

## ARTICLE

# KANT AND THE CONVENTIONALITY OF SIMULTANEITY

Adrian Bardon

In his Third Analogy of Experience, Kant argues that a universal system of mutual causal interaction-at-a-distance is presupposed in the very construction of experience, and thereby also can be assumed to hold of objects of experience qua appearances. This implies in turn a notion of objective simultaneity. I discuss whether Kant's project is rendered wholly obsolete by the relativity and conventionality of simultaneity as it is now understood under the theory of relativity. I conclude that, while major parts of his project are indeed obsolete, there may still be useful insights into time-awareness to be gleaned from his work.

Kant's three Analogies of Experience, in his *Critique of Pure Reason*, represent a highly condensed attempt to establish the metaphysical foundations of Newtonian physics. His larger intention is to show that universal mathematical laws of nature are possible in the face of Hume's concerns regarding law-like claims about nature; more specifically, Kant seeks to establish the applicability of the Newtonian spatio-temporal framework to experience, given that it is not itself an object of experience. His strategy is to show that the organization of experience in terms of a world of enduring substances undergoing mutual causal interaction is a necessary condition of the temporal ordering even of one's own subjective states, and thus of coherent experience itself. According to this view, it is because all experience is subject to this condition that it is possible to make universally valid claims about causality in nature – such as Newton's laws of dynamics. The laws of dynamics, in turn, define the spatio-temporal framework of Newtonian physics.<sup>1</sup> In this paper, I discuss Kant's efforts in this area in light of contemporary relativity theory, particularly with regard to the conventionality of simultaneity. I suggest that, while his project is

<sup>1</sup>See Friedman, *Kant and the Exact Sciences*, 143.

obsolete in major respects, there may still be useful insights into time-awareness to be drawn from his work.

The Third Analogy is central to Kant's project. In it he addresses the necessary conditions of judgements about objective simultaneity:

Now if you assume that in a manifold of substances as appearances each of them would be completely isolated, i.e., none would affect any other nor receive a reciprocal influence from it, then I say that their *simultaneity* would not be the object of a possible perception, and that the existence of the one could not lead to the existence of the other by any path of empirical synthesis. For if you thought that they were separated by a completely empty space, then the perception that proceeds from one to the other in time would certainly determine the existence of the latter by means of a succeeding perception, but would not be able to distinguish whether that appearance objectively follows the former or is rather simultaneous with it. In addition to the mere existence there must therefore be something through which *A* determines the position of *B* in time, and conversely also something by which *B* does the same for *A*, since only under this condition can those substances be empirically represented as *existing simultaneously*. Now only that determines the position of another in time which is the cause of it or its determinations. Thus each substance . . . must simultaneously contain the causality of certain determinations in the other and the effects of the causality of the other, i.e., they must stand in dynamical community (immediately or mediately) if their simultaneity is to be cognized in any possible experience. But now everything in regard to objects of experience is necessary without which the experience of the objects itself would be impossible. Thus it is necessary for all substances in appearance, insofar as they are simultaneous, to stand in thoroughgoing community of interaction with each other.<sup>2</sup>

To understand this argument, it is helpful to think first in terms of its epistemological implications – i.e. what it implies about the conditions that must be met for judgements of simultaneous existence to be justified. Since all experience is successive, and absolute time is not an object of perception, the concurrent existence of objects of experience not experienced simultaneously is not self-evident. Thus, given a series of experiences A1–B1–A2 of two objects A and B, knowledge of the coexistence of A and B is dependent on knowledge of a relationship between A and B such that the state of A at a given time is connected with the state of B at that time. This means that knowledge of the coexistence of two items not simultaneously perceived depends on evidence of a connection between those items such that the existence or state of one item is dependent on the existence or state of the other.<sup>3</sup>

<sup>2</sup>Kant, *Critique of Pure Reason*, translated by Guyer and Wood, 318.

<sup>3</sup>For an exposition of Kant along these lines, see Guyer, *Kant and the Claims of Knowledge*, 267–76.

