or else "be entirely surrendered as a mere fantasy of the brain."(*CPuR*, A 91/B 123) In Kant's "Table of Categories" (*CPuR*, A 80/B 106), causality and dependence (cause and effect) is the second of the categories of relation. In order to establish the objective reality of "things in accordance with the categories", we need not only intuitions, but "always outer intuitions."(*CPuR*, B 291) As far as the concept of causality is concerned, the example Kant uses is motion, defined as "alteration in space". In fact, for Kant, it is only through motion that alterations in space can be made. Causality, as with the other categories, cannot be applied directly to intuitions but must be schematised. "The schema of the cause and the causality of a thing in general is the real upon which, whenever it is posited, something else always follows. It therefore consists in the succession of the manifold insofar as it is subject to a rule." (*CPuR*, A 144/B 183)

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3.9.3 Causality, as a category of relation, corresponds to the principles of the analogies of experience by which appearances are temporally ordered. (*CPuR*, A 176/B 218) In particular, causality corresponds to the second analogy which states that "all alterations occur in accordance with the law of the connection of cause and effect." (*CPuR*, B 232) Kant states that "I perceive that appearances succeed one another" and that thus "I really connect two perceptions in time" but I am only conscious of my imagination placing one state before and the other after. In order for the objective relation of the successive appearances to be determined, "the relation between the two states must be thought in such a way that it is thereby necessarily determined which of them must be placed before and which after rather than vice versa." It is only because we subject the sequence of appearances, and any change in them, to the law of causality that experience itself is possible. Consequently, Kant says, the appearances, as objects of experience, are only possible in accordance with the law of causality.(*CPuR*, A 188/B 234) In other words, causality cannot be derived from experience but is a condition of experience. Heisenberg's Uncertainty Principle, according to which causal laws are suspended at the quantum level, has been used to refute Kant's claim that the category of cause and effect is a necessary condition of experience. This will be discussed further in section 5.7.

3.10 CONCLUSIONS

3.10.1 Kant did not, as many commentators contend, accept the tenets of Euclidean geometry and Newtonian physics "without question". Kant, in fact, rejected Newton's concepts of space and time as absolute[37]. Nor did Kant believe that Euclidean geometry provides a unique body of necessary truths about the structure of physical space. The latter idea seems to be founded on a serious misunderstanding of Kant's views: Kant frequently emphasises that we can have no knowledge of the external world, no knowledge of things-in-themselves. Geometry is concerned with the properties of empirical space, but space, for Kant, is an *a priori* intuition; it is not physical, but

[37] It should perhaps be pointed out that Newton's laws only presuppose absolute time, but not absolute space, Newton's laws only require a four-dimensional, "Newtonian spacetime". (c/f Robert Disalle's "Newton's philosophical analysis of space and time" in *The Cambridge Companion to Newton*)

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transcendentally ideal and, as such, does not require that physical space be Euclidean. As Friedman has pointed out, Kant's theory of pure spatial intuition "does not provide, and does not attempt to provide, an independent epistemological foundation [for geometry]".[38] Kant even refers, indirectly, to the possibility of non-Euclidean geometry just as he refers to the possibility of a physical space of more than three-dimensions. These will prove to be important points in Chapter 5.

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[38] Michael Friedman, "Geometry, Construction and Intuition in Kant and his Successors," in Gila Sher and Richard Tieszen, eds., *Between Logic and Intuition: Essays in Honor of Charles Parsons*, Cambridge: Cambridge University Press, 2000, p. 193

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CHAPTER 4

4. EMPIRICAL AND ABSOLUTE REALITY

4.1 INTRODUCTION

4.2 Kant argues that his proof of the existence of an external world follows from the *a priori* structure of human understanding which is necessary for conscious experience. In his discussions of the external world, Kant emphasises, however, that there is a difference between absolute reality and empirical reality. He firmly believed that there is an independent, absolute reality outside the world of all possible experience; that there is a world of things as they are in themselves (the world of noumena[39]) and of reality as it is in itself. This is not, however, the world of things as they appear to us; it is not the world of phenomena; it is not the directly known world of actual experience. Things-in-themselves belong to absolute reality and are unknowable as such. For Kant, it is essential to distinguish between the "'object as appearance" and "the object as it is in itself"; between phenomena and noumena. (*CPuR*, B 69).

4.3 EMPIRICAL OBJECTS VERSUS THINGS-IN-THEMSELVES

4.4 Kant claims that what objects may be in themselves, apart from the receptivity of a subject's sensibility, remains completely unknown to the subject. (*CPuR*, A 42) Nevertheless, Kantian sensibility is not a Leibnizian "confused representation of things" — "It is not that by our sensibility we cannot know the nature of things in themselves in any save a confused fashion; we do not apprehend them in any fashion whatsoever." (*CPuR*, B 61-62) Furthermore, Kant denies Descartes' thesis that the existence of the external world must be inferred because "the inference from a given effect to a determinate cause is always uncertain, since the effect may be due to more than one cause" (*CPuR*, A 368). There is, according to Kant, no need to resort to inference in order to arrive

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[39] Kant distinguished two meanings of *noumenon*: one negative and the other positive. In the *negative* sense, a *noumenon* is "*not an object of our sensible intuition*. In the *positive* sense, the sense in which Kant uses the term, a *noumenon* is an *object* of a *non-sensible intuition* by which "we presuppose a special mode of intuition, namely, the intellectual, which is not that which we possess, and of which we cannot comprehend even the possibility." (*CpuR*, A 259/B 307)

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at reality since both the representation of self as thinking subject and representations which "mark extended beings" (*CPuR*, A 371) are immediate objects of perception — the only difference between the two is that the former "belongs to inner sense only" whereas the latter "belong also to outer sense" — for "in both cases alike the objects are nothing but representations, the immediate perception (consciousness) of which is at the same time a sufficient proof of their reality." (*CPuR*, A 371) Without the "sensible determination of permanence", substance, for instance, would mean simply a something which can be thought only as subject, never as a predicate of something else and as such would be of no use since it provides no information as to the nature of that which is thus to be viewed as a primary subject. As Kant notes: "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." (*CPuR*, A 147/ B 187) Schemas enable categories to be applied to appearances; they mediate between concept and intuition. (*CPuR*, A 138/B 177) Schematism enables judgements to take place through rules of synthesis of the imagination. Kant offers, as an example, the schema of the triangle which "can exist nowhere but in thought. It is a rule of synthesis of the imagination, in respect to pure figures in space." An object of experience or its image is never adequate to the empirical concept; "for this latter always stands in immediate relation to the schema of the imagination, as a rule for the determination of our intuition, in accordance with some specific universal concept." Kant provides a further example: "[T]he concept 'dog' signifies a rule according to which my imagination can delineate the figure of a four-footed animal in a general manner, without limitation to any single determinate figure such as experience, or any possible image that I can represent *in concreto*, actually presents." (*CpuR*, A 141/B 180)

4.5 In the "Transcendental Aesthetic", Kant explains that both *a priori* intuitions and *a priori* concepts are necessary conditions for human knowledge for, in order to know anything, it is necessary to have the concept of an object, but this can only be formed through the use of the Categories. All knowledge begins with experience and experience contains an empirical element;

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knowledge begins with the phenomena which are presented in immediate consciousness through the faculty of sensibility, but it is as necessary for the mind to make concepts sensuous as it is to make intuitions intelligible. We thus understand the world through the concepts that we have of it and the concepts are given meaning by reference to intuitions. While phenomenal experience of an object may vary depending upon our point of view, our concept of the object does not vary — that is, the concept of the object is independent of our point of view. Phenomena and concepts together form the basis of our objective world view and this is the real world of our experience. He asserts that immediate perception and coherence within experience are sufficient proof of the reality of outer objects, and that we are conscious of ourselves only in knowing something apart from ourselves. By positing his *a priori* structure of human understanding as the necessary condition for conscious experience, Kant claimed that he had refuted scepticism regarding the external world because "these external things, namely matter, are in all their configurations and alterations, nothing but mere appearances, that is, representations in us, of the reality of which we are immediately conscious." (*CPuR*, A 371-2). How successfully Kant refuted scepticism is still a subject of debate.

4.6 In the preceding passage, "alteration" must be understood to mean a "change of state" not a "change of substance"; differentiation between co-existing entities and an alteration would require that there be some persistent entity which undergoes the alteration. He states that permanence "is thus a necessary condition under which alone appearances are determinable as things or objects in a possible experience." (*CPuR*, A 189/B 232). This is a crucial point since two perceptions can be connected in time in two different ways, namely that either one or the other precedes in time. The "objective relation of appearances that follow upon one another is not to be determined through mere perception", but rather through "the relation of cause and effect, the former of which determines the latter in time." Experience ("empirical knowledge of appearances") is "thus possible only in so far as we subject the succession of appearances, and therefore all alteration, to the laws of causality." (*CPuR*, A 189/B 234) Kant thereby distinguishes between the knowledge of a determined existence and the undetermined existence of things (between *Dasein* and *Dasein der*

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Dinge); the former being known only as an appearance of "the existence of effects from given causes in accordance with the laws of causality." (*CPuR*, A 227/B 279)

4.7 The special conditions of sensibility are not the conditions of the possibility of things but only of their appearances. That all objects are located in space is a valid proposition only in as far as the proposition is limited to objects of our sensible intuition; the proposition is also universally valid if the objects under consideration are seen as outer appearances only. Space is objectively valid, is real, with respect to whatever is presented to us as an object outside ourselves; space is also ideal when things are considered in themselves through reason. Kant asserts, therefore, that space is both empirically real and transcendentally ideal. Without its limitation to possible experience, space is nothing at all and cannot be looked upon as something that underlies things in themselves (*CPuR*, A 27-28/B 43-44).

4.8 Not only is our world view empirically real, it is also transcendentally ideal since it arises within our cognition. Transcendental ideality is required to support Kant's doctrine of things in themselves. Kant insists that transcendental idealism "removes all difficulty in the way of accepting the existence of matter on the unaided testimony of our mere self-consciousness" (*CPuR*, A 70). Further, all of "our knowledge falls within the bounds of possible experience, and just in this universal relation to possible experience consists that transcendental truth which precedes all empirical truth and makes it possible." (*CPuR*, A 146/ B 185) "Reality, in the pure concept of understanding, is that which corresponds to a sensation in general; it is that, therefore, the concept of which in itself points to being (in time)." (*CPuR*, A 143/B 182) Kant contends that both inner and outer objects "are nothing but representations, the immediate perception (consciousness) of which is at the same time a sufficient proof of their reality." (*CPuR*, A 371)

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4.9 OBJECTIONS TO KANT'S THEORY OF THE THING-IN-ITSELF

4.10 Objections to Kant's position on things-in-themselves could be given on both metaphysical and epistemological grounds. The objections rely, in part, on the idea that Kant seems to apply the categories of reality and causality to things-in-themselves, in that he claims:

a) that things-in-themselves exist;

b) that "outer objects" exist in space and time independently of our perceptions of them; and

c) that these perceptions are determined, or "caused", by things-in themselves.

