Is Structure Not Enough?

Ioannis Votsis†‡

This paper counters an objection raised against one of Bertrand Russell's lesser-known epistemological views, viz. "structural realism" (SR). In short, SR holds that at most we have knowledge of the structure of the external (i.e., physical) world. M. H. A. Newman's allegedly fatal objection is that SR is either trivial or false. I argue that the accusation of triviality is itself empty since it fails to establish that SR knowledge claims are uninformative. Moreover, appealing to Quine's notion of ontological relativity, I suggest that far from being false, SR knowledge claims seem to be the most that we can hope for.

1. Introduction. A crucial turning point in Russell's philosophy came in the early 1910s when he embraced A. N. Whitehead's suggestion that the application of logicist methods should be extended beyond the domain of mathematics to that of physics (see Russell [1918] 1957, 156–157). Following the success that logical constructions of mathematical objects had in *Principia Mathematica,* the idea of utilizing logic to define the objects of physics seemed quite appealing. Employing such logical constructions with sense-data—the allegedly pure objects of our perception—as the logical atoms had the obvious advantage of eliminating doubtful inferences to physical objects, the nature of which, as Kant had argued, would remain forever unknown to us. By 1921 Russell had assigned the role of logical atoms to events, the more neutral, neither decidedly physical nor decidedly mental, elements that fitted nicely with his newly discovered affection for neutral monism. Moreover, he had assigned the role of the objects of direct acquaintance to percepts, those events that occurred within one's head.

†To contact the author, please write to: Centre for Philosophy of Natural and Social Science, London School of Economics, Houghton Street, London WC2A 2AE, UK; e-mail: i.votsis@lse.ac.uk.

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Despite these shifts, Russell's commitment to the project of logical construction remained firm.

It was not until *The Analysis of Matter* (1927) that Russell wholeheartedly embraced and developed the structural viewpoint.[1] There he presented a causal theory of perception and argued that it is both reasonable and fruitful to assume the existence of causes (i.e., events) external to our mind admitting however that we should "not expect to find a *demonstration* that perceptions have external causes" ([1927] 1992, 198; my emphasis). He then argued that though we have direct knowledge of the "intrinsic character," "nature," or "quality" (i.e., the first-order properties and relations) of percepts, the same does not hold for events in the external world. The only way we attain knowledge of the latter is by drawing inferences from our perceptions. Assuming that similar causes (i.e., events) have similar effects (i.e., percepts)— a *roughly* one-to-one correspondence between stimulus and percept—Russell argues that relations between effects *mirror* relations between causes. Thus, from the structure of our perceptions we can "infer a great deal as to the structure of the physical world, but not as to its intrinsic character" ([1927] 1992, 400). At most, what can be known is the logical form or structure, i.e., the second or higher-order properties and relations, of events in the external world.

But what exactly did Russell mean by "structure" when he said that we can infer the structure of the external world from the structure of our perceptions? Talk of "structure" or "relation-number"—Russell uses these concepts interchangeably—is invariably talk of the structure of a relation or of a system of relations (this latter notion signifying one or more relations defined over a single domain). The structure of a relation is simply "the class of relations similar to the given relation" ([1927] 1992, 250). Russell employs the notion of "similar relations," i.e., isomorphic relations, to convey the idea that we are interested only in the logico-mathematical properties of a relation and not the relation itself for we have no direct access to it.

2. Newman's Bifurcated Challenge. In 1928, one year after the publication of Russell's *The Analysis of Matter,* M. H. A. Newman, a famed mathematician and later-to-become Bletchley Park collaborator, published a paper in which he argued that the SR claim that we can know only that the structure of the external world, is, as it stands, either trivial or false. Newman's paper went almost unnoticed in the ensuing decades until Demopoulos and Friedman (1985) brought it back to the limelight. But let us take a closer look at the challenge.

