University of Alberta

Relations All The Way Down?
Exploring the Relata of Ontic Structural Realism

by

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Abstract

An increasing number of realists about science believe that what science really tells us about are the world's structural features. For these realists, then, we should restrict our realist commitments: the theoretical objects described by science are not the kinds of entities towards which we ought to take a stalwart realist stance. Instead, it is the structure in which those objects stand that takes pride of place in our commitments. This is structural realism.

Recent years have seen a growing number of structural realists joining James Ladyman (1998) in defense of the claim that structural realism's best formulation is one which insists that in fact there are no objects. Thus, as Ladyman says, we should commit ourselves to the structure, because that is all there is. This is ontic structural realism (OSR).

Yet, the very presentation of OSR is jarring: How can we have structure, if there are no objects? Here in, I take up the task of providing a coherent metaphysical underpinning which can help to alleviate the tension that arises with OSR's main ontological postulate. After presenting the motivations for OSR, I argue that the metaphysical view that OSR requires can be found within the old warhorse, bundle theory.

I argue that either OSR can embrace the revisionary nature of bundle theory, in which case the task of accounting for the jarring nature of OSR's fundamental claims can be waived; or, one can address

the jarring features of OSR by adopting an infinitism regarding the levels of reality. Such a defense still embraces the bundle theoretic approach, while simultaneously accepting the claim that there is no lowest, most fundamental level of reality.

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Exploring the Relata of Ontic Structural Realism

Introduction

i.1. 'Big Picture' Preamble. As philosophers, we can only very rarely accept the naïve account of things. And, as philosophers, we know that only very rarely is an issue *not* more complicated than it first appears to be. Philosophical issues about the truth of scientific theories prove to be no different, for they are mired in controversy. Trusting that there is this controversy – I'll outline it later – it seems that its presence should give pause to those who accept *every single* claim made by any particular scientific theory. On the flip side of course, the fact that science is so successful should give pause to those who think that science has *nothing* whatsoever to say about reality.

I am, ultimately, optimistic about the capacity of science to capture what the world contains, even though I recognize the need to take pessimistic arguments seriously. Navigating these two concerns – pessimistic and optimistic – is the focus of this dissertation, with a

special concern for presenting and defending two metaphysical bases for the realist view known as Ontological Structural Realism (OSR). OSR arises from considerations surrounding the optimistic and pessimistic concerns that motivate realism; metaphysical concerns for parsimony; and, finally, from concerns within our current scientific theories – especially those in the domain of physics.

Realism about science, which struggles with these three motivations, is a commitment to both the objects of the world as well as the relations. Structural realism, I suggest, can address the optimistic and pessimistic concerns motivating realism. Construed broadly, we might understand structuralism as a stance which defends the claim that our scientific theories capture the form or structure, rather than the content or objects, of the world. Thus, while realism consists of a commitment to both the world's objects as well as its relations, the 'structural' constraint on realism restricts realist commitment to relations only. The 'ontic' twist to structural realism – which addresses the concerns for parsimony, as well as the concerns from current scientific theories (like physics) – further refines structuralism: on this view we are committed to relations only, because there are only relations.

When it was first proposed (Ladyman 1998) OSR met a fair bit of

backlash; it was subject to a number of objections which threatened the very coherence of the view. Recent strides have been taken (e.g., French 2010; Ladyman 2007; Ladyman and Ross 2008) to try to address some of these concerns, but little has been said about how to substantiate the metaphysical underpinning of the OSR. For instance, one central question that will be taken up here is "How are we to understand OSR's claim that the world consists of relations without relata?". Indeed, much of the aforementioned backlash against OSR is directed at this claim for it appears to be incoherent: if there are no relata, how can there be relations? Relations, require relata. This – How can there be relations without relata? - is the '*intelligibility question*', and is the focus of the discussion in the final two chapters of this thesis. My hope is to present and defend two metaphysical accounts which can substantiate the sense in which there can be relations without relata.