4.11 On first examination, it would appear that Kant contradicts his own claim that we can have no knowledge of things as they are in themselves. Kant makes clear, however, that we can have no knowledge of things-in-themselves independently of our experiencing them. His application of the categories does not yield knowledge of things-in-themselves but is used in our thinking *about* them. As he states in the Preface to the Second Edition of the *Critique of Pure Reason*, "all possible speculative knowledge of reason is limited to mere objects of experience." He goes on to say that although "we cannot know these objects as things in themselves, we must yet be in a position at least to think them as things in themselves; otherwise we should be landed in the absurd conclusion that there can be appearance without anything that appears." (*CPuR*, B xxvi)

4.12 For Kant, the world of things as they are in themselves is not the world of things as they appears to us; it is not the directly known world of actual experience; it is not empirical reality. Things-in-themselves belong to absolute reality and are unknowable as such. "What objects may be in themselves, and apart from all this receptivity of our sensibility, remains completely unknown to us. We know nothing but our mode of perceiving them – a mode which is peculiar to us. . . . Even if we

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could bring our intuition to the highest degree of clearness, we should not thereby come any nearer to the constitution of objects in themselves." (*CPuR*, A 42-433/B 59-60)

4.13 What we do perceive are outer empirical objects which belong to empirical reality. Contrary to Hume, who held that there is no rationally defensible reason for thinking that there are outer objects, Kant held that perception "exhibits the reality of something in space" and that "the something that is to be intuited in space, necessarily presupposes perception." (*CPuR*, A 373) We thus directly apprehend the subjectively conditioned reality. Outer empirical objects (non-mental spatial objects) are therefore necessary for experience and continue to exist, although not in that form (i.e., they do not continue to exist as spatial objects), even when not being perceived — that is, they continue to exist as objects of possible experience. Moreover, Kant asserts that "the conditions of the possibility of experience in general are likewise conditions of the possibility of the objects of experience, and that for this reason they have objective validity in a synthetic a priori judgment." (*CPuR*, A 158/B 197)

4.14 Reality and Possible Experience

4.14.1 Both intuitions and concepts are required for experience or knowledge. In the "Transcendental Analytic", Kant provides an explanation of how the conceptual and the sensible components are connected in the structure of experience. Knowledge of the objective world requires, in addition to the space and time relations, other formal elements which, amid all the differences of content, remain the same. In the "Analytic", Kant set himself the task of setting forth these elements and establishing their *a priori* nature (or "ideality" in the sense in which it is used in the "Aesthetic"); and showing that by means of them, objective a priori knowledge is possible. It must be emphasised that, by objective world, Kant does not contend that the external world exists independently of the subject; for when he describes the external world as objective, he means that the subject holds a certain relationship with the external world in so far as he conceives himself to be a subject within an independent framework of objects.

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4.14.2 Categories alone are insufficient for pure understanding to prescribe to appearances "any *a priori* laws other than those which are involved in a *nature in general*, that is, in the conformity to law of all appearances in space and time." Special laws concerning empirically determined appearances "cannot in their specific character be derived from the categories, although they are one and all subject to them." Experience is required in order to obtain any knowledge whatever of these special laws; but it is "the a priori laws that alone can instruct us in regard to experience in general, and as to what it is that can be known as an object of experience." (*CPuR*, B 165) The conditions of the possibility of experience in general are also the conditions of the possibility of the objects of experience and thereby they have objective validity in a synthetic *a priori* judgement. (*CPuR*, A 156/B 195)

4.14.3 In the *Critique of Judgement*, Kant is concerned, in part, with finding a solution to the problem that sole reliance on the principles of pure understanding plus an unlimited number of empirical laws would be insufficient for a unified and systematically organised knowledge of nature, and would render impossible a unified knowledge of the world of experience:

> The problem, which lies a priori in our understanding, is to make a connected experience out of given perceptions of a nature containing at all events an infinite variety of empirical laws. The understanding is, no doubt, in possession a priori of universal laws of nature, without which nature could not be an object of experience, but it needs in addition a certain order of nature in its particular rules, which can only be empirically known and which are, as regards the understanding, contingent. These rules, without which we could not proceed from the universal analogy of a possible experience in general to the particular, must be thought by it as laws (i.e. as necessary), for otherwise they would not constitute an order of nature, although their necessity can never be cognized or comprehended by it. Although, therefore, the understanding can determine nothing a priori in respect of objects, it must, in order to trace out these empirical so-called laws, place at the basis of all reflection upon objects an a priori principle, viz. that a cognizable order of nature is possible in accordance with these laws. (*CJ*, 5:184-185)

4.14.4 The solution is to assume that there is a "law of the specification of nature in respect of its empirical laws" (*CJ*, 5:186) and that the universal laws of nature correspond to the conditions of possible experience. Kant is not concerned with the conditions for the existence of purposive

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structures in nature; rather, he is concerned with the particular orientation of knowledge when it judges something as purposive. He is, however, proposing that nature meets conditions of regularity; that there are objective conditions for the possibility of experience, and that subjective conditions alone would be insufficient to enable one to have experience. As he states in the *Critique of Pure Reason*, purposive unity must be in the "essence of the things" which constitute all objectively valid knowledge. (*CPuR*, A 694/B 722) The laws of nature order reality in such a way as to render its representation possible. In other words, nature is organised purposively: "nature specifies its universal laws according to the principles of purposiveness for our cognitive faculty" (*CJ*, 5:186)

4.14.5 Kant supported Lavoisier's theory of chemistry, (his *caloric* theory of gases in particular), and used it to conceive of a new theory of natural science. In the *Opus Postumum*, Kant introduces his new theory of matter which he claimed makes possible the transcendental foundation of natural sciences. Kant treats attraction and repulsion as modifications of the internal vibrations of a "universally and uniformly distributed world-material", a *caloric* or *aether*, which is the "universal basis of the moving forces of matter affecting the senses" and without whose presupposition an outer object of the senses [cannot] have an empirically possible object." Moreover, this "radical world-material is not problematic and merely assertoric, but apodictically certain. Its existence belongs to the transition from the metaphysical foundations of natural science to physics; and its recognition (according to a priori concepts of objects in appearance in general ... makes physics initially possible." (*OP*, 22:476) Kant deduces the existence of this world-material from the conditions of possible experience: "For just as there is only one space and only one time (as objects of pure intuition), there is likewise only one object of possible outer experience in the field of the causality of perception of outer things. For all so-called experiences are always only parts of one experience, in virtue of the universally distributed, unbounded caloric which connects all celestial bodies in one system and sets them into a unbounded caloric which connects all celestial bodies in one system and sets them into a community of reciprocity." (*OP*, 22:554n)

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4.15 CONCLUSIONS

4.15.1 For Kant, the metaphysical status of the phenomenal realm (the realm of sensible entities) is grounded in the knowledge of causation; the phenomenal world of causation is the product of the categories of human cognition. In the "Transcendental Aesthetic", Kant established the objective reality of noumena, and justified the division of objects into phenomena and noumena, "and so of the world into a world of the senses and a world of the understanding." (*CPuR*, A 249) Here the noumena are the objects of independent existence which have ontological objectivity but are unknowable.

4.15.2 Through his combination of intuitions and concepts, Kant avoids the idealism of the Empiricists since, on his view, we have an immediate impression of reality; we are immediately conscious of empirical reality. It must be made clear, however, that, in his discussions of empirical reality and things-as-they-are-in-themselves, of phenomena and noumena, Kant does not make metaphysical claims; he is, instead, making the epistemological claim that we have no knowledge of noumena "in terms of distinctive inner predicates." (*CPuR*, A 565/B 593) We may have, as Kant states, an "inextinguishable desire to find firm footing somewhere beyond the limits of experience" (*CPuR* , A 796/B 824) but modern developments in physics and mathematics seem to separate us further from the empirical world of experience and the world as it may be in itself. This is discussed further in the next chapter.

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CHAPTER 5

5. ADVANCES IN MATHEMATICAL AND PHYSICS AND THE CONDITIONS OF POSSIBLE EXPERIENCE

5.1 INTRODUCTION

5.2 Kant argues that experience must be spatial and temporal, and thus experience must also conform to the mathematics of space and time where geometry is the mathematics of space and where arithmetic is the mathematics of time. Experience derives its certainty from the fact that the objects of experience conform to the general truths of mathematics and physics, that is, in particular, to the general truths of Euclidean geometry and Newtonian physics. Given the development of non-Euclidean geometries; of the critique of absolute time and Euclidean space in relativity theory; and of the laws of causality in quantum mechanics, Kant's position should be re-evaluated. This chapter will examine whether these developments in mathematics and physics do in fact undermine Kant's conditions of possible experience.

5.3 BACKGROUND

5.3.1 Following the success of the techniques of mathematics—that is, deduction from "self-evident" axioms according to fixed rules , *a priori* methods, et cetera— philosophy and natural science were both strongly influenced in the seventeenth century by the mathematical model. In the eighteenth century, the mechanical model, particularly that of the Newtonian system, came to dominate. As Ernst Cassirer[40] notes, Immanuel Kant believed that Newton's system provided him with a fixed code of physical "truth" and that philosophical knowledge could be definitively grounded on the "factum" of mathematical natural science; that metaphysical speculations could be guided by data arising from "the mathematical consideration of motion in connection with knowledge of space"[41]. In

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[40] Ernst Cassirer, *Substance and Function. Einstein's Theory of Relativity*, pp. 352-353.

[41] Immanuel Kant, *Attempt to Introduce the Concept of Negative Magnitudes into Philosophy*, quoted Ibid, p. 351

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the twentieth century, however, new models arose and philosophers have now to take into account Einstein's Special and General Theories of Relativity and, in particular, Quantum Mechanics.