1. The term was coined by Grover Maxwell (1968).

2.1. The First Fork: SR is Trivial. Newman begins by noting that Russell's view, that we have no knowledge of the *physical* relations over and above their formal (i.e., structural) features, amounts to the assertion that "[*t*]*here* is a relation *R* such that the structure of the external world with reference to *R* is *W*" (1928, 144). He then urges us to consider the logical theorem that for "any aggregate A, a system of relations between its members can be found having any assigned structure compatible with the cardinal number of A" (1928, 140). According to this theorem, the mere number of members in an aggregate entails that there are systems of relations definable over those members having a specified structure. Thus saying, as structural realists do, that for a given class there exists a system of relations that specifies a structure, is not saying much, since this claim follows as a matter of logic by employing the above-noted theorem plus the cardinality of the given class. But surely knowing something about the external world must be discoverable empirically, not a priori. Yet the only thing open for empirical determination under Russell's view, according to Newman's argument, is the cardinality of the given class.

We can present Newman's result more formally but before doing so we need to set up a couple of definitions:

Definition 1: For any set U and any $n \geq 1$ an *n-place relation* on U is a set of ordered n-tuples $(\alpha_1, \ldots, \alpha_n)$ where each α_i is a member of U, i.e., an n-place relation-in-extension on U is a subset of U^n.

Definition 2: A (*concrete*) *structure* $S = (U, R_1, \ldots, R_m)$ is specified by:

(i) a nonempty set U (the domain of S);
(ii) a nonempty set of relations $R_1, \ldots, R_m$ on U.

Definition 3: A structure $S = (U, R_1, \ldots, R_m)$ is *isomorphic* to a structure $T = (U', R_1', \ldots, R_m')$ just in case there is a bijection $\phi: U \rightarrow U'$ such that for all $x_1, \ldots, x_n$ in U, $(x_1, \ldots, x_n)$ satisfies the relation R_i in U iff $(\phi(x_1), \ldots, \phi(x_n))$ satisfies the corresponding relation R_i' in U'.

Definition 4: An *abstract structure* Σ is an isomorphism class (or "isomorphism type") whose members are all, and only those, structures that are isomorphic to some given structure $(U, R_1, \ldots, R_m)$. (Note: This is what Russell claims we have knowledge of.)

We can now state the theorem upon which Newman's result is based:

Newman's theorem: Let $S = (U, R_1, \ldots, R_k)$ be a structure and V be a set. Suppose that there is an injection $\rho: U \rightarrow V$. Then, there exists a structure S′ whose domain is V and which has a substructure isomorphic to S.

The proof for this theorem can be given as follows:[2] We begin by defining the image of mapping ρ as $\rho(U) := \{x \in V: \exists\alpha \in U, \rho(\alpha) = x\}$. From this we know that $\rho(U) \subset V$ and since ρ is injective we know that $\rho: U \rightarrow \rho(U)$ is a bijection. Its inverse is thus, $\rho^{-1}: \rho(U) \rightarrow U$. We can now define a relation R_i', for each n-place relation R_i on U, on the set $\rho(U)$ as follows: $R_i' := \{(x_1, \ldots, x_n) \in V^n : x_1, \ldots, x_n \in \rho(U) \wedge (\rho^{-1}(x_1), \ldots, \rho^{-1}(x_n)) \in R_i\}$. In other words, R_i' is an n-place relation on V. Note that it follows from the definition of each R_i' that $\forall\alpha_1, \ldots, \alpha_n \in U, (\rho(\alpha_1), \ldots, \rho(\alpha_n)) \in R_i'$ iff $(\alpha_1, \ldots, \alpha_n) \in R_i$. This is the condition for an isomorphism. By repeating this for every relation R_i on U we define relations R_i' on V and hence have a structure $S' = (V, R_1', \ldots, R_k')$. If we now take the *restriction* of S′ to the subdomain $\rho(U) \subset V$ we observe that it is just the substructure $(\rho(U), R_1', \ldots, R_k')$ which is isomorphic to S, i.e., $(\rho(U), R_1', \ldots, R_k') \approx S$. This just means that save for cardinality constraints we can impose any structure on a set; that structure being of course set up by *some* relation(s). Thus, saying that "There exists a relation R which has a specified structure S" is not saying much since that follows trivially modulo cardinality constraints.