However, the real claim Kant is making about the necessary conditions of judgements of simultaneous existence is more fundamental: namely, a claim about the necessary conditions of the very thought of a determinate subjective ordering of experiences. Any current, complex mental state can represent a set of perceptions in any sequence. Because absolute time is not an object of perception, the relation between the objects of our perceptions and time is not itself given in experience. Neither does the content of any sequence of perceptions itself dictate a unique temporal interpretation. Because the time-order of one's experiences is not self-intimating, in order to make sense of the multiplicity of experience, one must think of one's perceptions as having an order determined by external events with a fixed order unto themselves. This does not mean, for Kant, the conscious application of a conceptual scheme to experience already known as such. For him, experience is itself both sensitive and cognitive in nature, in that coherent experience involves the bringing of sensory experience under concepts. The concept of an external world functions, he argues, as the *a priori* structure of experience itself by making possible a determinate ordering of one's sensitive experiences and reflections. Conceptualization of experience as experience of a world of causally related events and enduring substances undergoing alteration gives one a schema for interpretation of the time-order of one's perceptions. A mere succession of unrelated perceptions and an extended experience of an event are distinguished by the latter sequence being thought of as irreversible, such that the same perceptions in a different order would represent something different. The representation of some set of one's perceptions as having this irreversible characteristic is thus, in part, *constitutive* of the thought of an event. In this way, the very distinction between an objective order of things and events and the mere subjective flow of experience – necessary to thinking of the order of one's own experiences as having a determinate order – involves the application of the concepts of substance and cause. Thus Kant's claim in the First and Second Analogies that combination of perceptions according to the concepts of, respectively, substance and cause is constitutive of coherent experience.

To this Kant adds, in the Third Analogy, that the concept of 'dynamical community', or thoroughgoing mutual causal interaction, is similarly necessary to experience as we know it. Like time, absolute space fails to be an object of perception, so any sequence of perceptions, in terms of its content alone, is consistent with the experience of either coexistent or successively existing items. Consequently, the interpretation of successive perceptions as perceptions of objects existing in different places at the same time consists, in part, of the representation of those perceptions as reversible (i.e. could have occurred in reverse order without the state of affairs thereby represented being different). Hypothetical reversibility of perceptions, in other words, is (partly) constitutive of the thought of simultaneous existence just as hypothetical irreversibility of perceptions is (partly) constitutive of

the thought of an event. Thinking of some of our perceptions as reversible in this way involves thinking of them as being in a relationship with each other such that the content of each perception is partly dependent on the content of the others. The thought of this mutual dependence grounds the thought that the same perceptions could have occurred in a different order. Kant explains that, in turn, the only way to account for this mutual dependence is by reference to objects of these perceptions that are similarly in a state of mediate or immediate mutual dependence. Since the representation of objective simultaneity, like the representation of enduring substances and causally linked events, is part of the distinction between a merely subjective flow of experiences and an objective order of substances and events with their own time-determinations, the supposition of a mutually operative factor that helps to determine the spatial position of each coexisting object is necessary to coherent experience. Finally, since the appearance of simultaneity is impossible without this supposition, and since the world as it appears to us is the world that is the object of our factual judgements about nature, Kant adds that, in so far as we judge objects to be simultaneous, they really must be in just such a system of mutual interaction.

Kant thus proposed that a universal system of mutual causal interaction-at-a-distance is presupposed in the very construction of experience, and thereby also can be assumed to hold of objects of experience qua appearances. Though he does not explicitly say so in the *Critique*, his candidate for a mode of interaction ‘confirming’ the presumption of dynamical community is gravitation (as his defence of principles of immediate, universal attraction in the *Metaphysical Foundations of Natural Science* reflects.<sup>4</sup> According to Newton, of course, gravitation unites all items in the universe in a system of immediate mutual interaction under which the position of everything in space is partly determined by the position of everything else.

*A priori* knowledge of immediate action-at-a-distance and universal gravitational influence was essential, Kant thought, to the possibility of Newtonian physics in ways Newton did not appreciate. Newton defined true, absolute motion via the idea of a privileged centre of mass frame.<sup>5</sup> Kant saw the principles of immediate action-at-a-distance and universal gravitation, together with the principles of the Analogies that the laws of motion realize, to be necessary to the definition of absolute motion and to its meaningful application to experience in the form of laws of nature.<sup>6</sup> Consequently, he felt he had to explain how these principles function as *a priori* presuppositions in understanding motion, rather than as inductive or hypothetical propositions.

<sup>4</sup>Kant, *Metaphysical Foundations of Natural Science*, 50–61. See also, Friedman, *Kant and the Exact Sciences*, 157; and Watkins, ‘Kant’s Third Analogy of Experience’, 424.