5.4 METAPHYSICS AND CLASSICAL PHYSICS

5.4.1 A common metaphysical assumption in science is empirical consistency — there is an expectation that identical experimental systems should, statistically, always produce the same observations. In the Newtonian world as it is often interpreted, space and time were absolute; all motion had a cause; nothing was uncertain (that is, the world was deterministic). Werner Heisenberg stated, in a lecture delivered at Vienna University in 1935, that classical physics is based on a system of mathematically concise axioms and, therefore, the validity of classical physics appears to be absolute[42], but, this absolutist view of the world has been seriously undermined by developments in modern physics. There was doubt even earlier, however. In his pamphlet, *The Analyst*, George (Bishop) Berkeley questioned "whether the object, principles, and inferences of the modern Analysis are more distinctly conceived, or more evidently deduced, than religious Mysteries and points of Faith."

5.4.2 Indeed, confidence in the certainty of mathematics and natural sciences was undermined long before the advent of quantum mechanics. Early doubts about Euclid's Fifth Postulate concerning parallel lines cast doubt upon the truth and perfection of Euclidean geometry as a whole. With the invention of non-Euclidean geometries and with the paradoxes of the infinite discovered by George Cantor, faith in the truth and infallibility of mathematics was further weakened. For Ernst Cassirer, the axioms of geometry are never given or realised in experience and, therefore can never be validated or invalidated by experience; nor can they be derived from physical reality. The axioms "must be constructed in full independence of such reality; they refer to possibilities only."[43]

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[42] Werner Heisenberg, *Philosophic Problems of Nuclear Science*, p. 41.

[43] Ernst Cassirer, "The Concept of Group and the Theory of Perception", p. 18.

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5.4.3 According to classical physics, motion (and acceleration) of matter 'particles' occurred in a framework of absolute time and space and, in this framework, matter did not affect space. As Roger Penrose[44] has pointed out, however, although Newton was in some measure forced into an "absolutist" position when formulating his laws of dynamics, he included, as the fourth law in his original formulation of his laws of motion, the Galilean principle of relativity. This law was not included in his final version in the *Principia* since he had come to realise that his, now famous, three laws of motion were sufficient for deriving all the others. Newton used the notion of "absolute space" in the description of his laws of motion merely to render more precise the framework in which the laws applied.

5.4.4 Ernst Mach postulated, in *The Science of Mechanics*[45], that, rather than speaking of the acceleration of a mass relative to absolute space, one should speak of acceleration relative to the distant stars, thereby implying that the inertia of a body is influenced by far distant matter. This view had a considerable influence on Albert Einstein and, in particular, on the development of his theory of general relativity. Einstein rejected the 'particle' conception of matter and, in his theory, matter does affect space, as matter and space are united (that is, matter is spherically spatially extended and represented as a spherical field).

5.5 THE THEORY OF GRAVITATION

5.5.1 In Proposition 7 of the *Principia*, Newton states that "Gravity exists in all bodies universally, and is proportional to the quantity of matter in each." He goes on to say, in his discussion of "Gravitation toward Planets", that "We have already proved that all planets are heavy [or gravitate] toward one another and also that the gravity toward any one planet, taken by itself, is inversely as the square of the distance of places from the center of the planet. And it follows (by book I, prop. 69 and

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[44] Roger Penrose, *The Road to Reality*, p. 388

[45] Ernst Mach, *The Science of Mechanics, A Critical and Historical Account of Its Development*, Open Court Publishing, 1960,

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its corollaries) that the gravity toward all the planets is proportional to the matter in them." But Newton also wrote: "How these Attractions may be performed. I do not here consider. That I call attraction may be performed by impulse; or by some other means unknown to me."

5.5.2 Samuel Clarke emphasised Newton's anti-metaphysical point of view in his correspondence with Leibniz: "It is very unreasonable to call Attraction a Miracle and an unphilosophical Term; after it has been so often distinctly declared, that by that Term we do not mean to express the Cause of Bodies tending towards each other; but barely the Effect, or the Phenomenon itself, and the Laws or Proportions of the Tendency, discovered by Experience...."[46] It is, therefore, somewhat inaccurate to claim that Einstein's General Theory of Relativity falsified or contradicted Newton's theory of gravity since Newton had not attempted to describe what gravity is. In fact, while General Relativity reinterprets gravitational free fall as motion along a shortest-distance path, that is, as "geodesic motion", it nevertheless incorporates the basic dependencies between acceleration fields and spherical mass distributions of Newton's propositions.

5.5.3 Further, William Harper[47] claims that "the revolutionary change to General Relativity is in accordance with the evaluative procedures of Newton's methodology." Application of these procedures lead to increasingly accurate corrections to the planetary orbits of the Keplerian model and "made General Relativity do better than Newton's theory on Newton's own ideal of empirical success. Since its initial development General relativity has continued to improve upon what Newton's methodology counts as its clear advantage over Newtonian gravitation theory."[48] General Relativity may, then, be seen as a major improvement upon Newton's theory rather than as a Kuhnian paradigm shift. In particular, the development of both theories demonstrates the continuing attempt to provide ever more accurate measurements of, and predictions based upon, our empirical observations, but

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[46] Quoted by Alexandre Koyre in *From the Closed World to the Infinite Universe*, p. 271

[47] William Harper, "Newton's argument for universal gravitation", chapter 5 of *The Cambridge Companion to Newton*, pp. 174-194.

[48] *Op. Cit.*, p. 194.

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neither theory actually changes what it is that we actually experience. Just because we know of the theory of General Relativity, and even understand it, does not change the way we *experience* gravity. That is to say, we humans do not now experience gravitational free fall as geodesic motion.

5.6 THE CORRESPONDENCE PRINCIPLE

5.6.1 In 1923, Niels Bohr presented his "Correspondence Principle" according to which the behavior of quantum mechanical systems reduces to classical physics in the limit of large quantum numbers. While quantum mechanics may accurately describe microscopic objects, such as atoms and elementary particles; classical theories, such as classical mechanics and classical electrodynamics, accurately describe macroscopic systems. In other words, the predictions of the quantum theory and of the classical theories of physics must correspond whenever the quantum theory is being used to describe the behavior of systems that can be successfully described by classical theories.[49] Bohr's correspondence principle is intended to meet the requirement of unified science theories that the fundamental laws of physics be independent of the dimensions of the physical objects being described.

5.6.2 The conditions under which quantum and classical physics agree are referred to as the correspondence limit, or the classical limit, which occurs, according to Bohr's approximation, when the quantum numbers describing the system are large. Classical physics thus emerges as an approximation to quantum physics at the correspondence limit (that is, when mass×speed×distance is large compared to the Planck constant $\hbar$). Special Relativity satisfies the correspondence principle in so far as it reduces to classical mechanics at the limit of velocities which are small compared to the speed of light (that is, as $v/c \to 0$); and General Relativity reduces to Newton's theory of gravitation at the limit of weak gravitational fields. As James Trefil has observed "Quantum mechanics... doesn't displace Newtonian mechanics, but incorporates it as a limit. Scientific theories grow by incorporating what is already known and adding to it, just as a tree adds layers on the outside while preserving its

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[49] *The Columbia Encyclopedia*, Sixth Edition. 2001-05.

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heartwood."[50] Rather than the scientific revolutions proposed by Thomas Kuhn, this theory proposes that science evolves—specific theories may become extinct, others may be modified, and new ones added to the body of science. On this account, Newton's Laws have been limited in applicability, but not discarded.

5.6.3 The correspondence principle can be used in the selection of quantum theories corresponding to reality since the principle limits the choices to those that reproduce classical mechanics at the correspondence limit. As a consequence of this, David Bohm has argued that classical physics does not emerge from quantum physics in the same manner that classical mechanics approximates to Special Relativity for small velocities; rather, says Bohm, classical physics exists independently of quantum theory and cannot be derived from it. Quantum theory and classical physics can thus be said to have different areas of applicability.

5.6.4 In his book *Relativity and the Nature of Spacetime*, Vesselin Petkov has noted that the correspondence between Newtonian mechanics and the theory of Special Relativity has mostly epistemological content and that, consequently, this correspondence demonstrates only one side of the correspondence principle — its epistemological aspect — ; whereas the correspondence between Newtonian mechanics and quantum mechanics also has a clear ontological content in that "it reflects the correspondence between quantum and macroscopic physical laws." Petkov continues by pointing out that the "epistemological aspect of the correspondence principle operates at a simple level of the structural organisation of matter" thereby requiring that any new theory of the same level contain the preceding theories as limiting cases; that the new theory reduce to the already existing theory where the old theory operates successfully — as in the case of Special Relativity and Newtonian mechanics[51]. On the other hand, the ontological aspect of the correspondence principle applies to

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[50] James Trefil, *The Nature of Science*, p. 98.

[51] Newton's laws of gravity and motion provide an excellent approximation to the predictions of general relativity for those cases in which velocities are small compared with that of light, and masses are not too compact, and were used to measure the mass of a galaxy by observing the orbital speeds of the stars in experiments which gave rise to the Dark Matter/Dark Energy Hypothesis. According to the dark-matter hypothesis there is much more matter in the universe than that

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theories which describe neighbouring levels; the correspondence principle requires that, when a new theory describes a more fundamental level than that in which an existing theory operates, the new theory should reduce to the existing theory when applied to the "higher" level — as in the case of quantum mechanics and Newtonian mechanics.[52] It is reasonable to question which of these levels, or areas of applicability, best corresponds to the realm of possible experience. As argued in 5.7.3 below, quantum objects, for example, lie outside our realm of possible experience.

5.7 LAWS OF CAUSALITY

5.7.1 In the "Second Analogy: Principle of Succession in Time, in accordance with the Law of Causality" (*CPuR*, A 189-211/B 232-256), Kant argues that any change in time must conform to causal law; that all appearances are subject to laws, according to which their present state is a consequence of some prior state of appearances which are sufficient for the present state's existence. "In order that this relation be known as determined, the relation between the two states must be so thought that it is thereby determined as necessary which of them must be placed before, and which of them after, and that they cannot be placed in the reverse relation." (*CPuR*, B 234) This position would appear to be contradicted by the theory of Special Relativity since this theory has relativity of simultaneity as a consequence—for example, two observers in relative motion would each experience a class of different simultaneous events and, hence, events may occur in different sequences for each of the observers. This apparent contradiction is, however, not fatal to Kant's position since the "[T]wo observers in relative motion, using the ordinary three-dimensional language, will regard two different three dimensional 'slices' of the absolutely existing spacetime as their dimensional 'slices' of the absolutely existing spacetime as their presents"[53] and Kantian laws of causality are only applicable within the frame-of-reference of a particular observer, that is, to each observer's realm of experience.