2.2. The Second Fork: SR is False. Newman correctly points out "that it is meaningless to speak of the structure of a mere collection of things, not provided with a set of relations" and "[t]hus the only important statements about structure are those concerned with the structure set up . . . by a given, definite, relation" (1928, 140). The only way to avoid trivialization, according to him, is by specifying the particular relation(s) that generate(s) a given structure. That is, if we specify R, instead of just saying "There is a relation R that has a certain structure W," the fact that R has structure W is no longer trivial. The problem is that to specify R, one inevitably goes beyond the epistemic commitments of the structural realist, i.e., SR is rendered false.

Let us remind ourselves of the structural realist's epistemic commitments. Russell claims that we can at most know the second-order structure of physical relations but not the relations themselves for we have no epistemic access to them. A consequence of this view is that there is an underdetermination of the first-order physical relations by the abstract structure, since to any such structure correspond infinitely many such relations. For some this is the essence of Newman's problem. Ladyman certainly thinks so when he says: "[t]here are serious difficulties . . . which were raised by Newman (1928 . . . the basic problem [being] that structure is not sufficient to uniquely pick out any relations in the world" (1998,

2. Many thanks to Jeff Ketland for providing this proof.

412). To explain the objection better, consider first, the following example (taken out of context from Newman's paper) that illustrates two different relations that share the same abstract structure:

> Let a set, *A,* of objects be given, and a relation *R* which holds between certain subsets of *A*. Let *B* be a second set of objects, also provided with a relation *S* which holds between certain subsets of its members. . . . For example *A* might be a random collection of people, and *R* the two-termed relation of being acquainted. A *map* of *A* can be made by making a dot on a piece of paper to represent each person, and joining with a line those pairs of dots which represent acquainted persons. Such a map is itself a system, *B,* having the same structure as *A,* the generating relation, *S,* in this case being "joined by a line." (1928, 139)

Newman, like most mathematicians, tends to avoid using different symbols for a *set* and for some *structure* with that set as domain, since it is usually clear from the context what he is referring to. For the sake of clarity we shall use asterisks to indicate a structure as opposed to the set that constitutes the structure's domain. Thus, structure *A*** and structure *B*** have set *A* and set *B* respectively as their domain. The two relations, "being acquainted" and "joined by a line," are undoubtedly distinct from one another both intensionally (i.e., what they mean differs) and extensionally (i.e., what they denote differs). In this context, however, they are employed in such a way so that the structures they give rise to are isomorphic to one another, hence they share the same abstract structure. Now suppose that we are interested in only one of these relations but we have epistemic access to neither. If all we have knowledge of is abstract structure, as the structural realist suggests, we cannot distinguish between the two relations. And, of course, we do not just have two relations to choose from but infinitely many since there can be infinitely many bijective mappings that preserve the same structural properties.

Newman explores several ways in which the structural realist may try to distinguish between intended and unintended relations, two of which stand out. The first one is an attempt to dress the distinction as one between real and fictitious relations. Newman defines a relation as fictitious when "the relation is one whose only property is that it holds between the objects that it does hold between" (1982, 145). Real relations can then be implicitly defined as those relations that have more than just this property. This, according to Newman, is obviously not going to be of help since the *only knowledge* a structural realist would have of the real relations is exactly the same knowledge he would have of the fictitious ones, viz., that they hold between some objects. But what if we know something about these objects apart from their having a given abstract structure, could we not then claim to have a way to distinguish the real relations from the fictitious ones? For instance, if we fix the domain in the above example to the set *A* (i.e., the set whose members are people), then, at least prima facie, there is no longer a question of being unable to distinguish between the two relations "being acquainted" and "being joined by a line."