i.2. One Proviso. The reader should be aware of the fact that I am not directly concerned with interpreting scientific theories (for which I am not equipped). Rather, my project is to identify the motivations for a certain way of interpreting theories and try to find a metaphysical framework that accommodates these motivations. Accordingly, my approach to this dissertation will be two pronged: first I will outline how

a radical structural realist position might be motivated (chapters 1 and 2); then, I shall outline a prolonged defense of the metaphysics behind this stance (chapters 3 and 4). For this second prong, my proposal shall be disjunctive: either the metaphysical account in the third chapter, or the metaphysical account within the fourth chapter can be adopted to respond to much of the negative backlash against OSR. Before we get to either of these prongs, however, I shall provide a brief outline of the entire discussion ahead.

i.3. Chapter 1: Realism. The focus of the first chapter will be largely introductory. My main task will be to present the realist position, culminate it into one main realist thesis, and present the motivations for adopting a structuralist approach to realism. We shall find that what it means to be a realist is to be committed to both the (sometimes implicit) ontological claims made by our scientific theories, as well as to the claim that we can know something about the ontology of the world. I elaborate on the primary argument for realism, the no miracles argument, which turns out to be an inductive argument for the approximate truth of our theories.

In the same chapter I outline the main argument against realism, the *pessimistic meta-induction*. We shall find that the most threatening

version of the PMI, for realism, is actually not an inductive argument at all but rather an argument which suggests that past theories (which we now consider to be false) undermine the claim that success is linked to truth. Past theories have been successful, yet were false; so we have no reason to think that current successful theories will be true.

While I recognize the force of the pessimistic meta-induction, like others in the literature I think that this objection can be respected – but realism maintained – by turning to some form of structuralism. The final part of the first chapter begins to outline the structuralist position by briefly sketching some key distinctions for structuralism. While I cover a diverse number of distinctions, one important commitment made in this chapter is to the definition of 'structure'. In this work, 'structure' refers to relations.

i.4. Chapter 2: Epistemic Structural Realism. In this chapter I present one way to be a structuralist: epistemic structural realism (ESR). This realist structuralist view insists that we can know about the structure of the world but not about non-structural aspects (like objects). I focus on the positive thesis for this view (i.e., that we can know structure) and the negative thesis for this view (i.e., that we cannot know objects) in order to draw out two major problems for ESR. While neither of the

problems presented will be novel objections to ESR, I do bring together a number of disparate discussions in the (rapidly growing) literature.

The first trouble for ESR that I canvass is drawn from James Ladyman's (1998) seminal paper on ontological structural realism. It draws conclusions from current quantum mechanical theory about the nature of object-hood and individuality. The general point that Ladyman makes is that quantum particles violate the principle of the identity of indiscernibles, and that any realist stance about science had better account for this if it is to be considered a viable realist approach. I present a recent response to this problem (Saunders 2006) which suggests that the conflict between quantum particles and the principle of the identity of indiscernibles is overblown: we can distinguish quantum objects by the asymmetric relation that holds between them. I then present three responses to this line of argument.

The second trouble for ESR is one that derives directly from the adoption of ESR. Thus, while the previous problem was one which could affect any form of scientific realism, this second problem derives directly from the positive and negative theses of ESR. My conclusion will be disjunctive: in trying to get a clear interpretation of the central thesis we shall find that either there is nothing more to ESR than is asserted by scientific realism, or that ESR accepts an idleness – i.e., that

there are metaphysically inaccessible entities - which is highly objectionable.