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which is visible. As Lee Smolin points out in his book *The Trouble with Physics*: "The dark-matter hypothesis is preferred mostly because the only other possibility — that we are wrong about Newton's laws, and by extension general relativity, is too scary to contemplate."

[52] Vesselin Petkov, *Relativity and the Nature of Spacetime*, p. 179.

[53] Petkov, *Op.Cit.*, p. 125

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(This is further discussed in section 5.8 below.) In any case, the fact that simultaneity is relativised in spacetime does not necessarily entail that sequences can be reversed. If such could occur, then it would be possible for a signal to be sent into the past of the same event. According to Penrose, such *causality violations* are normally ruled out as "unphysical" and should be ruled out "for a classically acceptable spacetime."[54]

5.7.2 In his discussion of the anisotropy of time[55], Adolf Grünbaum notes that Hans Reichenbach pointed to "the seriality of the time of Newton's mechanics and of special relativity in the face of the complete time-symmetry of the fundamental laws of these theories." Grünbaum contends, nevertheless, that a universe with the property of entropy is temporally anisotropic— "its time exhibits a special kind of *difference in direction*." In such an irreversible kind of universe, "the classical entropy law precludes the occurrence of the same (*non*-equilibrium) *macro*-states at different times ..." He emphasises, however, that "when we speak of the anisotropy of time, this must not be construed as equivalent to making assertions about 'the' direction of time" and that "Reichenbach's assertions about 'the' direction of time rest on his incorrect supposition that there is a physical basis for becoming in the sense of shifting of a physically defined 'now' along one of the two physically distinguished directions of time." Grünbaum's characterisation of physical time as anisotropic, "involves no reference whatever to a transient division of time into the past and future".

5.7.3 Heisenberg's Uncertainty Principle[56] seems to be inconsistent with Kant's position on causality. Werner Heisenberg[57] states that "causality was taken by Kant as a condition for science.

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[54] Penrose, *Op. Cit.*, p. 409

[55] Adolf Grünbaum, *Philosophical Problems of Space and Time*, pp. 216-217

[56] From Wikipedia: "In quantum physics, the Heisenberg uncertainty principle or the Heisenberg indeterminacy principle — the latter name given to it by Niels Bohr — states that when measuring conjugate quantities, which are pairs of observables of a single elementary particle, increasing the accuracy of the measurement of one quantity increases the uncertainty of the simultaneous measurement of the other quantity. The most familiar of these pairs is the position and momentum."

[57] The information in this paragraph is taken from an interview with Werner Heisenberg conducted by David Peat and Paul Buckley in the early 1970's for broadcast as part of a CBC radio documentary series entitled *Physics and Beyond*. The interview was later published in *Glimpsing Reality: Ideas in Physics and the Link to Biology*.

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He says that if we cannot conclude from some fact that something must have been before this fact, then we do not know anything, and we cannot make observations, because every observation supposes that there is a causal chain connecting that which we immediately experience to that which has happened. If this causal chain does not exist, then we do not know what we have observed, says Kant. Quantum theory does not agree with this idea, and in fact proves that we can even work in cases where this causal chain does not exist." Causality is predicated on the idea of separation and action which terms are used in quantum theory as they were in classical theory. He goes on to say, however, that there must be an action from one point to the next point and that no action can happen if there is not this connection; that complete separation of two events may be possible in classical theory but not possible in quantum theory. So the terms "separation" and "action" must be used together with the fact of their limitation. Heisenberg explains this limitation in the following manner: "every system in physics (forget for the moment about biological systems) is always quantum theoretical, in the sense that we believe that quantum theory gives the correct answers for its behaviour. When we say that it is classical, we mean that we do get the correct or the necessary answers by using classical concepts (at least in that approximation in which we can describe the system by classical concepts). So a system is classical only within certain limits and these limits can be defined."[58] Kant limited application of his conditions for possible experience, and hence causality, to empirical reality.

5.7.4 Kant's view of causality seems also to be contradicted by the phenomenon of "quantum entanglement" in which particles which are arbitrarily far apart appear to influence each other, even though according to relativity this would imply that what appears to be causing an event from one point of view, from another point of view does not happen until after the effect being caused.[59] Again, the contradiction is only apparent since, according to Quantum Theory itself, which

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[58] Such limits are described by the Bohr's *Correspondence Principle* discussed in section 5.6 above.

[59] The fact that quantum mechanics predicted these non-local connections was originally pointed out by Einstein, Podolsky and Rosen.

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cannot provide an observer-independent view of reality, quantum objects lie outside our realm of possible experience, and consequently outside the area of applicability of Kant's laws of causality.

5.8 SPACETIME AND FOUR-DIMENSIONALITY

5.8.1 Einstein used the "Twin Paradox" thought experiment in an attempt to clarify the time-dilation effect of clocks in relative motion. In 1916, Einstein wrote that the laws of physics "must be of such a nature that they apply to reference systems in any kind of motion", and he concluded about two systems in relative motion, K and K', that from the physical standpoint, "the assumption readily suggests itself that the systems K and K' may both with equal right be looked upon as 'stationary', that is to say, they have an equal title as systems of reference for the physical description of phenomena." In other words, all observers are equivalent, and no particular frame of reference is privileged. In 1971, scientists used atomic clocks to verify Einstein's prediction. In addition to time-dilation, the length of any object in a moving frame will appear foreshortened, or contracted, in the direction of motion. The amount of contraction can be calculated from the Lorentz transformation. The length is maximum in the frame in which the object is at rest A clock in a moving frame will be seen to be running slow, or "dilated" according to the Lorentz transformation. The time will always be shortest as measured in its rest frame. The time measured in the frame in which the clock is at rest is called the "proper time".

5.8.2 We are, however, always in a rest frame and, according to both Galilean and Special Relativity, any two observers moving at constant speed and direction with respect to one another will obtain the same results for all mechanical experiments. If one imagines an observer travelling in a windowless spaceship moving at constant velocity, Galilean relativity asserts that there are no mechanical experiments that can be made inside the rocket that will tell the occupants that the rocket is moving . The question of whether the spaceship is moving or not has no meaning unless a reference frame is specified — that is, the question becomes "relative to what is the spaceship moving?" This fact is one of the cornerstones of Einstein's theories of relativity. Most people who have

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ever taken a train journey have been in the position of being unable to tell whether a train alongside them or their own train was moving. Our experience is restricted to our reference frame and the effects of time-dilation are a case in point: time-dilation cannot be experienced directly but only detected by comparison of results (differences in clock-times; differences in the ages of the twins in the Twin Paradox, et cetera).

5.8.3 The universe of everyday experience has three dimensions, and Einstein originally formulated his theory of Special Relativity using three-dimensional language, but his General Theory of Relativity demonstrates that the universe is actually made up of four (or more) dimensions. The core functionality of the General Theory of Relativity is to provide a two-way mapping of this four-plus dimensional space to the three-dimensional space of our everyday experience. Hermann Weyl tried to reconcile this apparent contradiction by seeking to connect the flow of time with mind and consciousness in the context of Special Relativity: "The objective world simply is, it does not happen. Only to the gaze of my consciousness, crawling upward along the life line of my body, does a certain section of this world come to life as a fleeting image in space which continuously changes in time."[60] According to this view, as our consciousness moves up the world tube of our body, it incorrectly interprets sensations as having been received from a three-dimensional world which is constantly changing in time.[61] There is here no contradiction with Kant's position that we impose the forms of space and time on our sensations and subject them to a synthesis: space "is nothing but the form of all appearances of outer sense. It is the subjective condition of sensibility, under which alone outer intuition is possible for us" (*CPuR*, A 26/B 42); and only "on the presupposition of time can we represent to ourselves a number of things as existing at one and the same time (simultaneously) or at different times (successively)." (*CPuR*, A 30/B 46) That the objects of our experience may not correspond to objects in the "real" world, or that the dimensionality of our empirical reality is not the

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[60] Herman Weyl, *Philosophy of Mathematics and Natural Science*, Princeton University Press, Princeton, 1949 p. 116.

[61] Petkov, *Op. Cit.*, p. 151.

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dimensionality of the "real" world would not have disturbed Kant. He, after all, specifically states that were the concept of space acquired *a posteriori*, we should "only be able to say that, so far as has been hitherto observed, no space has been found that has more than three dimensions"(*CPuR*, A 24/B 39). That is, space in the real world could have more than three dimensions, while the fact that space, as a necessary *a priori* representation, is three-dimensional remains true relative to the objects of experience. As Kant says, we can "speak of space, extended beings, and so on, only from the human standpoint. If we depart from the subjective condition under which alone we can acquire outer intuition, namely that through which we may be affected by objects, then the representation of space signifies nothing at all." (*CPuR*, A 27/B 43) In other words, we should not confuse the four-dimensionality or sub-dimensionality[62] of absolute reality with the three-dimensionality and flowing time of empirical reality.

5.8.4 According to Arthur S. Eddington[63], no matter how successful the theory of a four-dimensional world may be, an internal voice which whispers to us that "At the back of your mind, you know that a fourth dimension is all nonsense." As he says, it seems to be nonsense to say that my desk on which I am writing "is a collection of electrons moving with prodigious speeds in empty spaces, which relatively to electronic dimensions are as wide as the spaces between the planets in the solar system! What nonsense to say that the thin air is trying to crush my body with a load of 14 lbs. to the square inch! What nonsense that the star cluster which I see through the telescope obviously there now, is a glimpse into a past age 50,000 years ago! Let us not be beguiled by this voice. It is discredited."This is consistent with Kant's distinction between the *empirical* and *real* worlds; the distinction between the world of possible experience and the world of noumena. For Kant, a *noumenon* is an *object* of a *non-sensible intuition* by which "we presuppose a special mode of intuition, namely, the intellectual, which is not that which we possess, and of which we cannot

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[62] Sub-dimensional space refers to space that cannot be represented by a model no matter how many dimensions it occupies.

[63] Arthur S. Eddington, *Space, Time and Gravitation: An Outline of the General Relativity Theory*, p. 56.