Anticipating this reply, Newman argues that even if the domain of the objects has been specified, we are still left with the problem that we must "distinguish between systems of relations that hold among members of a *given* aggregate" (1928, 147; my emphasis). Demopoulos and Friedman elaborate that "[t]his is a difficulty because there is *always* a relation with the [same] structure" (1985, 628–629). Perhaps what is meant here is that isomorphic relations defined over the same domain can yet be different in some important respects. For example, suppose we make another mapping of *A* by painting a line between all, and only those, people that are acquainted. Let us call the resulting structure "C*" and its generating relation "T". Notice that *C** is isomorphic to *A**, which means that they share the same abstract structure, let us call it "S*". Notice also that *C** and *A** have the same set of objects as their domain, viz., set *A*. However, *A** and *C** are generated by different relations—at least if these relations are considered as relations-in-intension. *A** is generated by *R* while *C** is generated by *T*. Thus, knowing the abstract structure S* and fixing the domain to set *A* does not allow us to uniquely pick out the so-called intended relation, whatever that relation may be. But surely, being able to point to the intended relation must be an essential part of scientific enterprise and knowledge.

Newman's other attempt to distinguish between intended and unintended relations takes the form of a distinction between important and unimportant (or trivial) relations. But how is this distinction to be made, Newman asks, if we are to "compare the importance of relations of which nothing is known save their incidence (the same for all of them) in a certain aggregate" (1928, 147). The only way to do that without giving up SR, Newman reasons, would be to take the term "importance" as one of "the prime unanalyzable qualities of the constituents of the world," something he considers completely absurd (1928, 147).

Newman concludes that if we are to avoid trivialization we must surrender "the 'structure/quality' division of knowledge in its strict form" (1928, 147). But to surrender this distinction is to render Russell's SR false. As Demopoulos and Friedman explain "since it is indisputably true that our knowledge of structure is nontrivial—we clearly do not stipulate the holding of the structural properties our theories have—it cannot be the case that our knowledge of the unperceived parts of the world is *purely* structural" (1985, 630).

Finally, a note on the Ramsey sentence: Demopoulos and Friedman recast Newman's objection against the Ramsey sentence approach since the latter is advocated by some as the only way to express structural realism. Their main point is that if a theory Θ is consistent and all its observational consequences true then the truth of Θ's Ramsey sentence is guaranteed and hence structural realism nearly collapses into phenomenalism. Indeed, the only thing separating ESR from phenomenalism, say Demopoulos and Friedman, is the cardinality constraint. This is so because it is taken to say something, i.e., how many types of objects exist, about the unobservable world.

3. Russell's Concession. Shortly after the publication of Newman's paper, Russell wrote him a letter acknowledging that he was wrong in saying that only the structure of the physical world can be known (see Russell 1968, 176). Russell abandoned pure SR in his subsequent work (see for example Russell 1948), and never returned to address Newman's problem.

4. Modern Structural Realists. In recent years the ranks of SR have been growing. Most converts have their own idiosyncratic version of the theory (see, for example, Maxwell 1968, 1970a, 1970b; Worrall 1989, 1994; Redhead 1993, 2001; French 1998, 1999; Ladyman 1998a; French and Ladyman forthcoming; Chakravartty 1998). Beyond realism, even empiricists have expressed interest in the "structural" aspect of SR with Bas van Fraassen (1997, forthcoming) and Otávio Bueno (1999, 2000) branding their antirealist view "empiricist structuralism" and "structural empiricism" respectively. From all of these, the "epistemological" variety of structural realists (i.e., Grover Maxwell, Howard Stein, John Worrall, Michael Redhead, and Elie Zahar), share so much with Russell's SR that it comes as no surprise that Newman's objection would be dusted off and pitted against them (see, for example, Psillos 2001). One of the main differences between Russell and his modern counterparts is that the latter have traded talk about "events" and "percepts" for talk about "entities" and "observation terms/statements," something that we will also be doing for the rest of this paper. Maxwell (1970a) has argued that this move is legitimate by pointing out that Russell's distinction between knowledge by acquaintance and knowledge by description has strong affinities with the distinction between observation and theory that modern structural realists rely on. Though the transition from one framework to the other is not as harmless as Maxwell presents it to be, this issue does not affect the application of Newman's objection to modern structural realists and will not be tackled.