<sup>5</sup>Newton, *Isaac Newton’s ‘Philosophiae Naturalis Principia Mathematica’*, 586–7; see Friedman, 231 n.29.

<sup>6</sup>Kant, *Metaphysical Foundations*; see Friedman, 234–5.

Kant thus felt that his reasoning lent critical support to the project of establishing universal laws of dynamics, with one improvement on Newton being that there is no need under Kant's system to posit absolute time and space as infinite, self-subsistent entities.

Newtonianism has since been superseded by relativistic physics, which, interestingly, has a claim about simultaneity as a central consequence. Under Einstein's Special Theory of Relativity, the effects of gravity, like light, are propagated at a finite and constant speed; thus his conclusion that there is no such thing as absolute simultaneity. For a person (David) travelling quickly relative to a person (Manny) in the same inertial frame as some distant object ( $\Omega$ ), light travelling at the same outgoing and incoming speeds would be judged by David to reach  $\Omega$  at a different time than that which Manny would decide upon. Since there is no fact of the matter as to whose reference frame is the correct one, we can only speak meaningfully of simultaneity relative to a given inertial frame. While Prior<sup>7</sup> and Markosian<sup>8</sup> have each claimed that special relativity does not exclude an absolute and universal but unknowable time-order, most who have considered this proposition have agreed that, under relativity, the notion of synchrony independent of any frame of reference is meaningless. Kant was certainly not cognizant of this issue, as he was working under the Galilean presumption that light transmission is instantaneous.<sup>9</sup> Einstein specifically viewed his theory as implying the rejection of Kantian a priorism re time and space.<sup>10</sup> Is Kant's reasoning thus totally superseded?

One might suggest that Kant's theory about what is presumed in ordering our experiences in time is adaptable to a theory holding simultaneity to be relative to a reference frame. If we hold the time it takes light to travel to be constant, then simultaneity can be defined for any particular inertial frame. All we need to do to establish distant simultaneity is to suppose that, in synchronizing distant clocks, light travels at the same speed on the way out from one clock as it does on the way back. The halfway point between emission of the synchronizing signal and its return thereby can be designated as simultaneous with the reflection of the signal at the receiving point. While there would be other substantial implications for the physical laws he was attempting to ground, as long as our assumptions about simultaneity are 'inertial-frame-centric' Kant could still be claimed to describe successfully how we intuitively understand the relationship between our subjective order of experiences and the order of events we think of as determining the order of our experiences. As long as our description of reality is understood in

<sup>7</sup>Prior, 'The Notion of the Present', 323.

<sup>8</sup>Markosian, 'A Defense of Presentism', 73–5.

<sup>9</sup>Unlike gravity, Newton did *not* think that light is instantaneously transmitted, but evidently did not consider the relationship between the speed of light and inertial frameworks. See his *Opticks*, 350–2. My thanks to Eric Schliesser on this point.

<sup>10</sup>Albert Einstein to Max Born, after 28 June 1918, in *Collected Papers of Albert Einstein*, vol. 8B, 818. See Martinez, 'Conventions and Inertial Reference Frames', 453.

terms of coordinate systems, then those assumptions about simultaneity hold true as well.

This answer would fall short for two reasons. First, Kant's theory involves the presumption of instantaneous action-at-a-distance. It is not enough to have a theoretical mechanism that would allow us to establish simultaneity at a distance: he demands that we organize our experience according to the supposition that the states of the objects we experience are mutually causally-determining, and since neither light nor gravity nor any other effect is propagated instantaneously, there is no way to exclude changes to objects that fail to register on other objects until some time has passed.