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comprehend even the possibility." (*CpuR*, A 259/B 307) Despite this, we may continue to have, as Kant states, an "inextinguishable desire to find firm footing somewhere beyond the limits of experience" (*CPuR* , A 796/B 824)

5.9 CONCLUSIONS

5.9.1 In examining the development of non-Euclidean geometries; of the critique of absolute time and Euclidean space in relativity theory, and of the laws of causality in quantum mechanics, I am led to the conclusion that Kant's empirical reality coincides with our rest frame; a frame of reference within which we always experience maximum length and proper time. Our rest frame, our realm of possible experience, has three spatial dimensions and one time dimension which is continuously flowing, and in which Newtonian physics and Euclidean geometry apply. This proposition is in accord with the theory of Special Relativity since that theory discusses frames of reference in relative motion not what occurs within each frame of reference. While the theory of Special Relativity has meant that Galilean transformation[64] has to be abandoned, everyday experience is in agreement with the Galilean transformation which breaks down only at velocities that approach the speed of light. Niels Bohr's contention that, at least in the realm of quantum mechanics, objects exist in a certain way, as discrete actualities, because they are observed, is not that different from Kant's view that consciousness does not just condition knowledge and perception, it actually conditions external reality. If absolute reality exists independently as a sum of possibilities in accordance with the laws of quantum mechanics, then it is clear that we can never experience absolute reality, for we can never experience a probability directly—when tossing dice, for example, we experience the results of the tosses, not the probability of the results.

5.9.2 In attempting to understand the relationship between General Relativity and Quantum Mechanics we need to imagine a universe in which relative distances between particles are not

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[64] The Galilean transformation is used to transform between the coordinates of two reference frames which differ only by constant relative motion within the constructs of Newtonian physics. It gives the co-ordinates of the point as measured from the fixed frame in terms of its location in the moving reference frame. That is, $x' = x - vt$, $y' = y$, $z' = z$, $t' = t$, where x, y, z , and t refer to the fixed frame and x', y', z', and t' refer to the moving frame..

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restricted to three dimensions or non-sub-dimensional space. An observer viewing this universe can, however, only represent non-sub-dimensional space with a maximum of three dimensions. As a consequence, all dimensions above three collapse as described by the General Theory of Relativity and where sub-dimensional discrepancies exist, choices are made about the location of particles as described by Quantum Theory. Thus, although the observer has a restricted view of the universe, particles themselves need never be restricted to three-dimensional space and may also reside in sub-dimensional space. Since a human observer is unable to view the universe as it is in itself, his interpretation of the laws that govern this universe, as well as his representation of it, may well be distorted.

5.9.3 Craig Philpot has proposed in his article *The Relationship between the General Theory of Relativity and Quantum Theory: How they combine to form a Complete View of the Universe*[65], that particles maintaining their relative speeds may, as a result of the observer's mapping of the universe, be viewed as accelerating with respect to each other, thus causing the observer to conclude that he is witnessing an exception to the law of inertia, and thereby tempting him to develop a new law to explain it; but, by combining the General Theory of Relativity and Quantum Theory, an observer is able to map his distorted view back to the unrestricted universe and thus interpret the laws as they apply to the particles within the universe. Classic quantum mechanics presents a world existing apart from observation where matter and energy consist of waves that are deterministically governed by Schrödinger's Equation. These waves have physical reality based upon observable interference effects but, as Penrose argues, we should not try to ask what absolute reality is, but merely how it behaves, since it seems that "the more deeply we probe Nature's secrets, the more profoundly we are driven into Plato's world of mathematical ideals as we seek our understanding."[66] On this view, quantum particles cannot be objects of possible experience; and Quantum Mechanics

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[65] Craig Philpot, *The Relationship between the General Theory of Relativity and Quantum Theory: How they combine to form a Complete View of the Universe*, http://arxiv.org/abs/physics/0107050

[66] Penrose, *Op. Cit.*, pp. 1028-1029.

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seems to be somewhat consistent with Kant's notion of the relation between phenomenal, or empirical, reality in space and time and the world of things-in-themselves. As Heisenberg himself has stated: "Kant made the point that our experience has two sources: one source is the outer world (that is, the information received by the senses), and the other is the existence of concepts by which we can talk about these experiences. This idea is also borne out in quantum theory."[67] In his postulates of empirical thought, Kant distinguishes between the knowledge of a determined existence and the undetermined existence of things (between Dasein and Dasein der Dinge); the former being known only as an appearance of "the existence of effects from given causes in accordance with the laws of causality." (*CPuR*, A 227/B 279) Further, the act of observation, which collapses the wave function, can be viewed as conforming to the Kant's act of synthesis, "the act of putting different representations together, and of grasping what is manifold in them in one [act of] knowledge." (*CPuR*, A 77/B 103)

5.9.4 Alan Lightman remarks in his *A Sense of the Mysterious*, "[U]ltimately, we are forced to understand all scientific discoveries in terms of the items from daily life — spinning balls, waves in water, pendulums, weights on springs. We have no other choice. We cannot avoid forming mental pictures when we try to grasp the meaning of our equations, and how can we picture what we have not seen. As Einstein said in The Meaning of Relativity, 'the universe of ideas is just as little independent of the nature of our experiences as clothes are of the form of the human body.'"[68]

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[67] From an interview with Heisenberg, *Op. Cit.*

[68] Alan Lightman, *A Sense of the Mysterious*, N.Y.: Vantage Books, 2005, p.57-8. I am obliged to Dr. V. Zeman for this quotation.

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CHAPTER 6

6. EXPERIENCING A NEWTONIAN REALITY IN A NON-NEWTONIAN UNIVERSE

6.1 INTRODUCTION

6.2 A common metaphysical assumption in science is empirical consistency — there is an expectation that identical experimental systems should, statistically, always produce the same observations. In the "Newtonian" world, space and time were accepted as being absolute; all motion had a cause; nothing was uncertain (that is, the "world" was deterministic). As Werner Heisenberg stated in a lecture delivered at Vienna University in 1935, classical physics is based on a system of mathematically concise axioms and, therefore, the validity of classical physics appears to be absolute[69], but, this "absolutist" view of the world has been seriously undermined by developments in modern physics. This chapter will discuss whether the human cognitive function has evolved in such a way that visualisation, and hence experience, of a non-Euclidean space is impossible. For example, although Kant allowed that a space with more than three dimensions is a logical possibility, he held that "in anything representable through the imagination in spatial terms, the fourth [spatial dimension] is an impossibility."[70] Poincaré and Einstein would have agreed that we cannot experience more than three spatial dimensions. Why this appears to be the case bears examination: are our cognitive functions such that we are *incapable* of experiencing more than three spatial dimensions; could we learn how to have such experience; or, conversely, is it something about the nature of the real world itself that prevents us from having such experience?

6.3 In this chapter, I will argue that Kant's theories of the faculties of knowledge and the functions of reason are consistent with and even seem to have anticipated modern developments in evolutionary psychology and, in particular, the massively modular mind hypothesis which, I contend

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[69] Werner Heisenberg, *Philosophic Problems of Nuclear Science*, p. 41.

[70] *Kant's Inaugural Dissertation and Early Writings on Space*, §9, p. 10.

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supports the argument that we necessarily experience an empirical reality which has three spatial dimensions and one time dimension, and in which Newtonian mechanics and Euclidean geometry apply, regardless of whether or not absolute (or physical) reality has four, or more, dimensions.

6.4 WHAT IS KNOWLEDGE?

6.4.1 Analytic knowledge is, classically, "knowledge" that is true by analysis of language, by tautology: e.g., "a black cat is black." In this sense, analytic knowledge is a priori: prior to empirical observation, to sense perception. A priori knowledge is considered to mean propositional knowledge that can be had without, or "prior to", experience. For example, mathematics and logic are generally considered a priori disciplines, in which statements such as "1 + 2 = 3" are considered to be a result of reflection alone. But how are mathematical abstractions derived? Children learn arithmetic through reference to real situations: "add one apple to two apples" – that is, the foundation for learning mathematics is not abstract. An examination of natural languages would be useful to show if an abstract, unit-neutral, numbering system is a relatively late adaptation: English, for example, still retains some remnants of earlier, class-specific numbering systems in "pair of gloves", "brace of pheasants", et cetera; while Japanese today still uses different numbering systems for different classes of objects.

6.4.2 The history of mathematics is rife with examples of justified beliefs that turn out to be false – Frege's Basic Laws of Arithmetic[71] is a prime example. In addition, some propositions which appeared to be true based on reflection alone have been overturned by empirical evidence: for example, that "the shortest distance between to points is a straight line" appears to be justified by definition but has been shown to be untrue by advances in physics. Several studies on how students learn mathematics postulate that there are stages of development in mathematics and learners typically go through a procedural-orientated phase before they can effectively use conceptual

[71] Kornblith, Op. Cit., p. 124

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knowledge[72]. This is based upon Piaget's understanding of how procedural knowledge can be integrated or "assimilated" into one's conceptual schema, "the heart of the process involves assimilating the new material into appropriate knowledge networks or structures."[73]

6.4.3 Empirical investigation may be necessary to determine whether or not *a priori* knowledge actually exists. The Innate Knowledge thesis asserts that we have *a priori* knowledge, but, according to this thesis, intuition and deduction are not the source of such knowledge—*a priori* knowledge is part of our rational nature. Experience may trigger our awareness of this knowledge, but it does not provide us with it. When Kant refers to *a priori* knowledge, he is referring to "knowledge absolutely independent of all experience." (*CpuR*, B 3) When he refers to the conditions of possible experience, he is referring to *pure a priori* knowledge— which has "no admixture of anything empirical."[74] Pure *a priori* knowledge is necessary for experience whereas innate knowledge is not. If *a priori* knowledge does exist, it must be "hard-coded"; that is, it must have developed at some pre-linguistic or even pre-rational phase. A study of evolution of organisms and their environment may be the only way to determine what *a priori* knowledge is or even if it exists at all. The theory that the mind is modular and that some of these modules are Chomsky modules may prove to be a way of explaining how *a priori* knowledge could exist "hard-coded in the brain."

6.4.4 Conceptual knowledge, or "semantic memory", is the type of knowledge that allows one to recognise, understand, interact with, and talk about the objects of perception. But how is this information represented and stored in the brain? Procedural knowledge is the knowledge of rules, algorithms; the procedures of formal language or symbolic representations. Can procedures be learned by rote? Is it possible to have procedural knowledge about conceptual knowledge?

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[72] Davis, G., Gray, E., Simpson, A., Tall, D. and Thomas, M. (2000). "What is the object of the encapsulation of a process". *Journal of Mathematical Behavior* 18(2),223-241.

