

Intrinsic, extrinsic, and the constitutive *a priori*

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Abstract

On the basis of what I call physico-formalist philosophy of mathematics, I will develop an amended account of the Kantian–Reichenbachian conception of constitutive *a priori*. It will be shown that the features (attributes, qualities, properties) attributed to a real object are not possessed by the object as a “thing-in-itself”; they require a physical theory by means of which these features are constituted. It will be seen that the existence of such a physical theory implies that a physical object can possess a property only if other contingently existing physical objects exist; therefore, the intrinsic–extrinsic distinction is flawed.

Introduction

1. There is a long-standing debate in contemporary metaphysics about the precise definition of *intrinsic property*. The great majority of the suggested definitions are some enhanced version of Jaegwon Kim’s (1982) definition, expressing the following simple idea:

Intrinsic properties are the properties a particular object would have even if no other contingently existing objects existed in the world. (Allen 2018)

Although Kim’s definition has been widely accepted as basically adequate criterion of intrinsicity, it has been challenged by subtle examples and amended at several points. Beyond these improvements, the intrinsic–extrinsic distinction is often discussed in a wider context of other closely related metaphysical problems, such as categorical–dispositional, pure–impure, relational–non-relational, interior–exterior distinctions; the problem of identity, duplicate, persistence; or the problem of Cambridge change. (E.g. Lewis 1983; Sider 1996; Humberstone 1996; Vallentyne 1997; Langton and Lewis 1998; Francescotti 1999; Lewis 2001; Marshall 2016; Marshall and Weatherson 2018).

It is not my intention, however, to review these debates, as the aim of this paper is to challenge the concept of intrinsicity from a completely different point of view and to show that the intrinsic–extrinsic distinction is flawed on a more fundamental level.

2. Accordingly, my analysis will be restricted in two significant senses:
 - (a) The discussion will be restricted to the case of ordinary physical properties of physical objects.
 - (b) The whole analysis will remain within a radical physicalist ontological doctrine: The world can be completely accounted for by assuming that only physical entities exist.

Constitutive *a priori*

3. An object can possess a property X only if the term X has meaning. This might sound too radical. Probably, a less radical statement would be easily accepted: The knowledge claim that an object possesses a property X is possible only if the term X has meaning. But, just here is the philosophically relevant point: this is not simply a matter of semantics. As Reichenbach pointed out in his *Relativity Theory and A Priori Knowledge* (1920), the coordinative definitions, that is, the semantic *conventions* by which physical quantities or conceptions are defined in empirical terms, play *constitutive* role; they are constitutive *a priori*. “They define the individual elements of reality and in this sense *constitute* the real object.” (p. 53)

Reichenbach sharply distinguishes two different aspects of Kantian *a priori*:

Kant’s concept of a priori has two different meanings. First, it means “necessarily true” or “true for all times,” and secondly, “constituting the concept of object.”

The second meaning must be clarified. According to Kant, the object of knowledge, the thing of appearance, is not immediately given. Perceptions do not give the object, only the material of which it is constructed. Such constructions are achieved by an act of judgment. The judgment is the synthesis constructing the object from the manifold of the perception. For this purpose it orders the perceptions according to a certain schema; depending on the choice of the schema, either an object or a certain type of relation will result. Intuition is the form in which perceptions present the material—thus performing another synthesis. But the conceptual schema, the category, creates the object; the object of science is therefore not a “thing-in-itself” but a reference structure based on intuition and constituted by categories. (pp. 48–49)

4. Let me give an example. Electrodynamics begins with the operational definitions of the basic electrodynamic quantities. For example, electric field strength is defined as the force felt by the unit test charge in electromagnetic field, when the test charge is at rest.¹ This operational definition, therefore the notion of physical quantity called electric field strength is *a priori* in the sense that it is prior to our empirical knowledge about the electromagnetic field. There are no empirical facts which would determine the *convention* by which this physical quantity is defined. In other words, the electromagnetic field, as a “thing-in-itself” does not determine that such a physical quantity is necessarily introduced for its characterization, as one of its fundamental feature. (In fact, the so called “displacement vector”, a different physical quantity having a completely different operational definition, is an equally good alternative for the description of electromagnetic field.)

Once electric field strength is introduced, we can observe empirical facts about it. We can measure, for example, the electric field strength around a point charge being at rest, and, by inductive generalization, we can ascertain the Coulomb Law: $E = \frac{kQ}{r^2}$. To be sure, the law of physics we ascertained is *a posteriori*; it can be known only from empirical observations. But the *features of the physical reality* that the physical law talks about is *a priori* constructed by us.