Second, Kant's claims about time-ordering are particularly hard to jibe with the *conventionality* of simultaneity. Simultaneity of an event with one taking place in its absolute elsewhere is not only relative but conventional. The assumption, in establishing distant synchrony, of the equality of the one-way speeds of light is a convention, or stipulation, as opposed to an empirically provable fact. Sklar explains that a part of a theory is a convention when that part of the theory 'can be changed without the total theory suffering any changes in its prediction in a certain specified class, be that class the class of "causal facts" or the class of "directly observable consequences".'<sup>11</sup> Some facts predicted by a given empirical theory, he continues, fall within the domain of direct observability, and some do not. Some components of a theory may be altered without changing the directly observable predictions of the theory, as long as compensating changes are made to other components of the theory. As long as the resulting theories have the same observational consequences, the choice between them is a matter of convention rather than a choice between 'genuinely alternative theories about the nature of the world'.<sup>12</sup> The choice between theories according to which two space-like separated events are simultaneous and ones in which they are not is generally regarded to be conventional in this way. Given two distant objects R and S in the same non-accelerating frame, suppose a light ray leaves R at  $t_1$ , arrives at S (say, a mirror facing R) coincident with event E at S, and arrives back at R at  $t_2$ . For Einstein it was only a 'stipulation' [*festsetzung*] for the sake of *defining* distant synchrony that the time taken by the light ray on the return trip is supposed to be equal to the time it takes on the outgoing trip.<sup>13</sup> One way to illustrate this point is to note that synchronization of distant clocks depends on transmission of a signal between them, and the measurement of the speed of the signal transmission depends on synchronization of the same distant clocks. Thus, distant simultaneity is a matter of definition by stipulation. Depending on what values we assign to the speed of light on each leg of the trip, an event at

<sup>11</sup>Sklar, 'Spacetime and Conventionalism', 952.

<sup>12</sup>Ibid.

<sup>13</sup>Einstein, *Relativity: The Special and the General Theory*, 23. See Martinez, 453.

R falling anywhere between  $t_1$  and  $t_2$  could be coincident with E.<sup>14</sup> If we do not suppose that the one-way speed of light is isotropic, there are broad consequences for our physics. Newton's first law, as currently understood, could not be upheld, along with many other physical laws and/or the metrics we use to measure velocity, force and distance. However, light anisotropy plus a much more complicated metric and/or set of physical laws could be consistent with observation. Consequently, the method of synchronization and the time of E is a matter of stipulation or convention, chosen because it allows for the simplest set of laws of nature.

By contrast, simultaneity is non-conventional under Newtonianism. One way to illustrate this fact is by noting that if there were no theoretical limit on relative velocity, then distant simultaneity for one observer could, effectively, constitute local simultaneity for an idealized observer moving relative to the first.<sup>15</sup> Without limits on travel or transmission speed, the simultaneity of any pair of events would be, theoretically, directly observable and so, non-conventional.

Some theorists have objected to characterizing simultaneity as conventional within reference frames. Putnam (1974) argued that maximization of the internal coherence and simplicity of our science should be a consideration in our very understanding of scientific terms.<sup>16</sup> While it is possible, consistently with observation, to vary the temporal range of distant events that could be considered simultaneous with a local event by imagining, say, arbitrarily curved spacetimes, a particular set of stipulations would result in a significantly simpler total science:

Suppose metric  $M_1$  is one which leads to a Newtonian physics for the entire world. Suppose that metric  $M_2$  leads to a physics according to which all objects are contracting towards the center of a certain sphere at a uniform rate. This contraction is undetectable because, according to the physics based on the metric  $M_2$ , measuring rods themselves are contracting at the same rate. The universal contraction affects all measuring rods the same way. The laws of the physics based on the metric  $M_2$  are infinitely more complicated than the laws of the physics based on the metric  $M_1$ . The fundamental principles of the physics based on the metric  $M_2$  – the existence of universal forces and the universal contraction towards the center of the sphere – are totally counter-intuitive; and distances according to the metric  $M_2$  cannot be computed in practice and are totally unusable in practice . . . [If] coherence can determine *reference*, then why should we not say that in a world one of whose admissible descriptions is the metric  $M_1$  and the physics based on the metric  $M_1$ , the distance according to the metric  $M_1$  is what we *mean* by distance, i.e., that it is to *this* magnitude that we are referring when we use the word 'distance'?<sup>17</sup>

<sup>14</sup>Janis, 'Conventionality of Simultaneity', in *Stanford Encyclopedia of Philosophy*. <http://plato.stanford.edu/entries/spacetime-convensimul/>

<sup>15</sup>Sklar, 958.

<sup>16</sup>Putnam, 'The Refutation of Conventionalism'.

<sup>17</sup>*Ibid.*, 33–4.

Ohanian's attack on conventionalism draws on a similar rationale.<sup>18</sup> Ohanian argues that it would be consistent with Einstein's treatment to define an inertial frame (or, for Einstein, 'system of coordinates') as a system in which Newton's laws of motion are valid to a first approximation. If we reject standard synchrony, however, pseudoforces are introduced and those laws cannot stand in their usual form.