[73] Hiebert, J. Lefevre, P."Conceptual and Procedural Knowledge in Mathematics: An Introductory Analysis", ed. Hiebert,J. *Conceptual and Procedural Knowledge: The Case of Mathematics*. Hillsdale, NJ: Erlbaum, 1987

[74] Kant provides the example of the proposition "every alteration has its cause" which, "while an *a priori* proposition, is not a pure proposition, because alteration is a concept which can only be derived from experience." (*CpuR*, B 3)

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6.4.5 During his analysis of synthetic knowledge, Kant believed that consistency alone is insufficient for linking together concepts in a synthetic judgment; he believed that there must be something else, a tertium quid which one uses to synthesize the separate concepts in a synthetic judgment. When considering empirical synthetic judgment, Kant was satisfied with the answer that sense experience constitutes the tertium quid. Kant had philosophical problems when it came to synthetic a priori judgments, however. If knowledge that is both a priori and synthetic (mathematics, according to his example), such knowledge would have to be justified by some other tertium quid. In my opinion, that knowledge is a set of natural kinds housed in a massively modular mind presents a fruitful direction for solving Kant's problem; indeed this theory seems best equipped to answer what each kind of knowledge is, whether *a priori*, *a posteriori*, analytic, synthetic, or combinations thereof.

6.5 THE THEORY OF THE MASSIVELY MODULAR MIND

6.5.1 The theory that the mind is massively modular follows from developments in evolutionary psychology. Leda Cosmides and John Tooby have presented the following as the five basic principles of evolutionary psychology:

- Principle 1. The brain is a physical system. It functions as a computer[75]. Its circuits are designed to generate behaviour that is appropriate to your environmental circumstances;
- Principle 2. Our neural circuits were designed by natural selection to solve problems that our ancestors faced during our species' evolutionary history;
- Principle 3. Consciousness is just the tip of the iceberg: most of what goes on in your mind is hidden from you. As a result, your conscious experience can mislead you into thinking that our circuitry is simpler than it really is. Most problems that you experience as easy to solve are very difficult to solve – they require very complicated neural circuitry;
- Principle 4. Different neural circuits are specialized for solving different adaptive problems;
- Principle 5. Our modern skulls house a stone age mind.[76]

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[75] As Murray Clarke has pointed out, the brain functions more like a network of hundreds, even thousands of computers.

[76] Leda Cosmides and John Tooby, *Evolutionary Psychology: A Primer*, Center for Evolutionary Psychology, University of California, Santa Barbara, © 1997

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6.5.2 The findings resulting from experiments conducted by evolutionary psychologists led many to support the idea that the mind is modular. According to preparedness theory, humans and other animals have certain innate predispositions that cause them to acquire, for example, fear responses to certain classes of stimuli more readily then others and from the strict behaviourist viewpoint, all stimuli have equal potentiality for becoming phobic stimuli. In other words, there is a non-random distribution of fears and phobias due to the mediating effect of selective associations. For example, according to experiments performed by Michael Cook and Susan Mineka[77], monkeys appear selectively to associate snakes with fear. Further experiments with human subjects showed that they were more likely to form associations between electrical shocks and images of snakes than between electrical shocks and images of frayed electrical cords and damaged electrical outlets thereby suggesting a phylogenetic origin for this fallacious association. Further studies by Mineka and Arne Öhman[78] describe what they propose to be evidence for an evolved module for fear elicitation and fear learning. According to their study, this evolved module is "preferentially activated by stimuli related to survival threats in evolutionary history. Thus, fear-relevant stimuli lead to superior conditioning of aversive associations compared with fear-irrelevant stimuli. Second, the module is automatically activated by fear-relevant stimuli, meaning that fear activation occurs before conscious cognitive analysis of the stimulus can occur. Third, the fear module is relatively impenetrable to conscious cognitive control, and fear conditioning with fear-relevant stimuli can occur even with subliminal conditioned stimuli. Fourth, the amygdala seems to be the central brain area dedicated to the fear module. Finally, we propose that there are two levels of fear conditioning, with an emotional level that is relatively independent of the cognitive contingency level, each mediated by different brain areas."

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[77] Michael Cook and Susan Mineka. "Selective Association in the Observational Conditioning of Fear in Rhesus Monkeys" printed in the *Journal of Experimental Psychology: Animal Behaviour Processes*, 1990, Vol. 16, No. 4, 372-389.

[78] Susan Mineka and Arne Öhman, "Learning and Unlearning Fears: Preparedness, Neural Pathways, and Patients", Biol Psychiatry 2002;52:927–937 © 2002 Society of Biological Psychiatry

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6.5.3 In 1994, L. Cosmides and J. Tooby argued that selection pressures to solve adaptive problems that humans faced in the Pleistocene era can be expected to produce highly specialized cognitive mechanisms since different adaptive problems often require different solutions and "different solutions can, in most cases, be implemented only by different, functionally distinct mechanisms. Speed, reliability and efficiency can be engineered into specialized mechanisms because there is no need to engineer a compromise between different task demands."[79]

6.5.4 In order to test their theory that the mind is massively modular, Cosmides and Tooby, et al., embarked on a series of experiments using empirical methodologies most of which had been developed earlier to study human reasoning. Among these, were the Wason Selection Task[80] developed by Peter Wason in 1966 to determine if humans use scientific-hypothetico-deductive reasoning[81] to solve everyday problems; and base-rate neglect and conjunction fallacy tests both developed by A. Tversky and D. Kahnemann (1973 and 1982). The results of these tests demonstrate that humans have mental mechanism that are successful at Bayesian reasoning but also that the way these problems are presented plays a role in activating these mechanisms.

6.6 MIND MODULES AS MICROCOMPUTERS

6.6.1 Supporters of evolutionary psychology and /or the massively modular reasoning and processor model of cognition (MMRP), consistently use computer hardware analogies for the mind but these seem to be more appropriate for describing the brain. Describing mind modules as microcomputers seems to presuppose a direct link between the mind and the brain – that is, that there

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[79] L. Cosmides and J. Tooby, "Origins of Domain Specificity: The Evolution of Functional Organization", in *Mapping the Mind*, (L. Hirschfeld and S. Gelman, eds.), p. 89

[80] In the Wason Selection Task, a subject has to see whether a conditional hypothesis in the form of "if p then q" has been violated by one of four instances represented by cards. L. Cosmides and J. Tooby, "Cognitive adaptations for social exchange", from *The Adapted Mind* edited by J. Barkow, L. Cosmides, and J. Toobey, copyright 1992 by Oxford University Press.

[81] When applied to science, hypothetico-deductive logic is based on the idea, as developed by Karl Popper, that in order for an hypothesis to be truly scientific, it has to be falsifiable. Hypothetico-deductive reasoning involves extracting hypotheses from theory and creating a test environment in which the hypotheses are either confirmed or rejected with a result that either confirms or contradicts the theory

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is a direct mapping between modules and areas or physical circuits in the brain. While this may well prove to be the case, it has yet to be proved empirically. Some work has, however, already begun in this area. For example, according to studies by Mineka and Öhman[82], the amygdala seems to be the central brain area dedicated to the fear module.

6.6.2 Perhaps software and firmware analogies would be more appropriate: rather than microcomputers especially as the latter analogy seems suited to the idea of modules as domain-general processors rather than as the domain-specific[83] processors or Darwinian/Chomsky modules of which the Massively Modular Mind is mostly composed, at least according to many commentators such as Cosmides and Tooby, Fodor, Samuels, and Clarke. A domain-specific device only processes inputs belonging to some specific empirical domain. The input conditions of such a device may not, however, perfectly select all and only items in this domain, resulting in a degree of mismatch between its proper and its actual domain. Dan Sperber[84] gives the example of a face recognition device which functions to process faces even though its operation may also be triggered by merely face-like stimuli, such as masks. In computing, firmware is software that is embedded in a hardware device, that allows reading and executing the software, but does not allow modification, e.g., writing or deleting data by an end user. The Chomsky module, for example, has many characteristics of firmware. The Fodor-Chomsky model, which is defined as a complete, inviolate language module in the brain, one that performs all and only the functions of language without external influence, has many of the characteristics of firmware.

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[82] Mineka and Öhman, Op. Cit.

[83] "To say that a cognitive structure is domain-specific means (roughly) that it is dedicated to solving a restricted class of problems in a restricted domain. For instance, the claim that there is a domain-specific cognitive structure for vision implies that there are mental structures which are brought into play in the domain of visual processing and are not recruited in dealing with other cognitive tasks. By contrast, a cognitive structure that is domain-general is one that can be brought into play in a wide range of different domains." from "Massively Modular Minds: Evolutionary Psychology and Cognitive Architecture" from *Evolution and the Human Mind*, P. Carruthers & A. Chamberlain (eds.), Cambridge University Press.

[84] Dan Sperber, "Modularity and relevance: How can a massively modular mind be flexible and context-sensitive?", to appear in *The Innate Mind: Structure and Content*, edited by Peter Carruthers, Stephen Laurence, & Stephen Stich.

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6.6.3 It is necessary to emphasise that the sense data which is presented to a brain module is not a faithful rendering of the real world; rather, the modules construct a model from the data — a model which is continually being updated. This continual updating of the model is clearly demonstrated by certain optical illusions in which the sense data is compatible with more than one model: examples of illusions caused by multi-stable perception, evoked when the visual system is unable to determine a unique interpretation from a large number of ambiguous visual patterns, are the Necker Cube[85] and the Penrose Triangle[86]. The brain constructs a model from the sense data and, in the case of multi-stable perception, may flip back and forth between alternative models. Model construction when pertinent information is excluded can give rise to other types of illusion.

6.6.4 Further to the computer analogy, a cognitive module has its own "software" procedures and may also have a "data-base" of its own as well as receiving inputs from sources external to the module. Sperber's example of a face recognition module referred to above applies since such a module has both data about the faces which it is capable of recognising and also procedures dedicated to matching perceptual inputs to the data. Fodor[87] calls the fact that a particular module may only be able to draw on a limited data-base, if any, to process its inputs, "informational encapsulation". Now, human cognition as a whole exhibits context-sensitivity, but informationally-encapsulated devices have access to limited information and thereby exclude some information that

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[85] From Wikipedia: "The Necker cube is an optical illusion first published in 1832 by Swiss crystallographer Louis Albert Necker. The Necker cube is an ambiguous line drawing. It is a wire-frame drawing of a cube in isometric perspective, which means that parallel edges of the cube are drawn as parallel lines in the picture. When two lines cross, the picture does not show which is in front and which is behind. This makes the picture ambiguous; it can be interpreted two different ways. When a person stares at the picture, it will often seem to flip back and forth between the two valid interpretations (so-called multistable perception)."