5. All this means that the features (attributes, qualities, properties) attributed to a real object are not possessed by the object as a “thing-in-itself”; they require the existence of something else, an epistemic agent constituting them. This recognition outlines an argument against intrinsic–extrinsic distinction.

6. However, the Kantian–Reichenbachian account raises several problems. It is not clear at all what kind of ontological entity is involved by the required epistemic agency. Is it a contingently existing flesh and blood physical being? Or is it an abstract entity, as sometimes the Kantian “transcendental subject” is interpreted? (Carr 1999, p. 53) To what extent is a semantic convention free? Are there “coordinating principles”, “prescriptions for the conceptual side of the coordination”, as Reichenbach (1920, p. 54) presupposes? And what is the origin of such principles? Logic and mathematics? Are logical and mathematical truths *necessary* truths? If so, how to avoid then necessarily true synthetic *a priori* statements about the physical world? Finally, how to incorporate semantic and epistemological holism, the fact that “our statements about the external world face the tribunal of sense experience not individually but only as a corporate body” (Quine 1951)?

In the next sections, I will attempt to formulate the argument outlined in point 5, in such a way that the above mentioned problems will be resolved or avoided. To achieve this aim, however, I need to redraw a larger picture.

¹For the sake of simplicity I use this naive definition. For more precise operational definitions of electrodynamic quantities, see Gömöri and Szabó 2013.

Physico-formalist account of logic and mathematics

7. I begin with a physicalist account of logic and mathematics. How can the logical and mathematical facts be accommodated in a purely physical ontology? Physicalism denies the existence of mental and abstract entities; consequently, there is no room left for any kind of platonism or mentalism in the philosophy of logic and mathematics. Therefore, two possibilities are left: a Millian-style physical realist approach, and formalism. We can disregard from the Millian realism, in which mathematics itself becomes a physical theory, in the sense of physical theory as described in the next section. So, formalism – more precisely, what I will call physco-formalism – seems to be the only account for logic and mathematics that can be compatible with physicalism. Therefore, the formalist approach is our starting point.

First we need to clarify: What are the logical/mathematical facts? The formalist thesis can be summarized in one famous sentence of Hilbert: “Mathematics is a game played according to certain simple rules with meaningless marks.” (Bell 1951, 38) Accordingly, in the formalist account, a mathematical statement/fact/truth is like “ $\Sigma \vdash A$ ”. According to the formalist view, neither A nor the elements of Σ are statements, which could be true or false. They are just meaningless strings, formulas of the formal system in question. The entailment \vdash relation has nothing to do with “truth preserving if-then-type reasoning”; it simply stands for the fact that there is a finite sequence of meaningless strings of symbols, fitting into some structural patterns called “derivation rules”. As a visual illustration, Fig. 1 shows a short example: the first order axiomatic formulation of group theory and the proof that $p(e, p(e, e)) = e$ is a theorem. As this simple illustration shows, such an “evident truth” that “the unit element three times multiplied by itself equals the unit element” precisely means the existence of a sequence of formulas, (1)–(9) in Fig. 1, constituting a proof.

8. How can a formal system be accommodated in a purely physical ontology? Where are the states of affairs located in the physical world that make propositions like “ $\Sigma \vdash A$ ” true or false? For example, what are the facts of the physical world that make the sequence of formulas (1)–(9) a proof of $p(e, p(e, e)) = e$ in Fig 1? Consider the first formula (1) in the proof. From ontological point of view, what does it mean that it is nothing else but axiom (G2)? It means that the formula $p(e, x) = x$ in row (1) is the same as the formula $p(e, x) = x$ in row (G2). More exactly: it means the *physical fact* that the arrangement of black and white pixels on the screen of my laptop on which I am writing this paper – or the arrangement of ink particles on the printout – in row (1) and the corresponding arrangement of black and white pixels in row (G2) are similar (congruent). Similarly, what does it mean that formula $\forall x p(e, x) = x$ in (2) is obtained from $p(e, x) = x$ by the derivation rule (G)? It means that replacing the pixel-configuration ϕ in $\phi \vdash \forall x \phi$, with copy/paste, by $p(e, x) = x$ in (1), the resulted pixel-configuration is $p(e, x) = x \vdash \forall x p(e, x) = x$, such that