To conclude the chapter, I gesture at potential solutions to these troubles. One primary suggestion is that we reject the inference from relations to (underlying) intrinsic properties. Thus, we need to accept that 'structure' in our structural realism refers to extrinsic properties. I fill out this account in Chapter 3. The second method for fulfilling the requirements outlined to this point is to allow the inference to underlying intrinsic properties while simultaneously adopting a special stance towards whatever properties are inferred. The special stance, in short, is to suggest that the inferred non-relational intrinsic properties can ultimately be "structuralized" themselves. As we shall see, this will mean allowing the inference to intrinsic properties only on the grounds that those inferred properties can be decomposed, at a different level, into more relations. Ultimately then, this view embraces both substrata and bundles of properties, but at different levels. I shall explore this idea fully in the fourth chapter.

i.5. Chapter 3: Bundle of Relations Theory. In this chapter we get our first taste of the ontological turn that I shall be adopting in order to accommodate all the previously outlined concerns. I begin by developing

an 'ontic' postulate that captures the ontological turn that structural realism seems to require. From the formulation of the ontic postulate, we shall be immediately confronted with an objection that will occupy much of our time for the remainder of the discussion; I formulate this objection in terms of a question, *the intelligibility question,* 'How can there be relations without relata?'.

I then propose to set this troublesome question aside in order to develop the metaphysical position that is strongly suggested at the end of the previous chapter. Interestingly, this position turns out to be a version of a long entrenched metaphysical view, the bundle theory of objects. Suitably modified to respect the previous tensions from the first two chapters, the bundle theory view becomes a bundle of relations (BRT) view. I spend considerable time extolling the virtues of adopting BRT including the *revisionary* stance that the view entails. Significantly, the revisionary approach necessitates that the defender of BRT *refuse* to respond to the *intelligibility question*.

Once BRT is clearly in view, we shall find that a pressing concern has come to light: BRT seems to be committed to the existence of an infinite number of relations. I suggest a solution to this trouble: If a BRT theorist is uncomfortable with the idea of the claim that an infinite number of relations exist, she simply needs to commit herself to the

possibility of a particular kind of entity that I call an 'inner-reaching entity'. This is an entity that is entirely composed of relations, but where each of the composing relations takes others of the composing relations as relata.

i.6. Chapter 4: OSR and Infinitism. The main goal in this chapter is to present and defend a second metaphysical account that OSR might employ. To begin this chapter, however, I address two lacunae from the third chapter. First, I attempt to square BRT with a metaphysical view that involves levels of reality. I suggest that BRT can easily be adapted into such an approach. Second, I suggest that the appeal to inner-reaching entities made in chapter three is potentially troublesome, and that BRT might be better off being committed to an infinite number of relations. But, I further suggest that if this move is acceptable, then there is an alternative metaphysical account that OSR can adopt that is at least partially non-bundle theoretic.

This alternative enjoys a few key benefits. First, it can avoid complete commitment to the revisionary bundle theoretic metaphysics championed in the previous chapter, in exchange for a more traditional metaphysics involving intrinsic properties or substrata when levels of reality are taken in isolation from one another. Such a shift allows the

ontic structural realist's position to be more easily squared with the position adopted by the traditional metaphysician. The second, benefit (related to the first) is that the shift allows for a response to the intelligibility question. Both of these advantages are afforded the OSR position by a re-appraisal of the ontic postulate. Thus, I suggest that we reject the suggestion that we formulate the ontic postulate in terms of fundamentality. This shift in understanding is completed while bearing in mind the broader metaphysical desire to account for the world in terms of levels of reality. I then spell out what the ontology of such a view might look like, using the approach of two other theorists (Esfeld and Lam 2008) as a jumping off point.

These benefits, however, have a consequence, what I call *metaphysical infinitism* (or *infinitism,* for short), which is the view that there are an infinite number of hierarchical levels which make up the world. Specifically, this alternative approach to OSR's metaphysics which embraces the revised ontological postulate of the fourth chapter commits the structuralist to defending the claim that there is no lowest fundamental level of reality. While this might seem *prima facie* troubling, I shall argue that there is no reason to view this consequence as too costly. Thus, part of my task to close out the discussion of the that chapter will be to legitimate this metaphysical implication.