[86] From Wikipedia: "The Penrose triangle, also known as the tribar is an impossible object. It was first created by the Swedish artist Oscar Reutersvärd in 1934. The mathematician Roger Penrose independently devised and popularised it in the 1950s, describing it as "impossibility in its purest form". The tribar appears to be a solid object, made of three straight beams of square cross-section which meet pairwise at right angles at the vertices of the triangle they form. This combination of properties cannot be realized by any 3-dimensional object. Nevertheless, there do exist 3-dimensional solid shapes each of which, when viewed from a certain angle, has the appearance of possessing all the qualities mentioned in the above paragraph. That is, it appears the same as the pink, green, and yellow 2-dimensional depiction of the Penrose triangle on this page."

[87] Jerry Fodor, *The modularity of mind*, Cambridge , MA.: MIT Press, 1983; and *The Mind Doesn't Work That Way.* Cambridge , MA., MIT Press, 2001

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might, in principle, be pertinent to its producing the right outputs. According to Sperber, perceptual illusions are paradigm examples of this: "I (that is, a whole person) have the information that the two lines in the Müller-Lyer illusion are equal (say, I have measured them), but my visual perceptual device has no access to this information and keeps "seeing" them as unequal."[88] Cognitive reflexes are extreme cases of encapsulation for, if they are provided with relevant input, they immediately deliver their characteristic output, whatever might be appropriate in the given context.

6.6.5 While, according to many supporters[89] of the Massively Modular Mind Hypothesis, the mind is mostly composed of domain-specific modules, it may also contain some domain-general devices. Sperber suggests that working memory might be just such a device: one that "processes inputs whatever their contents, and manages their level of activation for the benefit of other, inferential devices." Sperber goes on to say that he is unable to find a plausible example of a non-encapsulated mental device, "that is, of a device that would use the whole mental encyclopaedia as its database."[90]

6.6.6 Peter Carruthers in his article "Practical reasoning in a modular mind"[91] proposes that while the existence and many of the characteristics of mental modules can be explained by biological evolution, modules are not necessarily simply phenotypic expressions of genes, nor is the development of each and every module necessarily strongly canalised. On the contrary, according to Carruthers, it would be in the nature of modules to differ vastly from one another in many respects. "Pre-wiring" may be appropriate for some of the problems that cognitive modules deal with; while, for other problems, an effective modular solution may involve adding data to the proprietary database

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[88] Sperber, *Op. Cit.*

[89] Cosmides and Tooby, Fodor, Samuels, and Clarke, for example.

[90] Sperber, *Ibid*, Note 3: Sperber points to Fodor's suggestion that *Modus Ponens* inference, that is, an inference that takes as input any pair of beliefs of the form {P, [If P then Q]} and produces as output the belief that Q, is an example of non-encapsulation and, so Fodor argues, applies to pairs of premises in virtue of their logical form and is otherwise indifferent to their informational content. "An organism with a Modus Ponens device can use it across the board.". This is not, however, widely accepted.

[91] Peter Carruthers, *Practical reasoning in a modular mind*, http://www.philosophy.umd.edu/Faculty/pcarruthers/Practical-reason.htm

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of an otherwise predetermined module. In other cases still, the development of a module may involve drawing on information picked up from the environment not just to enrich the database but also to shape procedures. Varieties of modules range from innately specified modules to brain tissues that are merely ready to modularise competencies of a specific type.

6.7 KANT AND THE MASSIVELY MODULAR MIND THEORY

6.7.1 In the section entitled "The function of reason" in his *Groundwork of the Metaphysic of Morals*, Kant states that "[I]n the natural constitution of an organic being—that is, of one contrived for the purpose of life—let us take it as a principle that in it no organ is to be found for any end unless it is also the most appropriate to that end and the best fitted for it." (*GMM* , 395) This is a statement with which evolutionary psychologists should have no problem agreeing, even though they may not accept Kant's teleological view. Kant goes on to argue that, if the real purpose of nature is man's "preservation", then man is unlikely to have been endowed with reason to meet that purpose; for any simple act of self-preservation that man performs, he would be far better served by instinct than by reason. Further, Kant held that, rather than having an instrumental function, reason is used *a priori* and is not linked to the conditions of possible experience; "its true function must be to produce a will which is good, not as a means to some further end, but in itself." (*GMM* , 396) Kant's position is reminiscent of the version of the massively modular mind hypothesis[92] supported by Cosmides and Tooby that content specific mechanisms "will be far more efficient than general-purpose mechanisms", and that content-independent systems "could not evolve, could not manage their own reproduction, and would be grossly inefficient and easily out-competed if they did."[93]

6.7.2 The Massively Modular Mind Hypothesis is also consistent with Kant's contention that space and time are *a priori* intuitions in so far as the hypothesis holds that we have developed

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[92] The massive modularity hypothesis holds that the human mind is largely, or perhaps even entirely, composed of highly specialized cognitive systems or *modules* which are, according to evolutionary psychologists, mental structures that can be invoked in order to explain various cognitive capacities. (Carruthers, *Op. Cit.*)

[93] Cosmides and Tooby, "Cognitive Adaptations for Social Exchange" in *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*, III-H.

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modules for dealing with space and time and that we construct our models of the world using these, as well as other modules. Support for this view is found especially among English neo-Kantians such as John Campbell who, in his book *Past, Space, and Self*, presents an *a priori* account of conceptions of space and time.

6.8 Empirical Reality and the Theory of Modular Mind

6.8.1 Kant's view of space is that it is an *a priori* intuition: it is *a priori* in that it is not derivable from particular sensations and is presupposed in all our experiences; and it is an intuition in that it is not derivable from formal logic and is not derivable by abstraction from particular experiences. In his discussion of space and geometry[94], Poincaré differentiated between geometric space and perceptual space. First, he points out that images of external objects are often said to be localised in space, and even that they cannot be formed except on this condition. This space, which thus acts as a frame prepared in advance for our sensations and representations, is identical with that of the geometricians and that it possesses all the same properties. Poincaré lists some of the most essential characteristics of geometric space: it is continuous; it is infinite; it has three dimensions; it is homogeneous, that is to say that all its points are identical to one another; it is isotropic, that is to say that all the straight lines passing through a given point are identical to one another. Perceptual space (visual, tactile, and motor) differs from geometric space in being neither homogenous nor isotropic, nor can it be even said to have three dimensions. We do not, so Poincaré continues, represent to ourselves external bodies in geometric space, but we reason on these bodies as if they were situated in geometric space. In a supplement to his chapter on experience and geometry[95], Poincaré poses the question: "When we say space has three dimension, what do we mean?" His answer is that we simply mean that "the totality of the class of changes, or, better, the corresponding class of muscular sensations appears to us with the characteristics of a physical continuum of three dimensions". Poincaré states that our experiences have bearing, not on space but, rather, on our

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[94] Henri Poincaré, *The Foundations of Science*, pp.66-80

[95] *Ibid.*, 89-91.

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body and its relations with the neighbouring objects. Further, our mind has adapted itself to the conditions of the external world through natural selection and it has adopted the geometry most advantageous (or most convenient) to the species. Poincaré concludes that "geometry is not true, it is advantageous."[96]

6.8.2 Clearly, Kant would disagree with Poincaré's last point since Kant held geometry was both synthetic and *a priori*, but, I contend, Poincaré's ideas on space and our experience of it are not inconsistent with those of Kant. Bearing this in mind, we find that one of Sperber's examples to be very relevant: "human infants (and other baby animals also) perceive and avoid vertical drops in terrain, even if they have had no experience of falling before ... This is an obvious modular adaptation to a serious hazard facing animals moving on the ground. To be efficient, this particular module had better not depend on learning. It is as good an example of an innate cognitive module as one may ever hope to find."[97] This is not to say, however, that we naturally *understand* Euclidean geometry and Newton's laws. There are differences between types of modules - those that don't require prior experience to function correctly, such as the avoidance of vertical drops, and others that require experience such as language modules - which will not develop properly without language input at an early age. Even if we have to learn Newton's laws and the axioms of Euclidean geometry in order to apply them explicitly, we use them on a daily basis without being conscious of the fact. Whenever we cross the road safely, or drive a car, we are applying Newton's Laws of Motion and making decisions based on analyses of velocities, distance, et cetera, without ever necessarily being aware of it.

6.8.3 In the chapter entitled "The Mind Almost Works That Way"[98], Clarke discusses the study by Hermer and Spelke on spatial reorientation the result of which suggests that both adult rats

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[96] Poincaré, *Op. Cit.*, p. 91.

[97] Sperber, *Op. Cit.*

[98] Murray Clarke, *Reconstructing Reason and Representation*, pp. 19-42.

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and young children spatially orient themselves by appeal to an innate, informationally-encapsulated, task specific, modular, computational mechanism. This mechanism, according to the authors of the study, appeals to the geometric properties of the environment— a room in this case. The adult rats and children appear to reorient themselves using properties such as length of a wall and angles. By contrast, adult humans reorient themselves by additionally using non-geometric properties, such as wall colour or pattern, or the categorical identity of an object. The authors conclude by suggesting that "there is a core cognitive process for representing the shape of the surrounding environment, and for using this representation to compute one's own position within the environment ... the system of geometric knowledge may have emerged early in mammalian evolution, and its central features appear to be found in other mammals."[99] Clarke comments that this study is an example "not just of abduction, but of natural kind geometric knowledge concerning spatial reorientation" and that the authors of the study "suggest that common cognitive processes are to be expected across species especially when they are compared at early point in ontogeny."[100] Clarke continues: "what is important to note here is that we possess geometric knowledge in the sense that we innately know that the correct way to spatially reorient ourselves is to appeal to the shape of the environment in which we find ourselves when reorienting. Moreover, we innately know that we should appeal to nongeometric knowledge of the environment when appeals to geometric factors are insufficient to produce correct results concerning where hidden objects in a room might be." Clarke concludes by stating that "spatial reorientation depends on an MMRP [the Massively Modular Representation and Processor Model of Cognition] module that utilizes a domain-specific, task-specific body of knowledge in conjunction with a domain-specific, task-specific computational mechanism."[101]

6.8.4 According to evolutionary psychology, we have to develop mental faculties in order to have perceptions and, hence, experience; further, these faculties determine the form of our

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[99] Quoted in Clarke, *Op. Cit.*, p. 39.

[100] *Ibid*, p. 147.

[101] *Ibid*, p. 148.