Alphabet

VARIABLES	x, y, z, \dots	
INDIVIDUAL CONSTANTS	e	(IDENTITY)
FUNCTION SYMBOLS	i, p	(INVERSE, PRODUCT)
PREDICATE SYMBOL	$=$	
LOGICAL SYMBOLS	$\forall, \neg \rightarrow$	
OTHERS	$(,), ,$	

Derivation rules

(MP)	$\{\phi, (\phi \rightarrow \psi)\} \vdash \psi$	(MODUS PONENS)
(G)	$\phi \vdash \forall x \phi$	(GENERALIZATION)

Axioms

(PC1)	$\phi \rightarrow (\psi \rightarrow \phi)$	
(PC2)	$(\phi \rightarrow (\psi \rightarrow \chi)) \rightarrow (\phi \rightarrow \psi) \rightarrow (\phi \rightarrow \chi)$	
(PC3)	$(\neg \phi \rightarrow \neg \psi) \rightarrow (\psi \rightarrow \phi)$	
(PC4)	$\forall x (\phi \rightarrow \psi) \rightarrow (\phi \rightarrow \forall x \psi)$	(GIVEN THAT x IS NOT FREE IN ϕ)
(PC5)	$\forall x \phi \rightarrow \phi$	(GIVEN THAT x IS NOT FREE IN ϕ)
(PC6)	$\forall x \phi(x) \rightarrow \phi(t)$	(IF t IS A TERM WHICH IS FREE FOR x IN $\phi(x)$)
(E1)	$x = x$	
(E2)	$t = s \rightarrow f^n(u_1, u_2, \dots, t, \dots, u_n) = f^n(u_1, u_2, \dots, s, \dots, u_n)$	
(E3)	$t = s \rightarrow (\phi(u_1, u_2, \dots, t, \dots, u_n) \rightarrow \phi(u_1, u_2, \dots, s, \dots, u_n))$	
(G1)	$p(p(x, y), z) = p(x, p(y, z))$	
(G2)	$p(e, x) = x$	
(G3)	$p(i(x), x) = e$	

Theorem: $p(e, p(e, e)) = e$

PROOF:

(1)	$p(e, x) = x$	(G2)
(2)	$\forall x p(e, x) = x$	(G)
(3)	$\forall x p(e, x) = x \rightarrow p(e, e) = e$	(PC6)
(4)	$p(e, e) = e$	(2), (3), (MP)
(5)	$\forall x p(e, x) = x \rightarrow p(e, p(e, e)) = p(e, e)$	(PC6)
(6)	$p(e, p(e, e)) = p(e, e)$	(2), (5), (MP)
(7)	$p(e, e) = e \rightarrow p(e, p(e, e)) = p(e, e) \rightarrow p(e, p(e, e)) = e$	(E3)
(8)	$p(e, p(e, e)) = p(e, e) \rightarrow p(e, p(e, e)) = e$	(4), (7), (MP)
(9)	$p(e, p(e, e)) = e$	(6), (8), (MP)

Figure 1: Group theory and one of its theorems

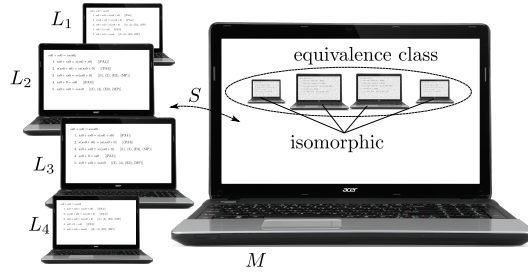


Figure 2: In order to isolate the common essential features of different physically existing formal systems $L_1, L_2, L_3, \dots, L_n$ we must have a “meta-theory” of $L_1, L_2, L_3, \dots, L_n$, using another physically existing formal system M .

the left hand side is similar to the pixel-configuration $p(e, x) = x$ in (1) and the right hand side is similar to $\forall x p(e, x) = x$ in (2). And so on and so forth.

Of course, a formal system can be thought of in different physical forms; written with ink on paper, in the form of brain states and brain processes, in the form of electronic states and electronic processes in a computer, etc. What is important is the following observation:

***The physico-formalist thesis** The logical and mathematical facts, since being formal facts, are nothing but physical facts of physically existing formal systems consisting of signs and derivation patterns embodied in concrete physical objects, concrete physical configurations, and concrete physical processes. (Szabó 2003; 2012; 2017).*

The physico-formalist account remains completely within the physicalist ontology: there is no need for hypostatized entities – abstract, conceptual, or mental formal systems – which exist over and above the physically existing formal systems embodied in concrete physical objects, concrete physical configurations, and concrete physical processes.