Chapter 1

Scientific Realism:

The Road to Structuralism

1.1 Realism

1.1.1. Preamble: Realism, Idealism, and Science. Broadly construed, 'realism' is intended to contrast with 'idealism'. Both of these are stances concerning the putative existence of an external, mind-independent world. As most of us know, for the idealist there is no external mind-independent world: everything that is, exists in a (perceiving) mind. If there were no minds, then there would be no external world. The realist denies this. What there is in the world does not depend on the existence of perceiving minds: it exists mind-independently. This is the metaphysical commitment of realism *simpliciter*.[1] Often realism is coupled with an epistemological commitment, to the effect that we can *know,* at least some of the time, something about these mind-independent entities; though, this condition is not a necessary

1 Realism in the sense that I am discussing here should not be confused with the semantic realism (T-realism, hence forth). The latter consists of the claim that what makes a sentence true is its correspondence with the world. So to hold to T-realism about the claim 'Barack Obama is the 44 President' is to believe that the state of the world is such that it makes that claim true (or false). T-realism is compatible with idealism or realism, because all that T-realism requires is that the world make the sentence true or false. It does not require that the world be mind-independent or mind-dependent; "Barack Obama is the 44th President" can as easily be true of a world of ideas, as it can be true of a mind-independent world.

component or realism.

I am a realist: I think there is a mind-independent world. And, I subscribe to the epistemic addition as well: we can know something about this mind-independent world. But when I announce that I am also a *scientific* realist, I mean something more than that I am a realist *simpliciter*. To be a scientific realist is to believe that the world is something like how our scientific theories tells us it is. Being a realist *simpliciter*, then, does not commit one to scientific realism.

Scientific realism, however, does imply realism. One cannot be a realist about science, and an idealist about the world. This is because to be a scientific realist is to accept that what science tells us about the world is accurate. And, (almost) every scientific theory explains phenomena by stipulating that *there are* certain mind-independent entities. Think about a simplified theory behind the workings of an atomic bomb: splitting atoms, it is claimed, releases neutrons which can then go on to split other atoms, releasing more neutrons which split more atoms, and so on. A high number of split atoms in a short period of time results in the devastating explosion due to the huge release of energy.

A scientific realist understands this account as asserting that these entities – e.g., neutrons, atoms – exist mind-independently. Thus,

scientific realism entails realism *simpliciter*. Of course, there is an epistemic aspect to scientific realism as well which parallels the epistemic aspect realism *simpliciter*: we can know (some of the time) the nature of the unobservable world, as revealed by science. Henceforth, I'll use 'realism' to refer to *scientific* realism which includes this epistemic commitment.

1.2 Scientific Realism: Specifications and Arguments

1.2.1. Scientific Realism. 'Realism' as I am using the term, can be initially captured by Richard Boyd: "Scientific realists hold that the characteristic product of successful scientific research is knowledge of largely theory-independent phenomena and that such knowledge is possible (indeed actual) even in those cases in which the relevant phenomena are not, in any non-question-begging sense, observable" (Boyd 2008). On the face of it, this is a *purely* epistemic formulation which mimics Hilary Putnam (1978) who claimed that realism encompasses two claims: 1) the belief that scientific theories are approximately true; and that 2) key theoretical terms are genuinely referential.[2]

More recent formulations have made an attempt to highlight the

2 Putnam (1978, 20). Importantly, Putnam limits realism to mature theories. I shall address this refinement shortly.

metaphysical aspects of realism, however. Stathis Psillos (1999), much the same as I, takes a metaphysical thesis to be an important aspect of realism; indeed a metaphysical component is one of three theses of realism for Psillos. And, Anjan Chakravartty (2007) explicitly links scientific realism both to realism *simpliciter* as well as a metaphysical component when he says that scientific realism is "the view that scientific theories describe the nature of a *mind-independent world*" (2007, 4; emphasis added). Finally, James Ladyman (somewhat ironically) explicates the metaphysical implications of science when he states, "Hence, if the theories employ terms that purport to refer to unobservable entities such as electrons, or gravitational waves, then... we ought to believe that there really are such entities having the properties and exhibiting the behaviour attributed to them" (2008, 57). Importantly, then, realism has moved beyond an emphasis on the mere epistemological commitment to entities, towards an ontological component. I think it is important to bear both of the these commitments in mind.