5. Solution. What will be argued for in this section is that upon closer scrutiny the accusation of triviality is itself empty since it fails to establish in what way SR knowledge claims are uninformative. Moreover, it will be argued that the idea that we can uniquely pick out physical relations or indeed their relata is based on a myth.

First of all, it should be admitted that if all the structural realist is arguing for is the idea that there exists a relation with a particular structure, then this is obviously uninformative since it holds merely by appeal to the definition of the concept of structure. But the structural realist is saying something more than this. He is saying that we have an *empirically* identified abstract structure that is, of course, instantiated by many concrete structures (and hence relations). One of these concrete structures represents the physical system under consideration (i.e., the system that is the subject of our observations).

Is the above claim trivial? Before we can answer this question we first need to understand what exactly is meant by the characterization that SR knowledge claims are trivial. Usually, by the term "trivial" we mean that the information on offer is of little or no importance. This, of course, is an issue whose evaluation depends on the criteria employed. So, in what way are the knowledge claims of SR of little worth or importance? The well-rehearsed answer is that the information they offer can also be derived *a priori* from set theory modulo a cardinality constraint, hence the only important information contained in the structural realist claims concerns the cardinality of the domain. This seems to imply that any information contained in a statement that is also derivable a priori lacks importance.

There is a very simple and straightforward reply to this, which can be given with the following example: Take the numbers 133 and 123. I can, restricting myself solely to arithmetic, perform various operations on these numbers. One such operation is addition. Similarly, if I had two collections of 133 and 123 physical objects respectively, I could count them one by one, and would reach the same result. Despite the similarities, there is an important difference between the two cases. The latter case is one in which the result is a property that is then ascribed to the physical world, in particular to the physical objects under consideration, and not merely an exercise of arithmetic. This claim is warranted by the employment of an *empirical method* to arrive at the given number. The main point is quite simple: The fact that arithmetic allows me to do this a priori does not mean that the information that I have reached counting objects is of little or no importance. One need only consider the consequences if I had made an error in counting.

The same argument can be applied to the SR case. Provided that we have the right cardinality we can set up any structure we want a priori just by appeal to the theorems of set theory and in particular Newman's theorem. But we can also reach the same structure a posteriori. Empirical investigation leads us to the discovery of relations between observables. By deduction we get the abstract structures of these relations. Appeal to

Russell's aforementioned assumptions, which are questionable but not the target of Newman's objection, allows us to infer that relations between observables and the corresponding relations between unobservables share the same abstract structures. The *method* of arriving at the abstract structures is at least partly empirical in that the discovery of relations between observables is an empirical matter. The fact that set theory also allows me to derive the same structures a priori does not mean that the information I have reached is devoid of importance.

One further consideration should make the effectiveness of the general point sharper. Using the above *a priori method,* set theory allows us to set up any structure we like. It is a fact of the expressive power of mathematics that it can give us all the structures that satisfy any given cardinality constraint. No structure is privileged in this sense. The structural realist's *a posteriori method* guarantees that some structures are privileged over others. We choose those structures that are instantiated by relations between observables. In the above example, this would be analogous to the fact that although arithmetic allows me to sum any two numbers, there is only one number that can be correctly ascribed to the aggregate of the two collections of physical objects under consideration.