Martinez and Macdonald each reply that 'inertial frame' does not have to be defined as above, so no particular set of laws of dynamics is indispensable.<sup>19</sup> More importantly, the new dynamical equations that would be required under different synchrony conventions 'do not predict any differences whatsoever in the actual material behavior of physical systems', and so the laws of dynamics are, in this sense, also conventional.<sup>20</sup>

Ohanian answers that 'some choices of coordinates and of synchronization play a preferential role, because they permit us to express the laws of physics in their simplest form'.<sup>21</sup> The laws of dynamics, he points out, take their simplest form only under standard synchrony.

Macdonald counters that this just means that the usual definitions of inertial frames and synchrony are non-conventional only under the requirement that the laws of physics take their simplest form; but there is no such requirement.<sup>22</sup> In making a case for conventionalism, Poincaré argued that the meaning of  $F = ma$ , for example, depends on what we have stipulated 'force' to mean, which depends in turn on the metric of time we have chosen.<sup>23</sup> One metric may be preferred because it allows simpler laws of nature, but it remains a choice otherwise unconstrained by observation or experiment.<sup>24</sup> Putnam's claim that the meaning of our physical terms is determined by our choice of language, and that our choice of language is determined by the simplicity and internal coherence of the resulting physics, at best just relocates conventionality to the level of language selection: the choice of a language operationalizing a simpler physics would be as much a convention as the choice of a simplest set of laws.

There seems no way around the conventionality of simultaneity, along with the finitude of the speed of causal transmission.<sup>25</sup> Does Kant's reasoning about the necessary conditions of time-awareness fail without instantaneous action-at-a-distance and non-conventionality of distant

<sup>18</sup>Ohanian, 'The Role of Dynamics in the Synchronization Problem'.

<sup>19</sup>Martinez; Macdonald, 'Comment on 'The Role of Dynamics in the Synchronization Problem,' by Hans C. Ohanian'.

<sup>20</sup>Martinez, 452. See also Robin Le Poidevin, *Travels in Four Dimensions*, 11.

<sup>21</sup>Ohanian, 'Reply to "Comment(s) on 'The Role of Dynamics in the Synchronization Problem'," by A. Macdonald and A. A. Martinez', 456.

<sup>22</sup>Macdonald, 455.

<sup>23</sup>Poincaré, *Foundations of Science*, Ref. 15b, 227; see Martinez.

<sup>24</sup>See Martinez.

<sup>25</sup>See Janis for a discussion of other, earlier, attempts – such as Malament's – to deny conventionality.

simultaneity? He thinks that Newton's laws, and the four-dimensional spatio-temporal framework they define (composed of time and an infinite Euclidean three-dimensional space), gain their legitimacy as a description of experience from the fact that we must impose them on nature as part of the primordial organization of our own perceptions. The conventionality of time, and the corresponding conventionality of the laws governing physical systems, forces us to reject his project of providing a metaphysical foundation for physical laws. Kant's intention was to show that universal, mathematical laws of nature are possible. One way to do this would be to show that certain generalizations are applicable to nature just because certain ways of organizing experience corresponding to those generalizations are necessary to time-determination, and thus to coherent experience. The possibility of coherent experience thus shows that nature qua object of experience must be organized this way, or else it cannot be an object of experience for us. The problem with this approach is its dependence on a reductionist idealism. The fact that we must organize experience in a certain way does not mean the world (of 'appearances') really is that way unless we reduce appearances to the level of mere representation. Attempts like this to demonstrate synthetic propositions *a priori* always seem to have presupposed idealism.<sup>26</sup>

The rejection of any idealist programme does not mean that Kant cannot have something interesting to say about time-awareness. There is a more modest way to read some of his claims about time-ordering such that they are more plausible, and may even have some predictive value.<sup>27</sup>

Barry Stroud has for some time been promoting the idea of 'indispensable' beliefs and conceptual frameworks. A belief or conceptual framework is indispensable in this sense when it makes some contentful thought or knowledge-claim possible. For example, Stroud has argued that beliefs about colour-instantiation are necessary to the attribution of colour-perceptions to others.<sup>28</sup> Since scepticism regarding claims about the colour of things requires the attribution of colour-perceptions, claims about colour – while still, potentially, individually false – are invulnerable to any blanket scepticism regarding the appropriateness of such claims that rests on concerns about the very applicability of the concept of colour to things. This is an example of what he calls a 'modest' transcendental argument.