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perceptions and experience; and the form precedes experience. This is in agreement with Kant's position that experience is synthetic, a product of the senses and understanding. This synthesis, "even that which renders perception possible, is subject to the categories; and since experience is knowledge by means of connected perceptions, the categories are conditions of the possibility of experience, and are therefore valid *a priori* for all objects of experience." *(CPuR*, B 161) The form of experience, according to the evolutionary psychologists is determined by modules in the mind which evolved in adaptation to our environment, while, for Kant, it is derived from *a priori* sensible intuitions. In neither case is there any presupposition that our objects of experience correspond to things-as they-are-in-themselves. Hence evolutionary psychologists would appear to agree with Kant that our mental faculties determine the content of our experience.

6.9 SPACE AND TIME

6.9.1 Evolutionary psychologists would agree with Kant that we do not perceive *space*, and that, while we perceive objects as being in certain spatial relationships one with another and, most importantly, with ourselves, these relationships are not part of the content of sensual experience. For both such psychologists and Kant, relationships between objects of perception are derived from a synthesis of sense impressions and, whether we prefer to state that the form of the perceived spatial relations, or *space*, is determined by modules in the mind or, agree with Kant's terminology, that the representation of space is an *a priori* form of outer sensible intuition, we still perceive objects as being in a three-dimensional space. Without the intuition of space and a synthesis of sense impressions, we would not be able to determine our frame of reference, or even have a unique frame of reference, because our perceived spatial relations could derive more than one of the five senses simultaneously. Moreover, visual sensations are subject to *saccades*, rapid eye movements between fixation points, and thus the perception of a fixed frame of reference requires that these rapid and jerky visual sense impressions be organised. An intuition of space therefore must be *a priori* and must be necessary for knowledge of objects of experience as Kant concludes.

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6.9.2 In the *Principia*, Newton defined "absolute time" as time that "without reference to anything external, flows uniformly"[102] and that "all things are placed in time with reference to order of succession."[103] The Newtonian structure of time is such that it flows equably and that equal intervals of time are objectively defined. The ideal Newtonian clock is, thus, an inertial clock — one that keeps proper time in an inertial frame. Kant's view that time is not objective and real could be taken as an attack on Newton's position but this is not really the case if one considers that time, for Kant, is a subjective condition, "a necessary representation that underlies all intuitions" that is given *a priori* (*CPuR*, A 31/B 46) whereas Newton' definition refers to time as measured by an ideal clock. Kant states that only "on the presupposition of time can we represent to ourselves a number of things as existing at one and the same time (simultaneously) or at different times (successively)." (*CPuR*, A 30/B 46) Advances in physics have rendered discussions of simultaneity (and succession) problematic — in the four-dimensional world, simultaneity is relative whereas in the three-dimensional world, simultaneity is absolute. There is no contradiction of Kant's (or Newton's) position, however, since, as even proponents of four-dimensional spacetime agree, our experience is limited to a three-dimensional cross-section of spacetime and absolute simultaneity holds for events restricted to this cross-section.

6.9.2.1 We experience acceleration as a detectable change in velocity in a three-dimensional space, not as a curved line in spacetime. It is likely that we evolved modules thus because the greatest acceleration that we could experience in the environment of evolutionary adaptation, consistently enough to affect evolution, was acceleration due to gravity which produces a radius of curvature in spacetime which is so large relative to human dimensions as to be undetectable without the use of advanced technology. Was there any evolutionary advantage for humans to be able to experience curves in spacetime? Apparently not. Any more than there was an evolutionary advantage for humans to be able to hear infra-sound or see ultraviolet waves.

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[102] Newton, *Op. Cit.*, p. 408

[103] *Ibid*, p. 410

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6.9.2.2 Given that there seemed to be some evolutionary advantage in experiencing acceleration as a detectable change in velocity in a three-dimensional space or, at least, no evolutionary advantage to being able to experience acceleration as a curve in spacetime, then the evolution of how we experience time is thereby determined. That is, we experience time as absolute and uni-directional — we evolved in such a way as to experience proper time, or time in an inertial frame.

6.10 CONCLUSIONS

6.10.1 We have no unmediated access to noumena reality. Evolutionary psychology supports Kant's contention that intuitions of space and time are necessary conditions of possible experience. Kant's realm of possible experience, and hence knowledge, is limited to *empirical* reality. In the Minkowski four-dimensional world, our "world" is a three-dimensional cross-section of spacetime and this cross-section corresponds with empirical reality, with the realm of possible experience. Newtonian physics is highly successful at describing mathematically this cross-section and, therefore, at describing mathematically Kant's empirical reality. Modern physics, on the other hand, attempts to describe, or at least mathematically, what the real world would have to be like to account for experimental results.

6.10.2 C. I. Lewis, in *Mind and the World Order*, observes that the "datum of our philosophic study is not the 'buzzing, blooming confusion' on which the infant first opens his eyes, not the thin experience of immediate sensation, but the thick experience of every-day life. This experience of reality exists only because the mind of man takes attitudes and makes interpretations. The buzzing, blooming confusion could not become reality for an oyster. A purely passive consciousness, if such can be conceived, would find no use for the concept of reality, because it would find none for the idea of the unreal; because it would take no attitude that could be balked, and make no interpretation which conceivably could be mistaken." Coping with what Douglas Adams, in his *Hitchhiker's Guide to the Galaxy*, has called the "Whole General Mishmash", that constitutes absolute reality, has

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required us to develop survival mechanisms. Our cognitive functions have evolved such that we only experience only the three-dimensional cross-section of spacetime. No matter how our technology advances, our realm of possible experience is restricted to empirical reality; technology cannot provide us with unmediated experience of the world as it is in itself.

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CHAPTER 7

7. SUMMARY

7.1.1 Kant's necessary conditions of possible experience do not presuppose the necessary validity of Euclidean geometry and Newtonian physics. Even though space and time may have the concept of necessity in their representation, this is not, according to Kant, the necessity of a concept. The necessity of time and space is "only a necessary condition of the subject for all perceptions of the senses". Kant asserts the empirical reality of space "(with respect to all possible outer experience), though to be sure at the same time we assert its transcendental ideality, i.e., that it is nothing as soon as we leave out the condition of the possibility of all experience, and take it as something that grounds the things in themselves." (*CPuR*, A 28/B 44) Just as Newton sought the mathematical laws that govern physical forces and did not attempt to describe the underlying causes of such forces, Kant sought the laws that govern the experience of empirical objects; he did not seek to describe the underlying causes of such objects.

7.1.1.1 Kant treats the principles of Euclidean geometry and Newtonian physics as transcendental principles which, for Kant, are the necessary conditions of the possibility of both science and ordinary experience. I agree with Leonard Nelson[104], that, far from denying the possibility of non-Euclidean geometry, Kant's theory is, rather, a prediction of it. It must be remembered that Kant claims that the axioms of geometry are synthetic and the existence of non-Euclidean geometry does not contradict this view. Just as our visual apparatus is such that it limits our vision to the visible spectrum (or, as it is sometimes called, the optical spectrum) portion of the electromagnetic spectrum and our aural apparatus limits our hearing to the frequencies between 20 and 20,000 hertz; our visual imagination is such that we are unable to visualize non-Euclidean spaces or any spaces with more than three dimensions. We are also limited to visualising a positively curved surface only if it is

[104] Leonard Nelson, "Philosophy and Axiomatics,", *Socratic Method and Critical Philosophy*,; p.164

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embedded in a Euclidean volume with an explicit extrinsic curvature. Hans Reichenbach discusses, in his *The Philosophy of Space and Time*, the possibility, occasionally maintained by mathematicians who have worked a great deal with non-Euclidean geometry, that they can gradually visualise it. He concludes that "[I]n the behavior of rigid bodies and light rays, nature has presented us with a type of manifold which approximates Euclidean laws so closely that the visualization of Euclidean space was exclusively cultivated. There can be no serious doubt that we are here concerned with the developmental adaptation to the environment, and that a corresponding development would have led to non-Euclidean visualization, had the human race been transplanted into a non-Euclidean environment." He continues that the "visual preference for Euclidean space therefore cannot depend on its special suitability for the visualization of natural objects, but rather on an *inherent property* that has no connection with the outside world."[105]

7.1.1.2 While attempts have been made to use computers to model non-Euclidean or multi-dimensional spaces, these models are still projected onto two-dimensional screens and even if, in the future, advances in technology could make it possible to project these models onto three-dimensional holograms, for example, our visual imagination would still be confined to three Euclidean spatial dimensions. Thus, although Kant could state that the axioms of Euclid could be denied without contradiction, our intuition is nevertheless limited by the form of space which we impose on the world.

7.1.1.3 Advances in physics and technology have vastly expanded our understanding of reality but this does not go hand-in-hand with an expansion of the realm of possible experience. In fact quantum mechanics, as it is currently formulated, supports the view that we can never form a true picture of the world-as-it-is-in-itself because of the actual role that measurement and observation play in the theory's description of fundamental reality — because of the role the observer plays, quantum theory cannot provide a picture of reality that is absolutely independent of the observer.

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[105] Hans Reichenbach, *The Philosophy of Space and Time*, pp. 82-83

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7.1.1.4 Newtonian physics and Euclidean geometry help us understand and describe empirical reality — the world of possible experience — and have proven to be extremely successful in so doing. When constructing buildings or bridges, when sending a man to the moon, we continue to use Newtonian mechanics because these activities are restricted to the medium-sized objects, distances, and velocities of our empirical reality. As long as the reality described by Newtonian physics and Euclidean geometry is not taken to be *absolute* reality, then empirical reality, the world of possible experience, is not undermined by non-Euclidean Geometry, the theories of Relativity and Quantum Mechanics, nor any other advances in mathematics and physics.

7.1.1.5 The external world of possible direct human experience has four dimensions (three spatial and one temporal) and contains medium sized objects, medium length distances, and medium velocities — in other words, the human cognitive faculties have evolved in such a way as to render the infinitesimally small objects and distances of Quantum Mechanics and the extremely large objects, distances, and velocities of General Relativity outside their frame of reference.

7.1.1.6 Kant did not contend that Euclidean geometry and Newtonian physics had absolute validity, but limited their applicability to nature "*so far as it can be perceived by our senses* (*ID*, 144). Newtonian physics is not only a useful way of describing and coping with empirical reality, but is a reflection of the way the human cognitive capacity synthesises the manifold of representations — that is, humans, and perhaps most other beings, synthesise a Newtonian reality. Non-Euclidean geometries and the theories of relativity and quantum mechanics cannot be used therefore to undermine Kant's necessary conditions of possible experience. Our experiential frame of reference conforms to Newtonian principles because these "concepts of reason are not derived from nature; on the contrary, we interrogate nature in accordance with these ideas, and consider our knowledge as defective so long as it is not adequate to them." *(CPuR*, A 645/B 673)

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