Realism, then, encompasses the following two theses (at least):

Epistemological Thesis **-** Our best scientific theories are *approximately* true, allowing us knowledge of

> (at least some of) the theoretical entities to which they refer.

> ***Metaphysical Thesis*** **-** Our best scientific theories give an *approximately* true account of what the world is like. (Psillos 1999, xix)[3]

I have not yet given reason for the inclusion of the "approximately" in "approximately true" in either of these theses. Nor have I adjusted realism so that it is able to accommodate the pessimistic induction which I have yet to introduce. I shall address both of these concerns in turn. First, however, for reasons of economy, let me combine the epistemological and metaphysical theses. We shall see this single formulation in the coming chapters:

> ***Scientific Realism*** - The world has mind-independent, objective features which are revealed to us (in approximate form) by scientific theories.

3 Psillos adds a third thesis, a semantic thesis. This thesis holds that theories are "truth-conditioned descriptions descriptions of their intended domain, both observable and unobservable." I agree that this thesis should be included but have indiscriminately run it together with the epistemological thesis because my primary focus will be on the metaphysical thesis.

1.2.2. Clarifications. As we have just seen, scientific realism involves a commitment to the *approximate* truth of our theories; to the existence of the mind-independent world as revealed by scientific theories; and to the potential to know *something* about these theoretical aspects. I shall take it as my task, currently, to explain the "approximate" clause before I get to arguments for realism as well as the crucial refinements in the face of pessimistic complaints.

One key feature of the realist stance is the humility that must play a central role. The "in approximate form", in ***Scientific Realism*** has two important senses that are meant to capture this humility. First, scientific theories appeal to laws. These laws are typically formulated mathematically, but are almost *always* idealizations or "ceteris paribus" laws. They capture the phenomena so long as we make certain simplifying assumptions about the situation. Take the ideal gas law: this describes the behaviour of gases under the two assumptions that the interactions of molecules are perfectly elastic, and that there is no intermolecular attractive forces. Neither of these assumptions are strictly speaking true; but given how successful the ideal gas law is in accounting for observable phenomena, we say that gases are covered by a law which *approximates* the ideal gas law.

Second, theories are dynamic. That is, they are often slightly modified to account for new phenomena. Accordingly, only the most naïve realist about science would suppose that the science of the current day is an exact account of the world. In fact, given that theories change as new phenomena arise, the realist about science would be wise to agree that current theories will be only partially similar to the theories of the years to come. Nevertheless the realist about science takes refuge in the fact that as scientists progress, accounting for new phenomena and modifying the theories, the theories *converge* on truth. Thus, the commitment to the "approximately" clause is also the realist's attempt to remain dynamically realistic in the face of theory modification.[4] With these points in mind, we can turn to the motivations one might have for being a realist.

1.2.3. Arguments for Realism: the NMA.[5] Realist intuitions are buttressed really only by one argument, the *no miracles argument* (NMA), which can be drawn from a passage in Hilary Putnam:

4 The realist has to account for a more pressing issue of the same flavour: the pessimistic meta-induction (PMI). This objection differs from the one just mentioned. Though I discuss the PMI in detail in sections to come, it's important to understand the difference. The PMI, but not the current 'theory-modification' concern, questions the connection that novel predictive success has with truth. Thus, the PMI is a direct assault on the realist's reasons for being a realist, and not merely a recognition of the process of science.