The critic may object that the punch of Newman's objection is that knowing only the abstract structures is not enough. But why is it not enough? Demopoulos and Friedman suggest, borrowing a concept from Quine, that without appeal to a background theory the structure cannot single out the intended from the unintended interpretations:

> From a contemporary, model-theoretic standpoint, this is just the problem of intended versus unintended interpretations: Newman shows that there is always some relation, R, (on the intended domain) with structure W. But if the only constraints on something's being the intended referent of "R" are observational and structural constraints, no such criterion for distinguishing the intended referent of "R" can be given, so that the notion of an intended interpretation is, in Quine's phrase, provided by our background theory, and hence, cannot be a formal or structural notion in Russell's sense. (1985, 633)

Demopoulos and Friedman correctly point out that observational and structural constraints are not sufficient to determine the referent of "R". Indeed, Quine argues that a background theory is required to fix the interpretation. But he also argues that this fixing is by no means absolute. For Quine, a background theory provides an interpretation for the structure of a theory by "picking a new universe for its variables of quantification to range over, and assigning objects from this universe to the names, and choosing subsets of this universe as extensions of the one-place predicates, and so on" (1969, 53–54). Even with a background theory at hand, however, "the intended references of the names and predicates have to be learned rather by ostention, or else by paraphrase in some antecedently familiar vocabulary." But, Quine goes on, "the first of these two ways has proved inconclusive" since it faces the usual problems of the indeterminacy of reference. The second of these then "is our only recourse; and such is ontological relativity." In other words, paraphrasing in some antecedently familiar vocabulary just brings us back to where we started for it is an appeal to another background theory. As Quine notes "[since] questions of reference of the sort we are considering make sense only relative to a background language [or theory], then evidently questions of reference for the background language make sense in turn only relative to a further background language" (1969, 54). That, of course, leads to a regress. The moral of the story is that the very choice of ontology/background theory is a relative matter.

The above illustrates that Demopoulos and Friedman's appeal to Quine, for their claim that we can avoid the problem of unintended interpretations by employing a (nonstructural) background theory, lies on a serious misrepresentation of his work. Ontological relativity shows that we cannot eliminate unintended interpretations altogether, i.e., we cannot uniquely pick out physical relations or indeed their relata. What we can do is impose observational and structural constraints to narrow down the number of unintended interpretations.

Quine draws a similar epistemological lesson to Russell. This comes out clearly in many of his writings.[3] For example in the discussion section of an article by Maxwell he makes the following comment: "One central plank in Professor Maxwell's platform is that our knowledge of the external world consists in a sharing of structure. This is to my mind an important truth, or points towards one" (1968, 161). Also, in a more recent article he says: "The conclusion is that there can be no evidence for one ontology over against another, so long anyway as we can express a one-one correlation between them. Save the structure and you save all" (1992, 8). Hence, far from being critical of SR, as Demopoulos and Friedman have suggested, Quine's views and especially his idea of a relativized background theory lend more credence to it.

The overall claim is not that the problem of unintended interpretations does not pose an epistemic obstacle. Rather, the claim is that it is a kind of obstacle that realists can live with and, if the structural realist or Quinean is right, must live with, for there is no *empirically justifiable* way in which we can uniquely pick out the ontology of the world. A "nonstructural" realist may, of course, object that there are ways in which we can

3. There are differences between Quine's 'global structuralism' view and SR that are not pursued here.

justifiably eliminate underdetermination altogether or at least restrict it even further by appealing to nonstructural considerations. This is a legitimate reply but one that needs to be backed up by evidence. Until that happens the "nonstructural" realist cannot substantiate his claim that SR cannot deliver as much knowledge of the world as can be had.

6. Conclusion. There is no denying that SR, just like any position in the scientific realism debate, faces a multitude of problems. The primary aim of this paper was to provide a reply to one such allegedly fatal problem. It has, I hope, been shown that SR is impervious to Newman's theorem. Thus, to answer the question of whether structure is enough: Once a structure has been singled out through a process of abstraction from relations that are grounded in observations, that structure is not only enough but must be enough for, unless a way can be found to uniquely pick out relations in the world, structure is the most that we can hope for.

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