The more limited reading of Kant's argument has him merely figuring out what, at a minimum, must be conceptually presupposed in time-determination. It is important to stress that he is concerned with the very possibility of ordering one's perceptions in time, not order construal. (Order construal in particular circumstances, as Dennett has argued, may be influenced by the

<sup>26</sup>Or perhaps an odd sort of verificationism: see Barry Stroud, 'Transcendental Arguments'.

<sup>27</sup>I wish to stress that the following is only a suggestion as to how we might salvage some of Kant's ideas by recontextualizing them; it is not intended as an interpretation.

<sup>28</sup>Stroud, *The Quest for Reality*.

contents of perceptions.<sup>29</sup>) Since the existence of a determinate time-order for perceptions is dictated neither by the content of those perceptions nor by the perceived relationship between those perceptions and absolute time, there must be some explanation as to how any ordering can take place. A more modest variation on Kant's answer would amount just to the claim that we must be working with a sort of *a priori* schema for interpretation of perception in terms of coexisting objects and sequential events and object-states, that it is because we conceptualize experience in terms of such objects and events that we understand how sequences of perceptions can be either reversible or irreversible, and that time-awareness depends in part on the construction of experience according to reversibility or irreversibility.

If true, this might help to explain the deeply counter-intuitive nature of the relativity and conventionality of time. If Kant is right in claiming that we must be working with a kind of *a priori* schema of interpretation pertaining to the ordering of experience vis-à-vis an objective world as a necessary condition of experience, it would make sense, from an evolutionary perspective, for the schema in place to be one that dictates the most economical interpretation under historically actualized conditions; that our brains should be hard-wired according to such an interpretive schema is predictable, given that we evolved under conditions that rewarded those organizational principles. In our day-to-day lives it is natural for us to think in terms of an objective and non-relativistic time-order, not because that is what perception uniquely reveals, but because that typically has allowed for an economical interpretation of experience in our accustomed environment. We should expect natural selection to favour a mechanism of interpretation that yields the simplest explanation of the flow of perceptions consistent with the effective arrangement of objects and events we actually experience.

What would we expect by way of the characteristics of the favoured schema? If we accept Kant's point that attribution of subjective experiences to objective coexistences, alterations and event-sequences makes time-awareness possible, the question becomes what set of rules determines time-awareness in the most economical manner while remaining sufficiently faithful to our species' accustomed environment. In that environment, a rule associating objective coexistence with simple reversibility of perceptions, without the complexities of relative or conventional simultaneity, would allow effective interaction with one's surroundings without relativistic caveats or conditional ordering depending on, for all practical purposes, inert stipulations. (Things might be different, in other words, if the speed of light were ten miles per hour, and relativistic effects were therefore an everyday part of existence.) As Kant explains, without a distinct experience

<sup>29</sup>Dennett, *Consciousness Explained*, 168. See Rebecca Roache, 'Mellor and Dennett on the Perception of Temporal Order', 233; and Adrian Bardon, 'Time-Awareness and Projection in Mellor and Kant', *Kant-Studien*, 67.

of absolute time, reversibility of perceptions is only thinkable in relation to objects of experience represented as existing simultaneously. Therefore, we need a schema according to which simultaneity can be perceived, and the presumption of instantaneous, mutual causal determination allows an interpretation under which the relation between order of perceptions and order of objects/events achieves its simplest expression.

The organization of experience according to an absolute time-order and instantaneous causal transmission suggests, in turn, the subsumption of experience under roughly Newtonian principles. Not Newton's laws themselves, of course, but rather, a pre-theoretical grasp of aspects of nature's operation that is the underpinning for the possibility and content of those laws. An understanding of the dynamics of physical systems consistent with Newtonianism, then, might be argued to be corrigibly natural to human cognition. Further, since Newtonianism works in terms of Euclidean space, one might argue the same for Euclidean geometry (also notoriously embraced by Kant as objectively necessary). *Pace* Kant, none of this would actually support claims as to the *truth*, or even the objective applicability, of particular laws of nature without an idealist conflation of appearance and reality. He was confident in thinking in terms not only of explaining a certain intuitive attachment to particular systems of understanding motion and space, but also of establishing their objective validity. Perhaps Kant's mistake, like Putnam's and Ohanian's, was in confusing economy with reality, and he embraced a more ambitious project as a result; but economy can have real effects, as when it accounts for the etiology of an innate schema of interpretation corresponding to Newtonian principles and presumptions.<sup>30</sup>

Wake Forest University

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