9. “Abstract” or “mathematical” formal system is often conceived as an entity obtained by *abstraction*, by isolating the common features in a number of particular physically existing formal systems. To maintain the physico-formalist thesis, it is worthwhile to illustrate that such an abstraction does not lead out of the realm of the physically existing formal systems.

Consider a number of different particular physically existing formal systems L_1, L_2, \dots, L_n , embodied in different particular physical systems (Fig. 2). To abstract from some peculiar properties of physical objects L_1, L_2, \dots, L_n , and to isolate the common essential features of them, first of all requires knowledge of the properties of the physical objects in question. That is, we must have a physical theory (M, S) – in the sense of the definition of physical theory in the next section – describing $L_1, L_2, L_3, \dots, L_n$, using *another physically existing formal system* M . Abstraction is a relationship, formulated in (M, S) , between

two, a more detailed and a less detailed, representations of $L_1, L_2, L_3, \dots L_n$. Only in a suitable formal system M it is meaningful to talk about similarity or isomorphism between the structures describing $L_1, L_2, \dots L_n$, and, for example, about the equivalence class of these structures, which could be regarded as the product of the abstraction process. But, all these are contained in M , a formal system existing in the physical world. Thus, abstraction does not lead out of the physical realm. It does not produce “abstract formal systems” over and above the physically existing ones. One physically embodied formal system can be applied in the description of another physically embodied formal system, that’s all.

10. Thus, any statement about a formal system – including a statement like “ $\Sigma \vdash A$ ” – is a statement of a physical fact; consequently, it has exactly the same epistemological status as any other statements about the physical world. This has far-reaching consequences, of course: Logical and mathematical truths express objective (mind independent) facts of a particular part of the physical world, namely, the facts of the formal systems themselves. As such, they are synthetic, *a posteriori*, not necessary, and not certain; they are fallible. But they have contingent factual content, as any similar scientific assertion, so they “can be true and useful and surprising” (Ayer 1952, 72). The logical and mathematical facts can be discovered, like any other facts of nature, just like a fact about a plastic molecule, or other artifact.

The fact that the formal systems usually are simple physical systems of relatively stable behavior, like a clockwork, and that the knowledge of logical and mathematical truths does not require observations of the physical world external to the formal systems explains the universal *illusion* that logical and mathematical truths are necessary, certain and *a priori*.

Physical theory

11. Following Carnap, a physical theory, providing a description of a certain part of physical reality, U , can be considered as a partially interpreted formal system, (L, S) . The formal system L is given by the language and the derivation patterns, and the axioms. Traditionally, the axioms are divided into the logical axioms (ideally, the first-order predicate calculus with identity), the axioms of some mathematical theories, and, of course, some physical axioms.

How can physical theory be accommodated in a purely physical ontology? The L -part is already solved by the physico-formalist interpretation of formal system and logical/mathematical fact. But, how can the physicalist account for *meaning* and *truth*? Again, first we need to clarify what it is that has to be accounted for; we need a definition of semantic relationship between formulas of a formal system and states of affairs in the physical world.

12. The definition will be based on the intuition we can learn from Gödel's construction of representation of the meta-arithmetic facts in Peano arithmetic, in the preparation of the first incompleteness theorem (e.g. Crossley et al. 1990, 62). In his construction, Gödel clearly defines, when we are entitled to say that a formula of a formal system (in his case, a formula of Peano arithmetic) represents/means/refers to a fact of the world outside of the formal system (in his case, a meta-arithmetic fact). *Mutatis mutandis*, we will repeat the same definition.