5 I refrain from offering a strict formulation of the NMA. This is not because one is not available (see, e.g., Psillos 1999); an earlier version can be found in J.C. Smart (1963)), but because my interests lay with exploring the structural realist position.

> "The positive argument for realism is that it is the only philosophy that does not make the success of science a miracle. That terms in mature scientific theories typically refer, ...that the theories accepted in a mature science are typically approximately true, that the same terms can refer to the same entities even when they occur in different theories – these statements are viewed not as necessary truths but as part of the only scientific explanation of the success of science, and hence as part of any adequate description of science and its related objects." (1978, 73)

This passage highlights some key features of the NMA. To begin, the NMA is an empirical argument: the (contingent) *fact* that our theories are highly successful at predicting observable results can be explained, and is *best* explained, by concluding that our theories are (approximately) true. Thus the NMA is an *abductive* argument: an inference to the best explanation (IBE) (cf., Psillos 1999). It is also, importantly, a contrastive argument: there are a number of ways that we might explain the fact that science can make successful predictions.

So, we might think that an explanation can be found along instrumentalist lines; if so, then theories would be *merely useful tools* for describing the observable outcomes. Or, we might suggest that theories accurately reflect the nature of the world; if so, then the theories' truth explains why they are so successful at predicting outcomes. The NMA claims that this second option, truth, is the *best* explanation, in the face of anti-realist, instrumentalist, alternatives.

But the denial of miracles is not a denial of miracles *tout court*. That is, the line that 'realism is the best explanation' applies to only *some* theories, not all theories. There is some debate just how to parse the theories for which the NMA is applicable and those for which it is not. Perhaps the best place to start is to note that the theories for which the acceptance of 'miracles' seems anathema are those which are *well confirmed* and *mature* theories. As my focus is elsewhere (i.e., ontic structuralism), I shall simply utilize an intuitive sense of what it means to be 'mature' as it has been characterized by Psillos. Mature theories are theories which

> “have passed the 'take-off point' (Boyd) of a specific discipline. This 'take-off point' can be characterized by the presence of a body of well-entrenched background beliefs

> about the domain of inquiry which, in effect, delineate the boundaries of that domain, inform theoretical research and constrain the proposal of theories and hypotheses. This corpus of beliefs gives a broad identity to the discipline by being, normally, the common ground that rival theories of the phenomena under investigation share." (Psillos 1999, 107-8)

Two Types of Confirmation. While maturity can be left to our intuitions, more needs to be said about confirmation. A theory can be well confirmed in two important senses. The first type of confirmation is the prediction of 1) previously known observable outcomes; the second is the prediction of 2) heretofore unknown (or unobserved) phenomena. Consider the Newtonian law of gravitation, which tells us that any two objects in the universe attract each other with a force that is proportional to the product of their masses, and inversely proportional to the square of the distance between the two. We can represent this law mathematically[6] and use this equation to 'predict', for example, where Mercury has appeared, and where it will appear, in night sky. Because Mercury's appearance in certain regions of the sky is 'expected'

6 The equation: $F_g = G[(m_1 \times m_2)/ r^2]$, where 'G' is the gravitational constant; 'm_1' and 'm_2' are the masses of the objects; and 'r' is the distance between the two objects.

or known before-hand , this is an example of type (1) success.

Perhaps this kind of success is not surprising at all. Some have claimed just this. The rise of a new theory had better keep in mind the scientific environment in which it is conceived because if it fails to do so, the theory is bound to fall short of accounting for that which our current theories already can account. And, in fact, the construction of new theories typically proceeds with specific phenomena in mind: If you know that there is an anomaly for current theories, then one way to account for this is to adjust one's background theories, methods, and current pet theory to accommodate for the anomaly. Thus, type (1) success is capable of being "built in" to a theory from the beginning. But if we can build success – at least type (1) success – into our theories, then there should be no surprise when the theory is successful; there is no miracle! If realist intuitions are going to be motivating then, they had better not be based solely on type (1) success.

Enter type (2) success, which cannot be dismissed by the anti-realist as easily. Type (2) success – *novel* predictive success – can be seen by considering the same theory, Newton's law of gravitation. In the 1800's, Neptune was the farthest known planet from the sun. And, for all the planets except Neptune, it was possible to chart accurately their orbital-positions. Neptune's actual observed location, however, varied

from the location suggested on its chart; it wasn't where it *should* be, according to the theory. As we all know, these discrepancies lead certain astronomers to postulate the existence of a planet further from the sun than Neptune, which was effecting the latter's orbit. We now know this planet as Uranus, and it was first observed because astronomers were able to use the discrepancies and Newton's laws in order to calculate where Uranus *should* be. This is *novel* predictive success: if Newton's laws are correct, then we could explain the anomalies in Neptune's orbit by stipulating that another planet (Uranus) farther from the sun, which was the cause of these discrepancies. Further, if the laws were correct, then they could be used to calculate the exact location of the 'new' planet, and thus allow us to locate it in a some specific region of the night sky. How could all this novel prediction be possible if Newton's laws are anything but true?

Consider another oft cited case of novel predictive (i.e., type 2) success: Poisson's prediction, derived form Fresnel's wave theory of light, of a bright spot in the center of a shadow cast by a perfectly round disc. This followed, according to Poisson, from Fresnel's characterization of light as transverse ocillatory motion in a mechanical ether. Poisson took this to be a *reductio* of Fresnel's theory (see e.g., Worrall 1989; Carrier 1991). Despite expectations, however, experiments *confirmed* Poisson's

prediction: A light spot at the center of a shadow cast by a disc was observed. This too is an example of novel predictive success.

A little clarification is best. These cases are examples of novel predictive success because the theories are either i) accounting for anomalies that they were not designed to explain – *use novelty*; or ii) predicting the occurrence of wholly new phenomena - *temporal novelty*.[7] Newton's advance accounted for some previous anomalies (i.e., irregular orbits as caused by another orbiting body) even though Newton's work was not developed with these specific anomalies in mind. So too, Fresnel's postulation of light as an oscillating entity in ether explains why the light spot at the center of a shadow cast by a disc should appear. But, Fresnel's case is special for it is only by stipulating that light had a certain nature (i.e., as transverse ocillatory motion in ether) that the light spot could have been predicted in the first place. The theory surely was not designed to produce the 'white spot' consequence, yet the world and the theory coincide. This is novel predictive success; and this strongly suggests the approximate truth of the theory.[8]

One could disagree that novel success, either 'use' or 'temporal', of mature theories is significant. Recall that the realist stance is

7 This defense can be found in Worrall (2007).

8 A useful way to characterize type (2) success then is to follow Worrall (2007): a theory has novel success if it is able to account for phenomena that it was not constructed to handle.

contrastive: either realism explains novel predictive success of mature theories or some other explanation does, e.g., the theory that we 'got lucky'. Those who disagree that novel success indicates truth seem to be happy to accept the second of these contrasts. Thus, some important recent motivations for this skepticism about realism are fueled by claims similar to those made by Kyle Stanford, to the effect that there is something self-defeating or *ad hoc* about insisting that not only success, but *novel* success of *mature* theories *requires* the truth of theories. He suggests, further, that we need a good reason to accept that these extra criteria are somehow better at 'picking out' true theories. He says:

> "Of course, *bare* appeals to maturity and/ or success threaten to undermine the explanationist defense of realism itself.... The point of that defense, after all, was that the empirical success of our scientific theories was supposed to demand the truth of those theories as its best or only explanation.... If we now insist that further conditions must be satisfied in order to trigger this explanatory demand, we will need a principled rationale for why just that sort of success remains a reliable indicator of the truth of the theories that enjoy

> it, when others that equally excited our initial admiration and credence failed to do so." (Stanford 2006, 144)