One is entitled to say that a formula A represents or means a state of affairs a in U , if the following two conditions are met:

- (A) There exist a family $\{A_\lambda\}_\lambda$ of formulas in L and a family $\{a_\lambda\}_\lambda$ of states of affairs in U , such that $A = A_{\lambda_0}$ and $a = a_{\lambda_0}$ for some λ_0 .
- (B) For all λ ,
- | | | |
|---------------------------------------|------|--------------------------------|
| if a_λ is the case in U | then | $\Sigma \vdash A_\lambda$ |
| if a_λ is not the case in U | then | $\Sigma \vdash \neg A_\lambda$ |

13. A few important remarks are in order.

- (a) As we have seen, to be a meaning-carrier is not simply a matter of convention or definition or declaration. Semantics *is not an arbitrary assignment* of states of affairs of the world to linguistic elements of the theory.
- (b) It is pointless to talk about the meaning of an *isolated* formula of the theory. (Semantic holism) It is not only because of condition (A), but also because in condition (B) a big part of the axiomatic system can be involved.
- (c) It must be recognized that condition (B) is exactly the same as the necessary and sufficient condition for the theory (L, S) to be *true*. That is, the two conceptions *meaning and truth are completely intertwined*.
- (d) The semantics, in the above holistic sense, is a part and parcel of physical theory. In case of empirical failure of a physical theory, semantics is one of the possible object of revision. In other words, semantics is as much hypothetical as any other part of the theory.

14. It must be clear that a_λ – as a symbol in the meta-language we use to describe the semantic relationship – stands for a state of affairs, a configuration of *the physical world*. Also, according to the physico-formalist approach “ $\Sigma \vdash A_\lambda$ ” and “ $\Sigma \vdash \neg A_\lambda$ ”, respectively, are states of affairs in *the physical world*, facts of the physically embodied formal system L . Thus, what we observe in condition (B) is a kind of regularity or *correlation between physical facts* of two parts of the

physical world, L and U. Combining this with the thesis of *the principle of common cause*², one must conclude that both semantic relationship and the truth of the physical theory (consequently, our *knowledge*) must be brought about by the underlying causal processes of the physical world, going on in the common causal past of the two parts of the world L and U. This underlying process is what we normally call *learning through experience*. That is, *no genuine knowledge of the physical world is possible without experience*. By the same token, *no semantically meaningful talk about the physical world is possible without experience*. There is no *a priori* meaning and there is no *a priori* truth.

15. Let us clarify then the role of logic and mathematics in our knowledge of the physical world. One might ask: if mathematics is only about the formal systems without meaning, how is it, then, possible that mathematical structures prove themselves to be so expressive in the physical applications? As Richard Feynman put it: “I find it quite amazing that it is possible to predict what will happen by mathematics, which is simply following rules which really have nothing to do with the original thing.” (Feynman 1967, 171)

We need to separate the sociological/practical aspect of this issue from the epistemological one. Let me start with the sociological aspect. From sociological point of view, by “mathematics” we mean that part of the axioms of L (see point 11) which is traditionally considered as non-physical axioms. It must be clear however that it is not “mathematics” *alone* by which the physicist can predict what will happen, but the physical axioms together with the logical and mathematical axioms. The physicist, keeping, as long as possible, the logical and mathematical axioms fixed – for good sociological/practical reason –, *tunes* the physical axioms such that the theorems *derivable* from the unified system of logical, mathematical, and physical axioms (together with the deduction rules) + the semantics, as a whole, be compatible with the empirical facts. Consequently, the employed logical and mathematical structures in themselves need not, and do not, reflect anything about the real world in order to be useful.

Let me recall an analogy I gave in my (2017). You can experience an analogous situation when you change the mouse driver on your computer (or just change the mouse settings): first you feel that the pointer movements (“derived theorems”) generated by the new driver (“mathematics”) according to your previously habituated hand movements (“physical axioms”) do not faithfully reflect the arrangement of your screen content (experienced world). Then, keeping the driver (and driver settings) fixed, you *tune* your hand movements – through typical “trial and error” learning – such that the generated pointer movements fit to the arrangement of your screen content.

Thus, there is no miraculous “preadaption” or “pre-established harmony” involved just because certain aspects of empirical reality “fit themselves into the forms provided by mathematics”. This is simply a result of the physicist’s

²I mean the Reichenbachian thesis that no correlation without causation; every correlation is either due to a direct causal effect, or is brought about by a third factor, a so-called common cause (e.g. Reichenbach 1956; Hofer-Szabó et al. 2013).

continuous choice from the store shelves of mathematics, and the continuous tuning the physical axioms.

From epistemological point of view the situation is even more simple. In a physical theory (L, S) , the formal system L is a single undivided whole. As a formal system, L can be the object of logical/mathematical investigation and knowledge. In itself, however, it has nothing to do with the physical world described by the *physical theory* (L, S) . In case of empirical failure of the physical theory (L, S) , any element of L as well as the semantics can be the object of revision. Through this continuous “trial and error” process, the physicist tunes the physical theory (L, S) , as a whole, be compatible with the experienced world; satisfy condition (B) in point 12.

Constitutive *a priori* reconsidered

16. Consider the following example. Given that L is consistent, one can easily see that the following statements cannot hold true at the same time:

- (i) A refers to a
- (ii) $L \vdash A$
- (iii) a is not the case in U

since (i) and (iii), according to condition (B) in point 12, would imply $L \vdash \neg A$, in contradiction with (ii). Therefore, observing that a is not the case we are not entitled to say that we observe that “ $\neg A$ ”. Simply because if a is not the case, then condition (B) fails, and the whole semantics is lost. Therefore $\neg A$ does not carry meaning at all. That is to say, we are not able to attribute a feature, whatsoever, to the physical reality in the situation when a is not the case.

17. Let us denote this unexpressed, unarticulated state of affairs by α^* . Once a modified (or completely new) theory, (L', S') , is constructed with a new family of state of affairs $\{a'_{\lambda'}\}_{\lambda'}$ and a new family of formulas $\{A'_{\lambda'}\}_{\lambda'}$, such that $\alpha^* = a'_{\lambda'_*}$ and condition (B) in point 12 is satisfied, the corresponding $A'_{\lambda'_*}$ will be attributed to α^* , as true feature of reality in state α^* .

18. This example not only confirms what was said in point 13 (d), but also sheds light on the constitutive role of semantics, similar to the constitutive role of Reichenbach’s coordinative definitions we described in point 3. There are however significant differences:

- (a) The whole account I developed remains within the clear and minimal ontological framework of physicalism.
- (b) All entities involved are contingently existing physical objects.

- (c) Whatever is the concrete physical process (point 14) producing the correlation required in condition (B) of point 12, that is, producing meaning and truth, it is a contingently existing part of the physical reality.
- (d) Therefore, the whole “epistemic agency” involved is embodied in the physical world.
- (e) The formal system in (L, S) plays, indeed, a similar role as Reichenbach’s “constitutive principle”; except that
 - L has a clear ontological status; it is a part of the physical world,
 - all facts of L are contingent facts of the physical world, therefore they do not generate necessarily true synthetic *a priori* statements about the physical world, for sure.
- (f) There is no “conceptual side of the coordination”. The constitutive role of formal systems by no means entitles us to say that there is a hypostatized *a priori* conceptual scheme in terms of which we grasp the experienced reality, and that this conceptual scheme generates analytic truths. For, what there is is anything but conceptual: we only have the physically existing formal systems which have no meaning. Once an otherwise meaningless formula of a formal system is provided with meaning, in the sense of point 12, it becomes true or false in a non-analytic sense.
- (g) Certainly, semantics plays constitutive role; not in the form of isolated operational definitions of physical concepts, but in holistic sense. Moreover, semantics is completely intertwined with the truth of the theory; also, not in the form of the truth of isolated predictions, but in holistic sense of (B) in point 12.
- (h) In fact, therefore, what plays the constitutive role is the whole theory (L, S) , though, the whole theory is certainly not *a priori*. As we have seen, however, apriority is not required for playing a constitutive role. That is why there is no tension, whatsoever, between the fact that the applied logical and mathematical structures as well as the constructed semantics can *change* (see point 17) when a theory is superseded by another one, on the one hand, and their constitutive role in furnishing reality, on the other (cf. Friedman 2001; MacArthur 2008; Ivanova 2011).
- (i) Finally, it is worthwhile to mention that the constitutive role of the theory (L, S) in furnishing “the »continuum« of reality” (Reichenbach 1920, p. 50) with objects, properties, and relations, in itself, by no means implies the denial of realism; the belief that the existence of the objects, properties, and relations posited by the theory is a real feature of reality. What is true about scientific realism is also

true about metaphysical realism – if the distinction is meaningful at all. For a “metaphysical” account must have the structure of (L, S) in order to be meaningful and true, just in the sense we described in point 12.

19. Thus, the corrected formulation of the argument against intrinsic-extrinsic distinction, outlined in point 5, is the following. The features (attributes, qualities, properties) attributed to a real object are not possessed by the object as a “thing-in-itself”; they require the existence of something else: a physical theory (L, S) by means of which these features are constituted. The existence of (L, S) however implies the existence of a physically embodied formal system L and a real causal process in the physical world producing the correlation required for both the semantics and the truth of the theory. All this means that a physical object can possess a property only if other contingently existing physical objects exist.

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