Consider a broad account of the dynamics of the discussion up to this point. We began with the realists about science. They initially were excited by the remarkable success that theories enjoy, and concluded that this is best explained by appealing to the truth of theories. In response to pessimistic appeals to the litany of theories that are false but which enjoyed success (more on this presently) – like the crystalline spheres of ancient and medieval astronomy; or the humoral theory of medicine; or the effluvial theory of static electricity (see Psillos 1999, 101-102) – the realist suggests that the initial position which focused merely on success should not have been quite what the realists were excited about; instead, they should have reserved themselves for those theories that were mature and novelly successful. But, now Stanford enters asking the telling question: What is it about novelty and maturity that links the theory to truth?

One way to respond to Stanford's complaint would be to run through the probabilities for such theories being true. Thus, we could consider the mature novelly successful theories and show how they were

more likely to turn out to be true that the merely successful ones. If mature novelly successful theories turn out to be more likely to be true theories than the merely successful theories then we would have some reason for believing that maturity and novelty were linked to truth in a way that mere success was not. It is not clear that such as argument can be made, however. (And if it could, there are certainly many others better equipped to make it than I.)

We might pursue another avenue, however. I suggested earlier that there were two kinds of 'novelty', (i) and (ii), present in the two examples I used in my discussion of confirmation. Recall that we have (i) *use novelty* and (ii) *temporal novely*. We see temporal novelty in the Fresnel case: the light spot phenomenon was unknown prior to its derivation from the theory; thus when the experiment was conducted and the spot observed, we get a novel success of the theory. But of course, the idea of temporal novelty engenders all kinds of troublesome contingencies. If another experimenter had, by happenstance, observed the spot on the disc that Fresnel's theory predicts, then the spot would not be a novel prediction, even if Fresnel was not aware of the spot himself. This, and similar reasons, prompt the introduction of the second type of novelty, *use novelty*. We see this novelty in the Newton-Neptune case: the irregular orbits were already known to Newton but

because he did not use these phenomena to construct of his theory, I suggested that they confirmed his theory's truth.

Stanford is looking for a reason to believe that novelty of both types is connected to truth. We might question, though, whether novelty picks out true theories or merely 'weeds out' the likely false and surely *ad hoc* theories. Thus, when I said novelty suggests the truth of the theories, I was mistaken: the successes suggest the truth of the theory, while the novel aspects ensure that the theory is less likely to be false or gerrymandered. If this is right, we will have two potential responses. We might suggest that both types of novelty serve this elimination role, or that only one type of novelty (presumably the temporal kind) plays the 'truth' role, while the other plays the elimination role.

Prima facie, the second response has pull to it. It just seems obvious to suggest that temporal novelty connects a theory to truth. Surely, it would be ridiculous to argue it is anything but a confirmation of the theory: it was, for example, highly unlikely (indeed, deemed an absurdity) that the spot would appear under the conditions of the experiment; so, its appearance indicates that truth of the theory, *pace* Stanford. Of course, taking this line means embracing the contingencies that allowed this phenomenon to be, truly, *temporally* novel – something

which should make theorists more than a little uncomfortable given that "there is at most a difference in *degree* between use novelty and temporal novelty" (Psillos 1999, 107).

The first proposal – that both use and temporal novelty eliminate false theories - seems more promising. If we hold that the two kinds of novelty are really akin, then we could suggest that this united front seeks not to include the true theories, but to exclude the false ones. This is all the more promising when we realize that (at least) one prominent writer introduces the idea of novelty in contrast to the idea of *ad hoc* theory construction. Thus, Psillos says: "...any theory (and for that matter, any wild speculation) can be made to fit the facts – and hence to be successful – simply by 'writing' the right kind of empirical consequences into it" (1999, 105). This kind of accommodation of facts, where we 'write in' the consequences, is surely *ad hoc* and should not invite considerations of truth-connections.[9] But theories which lack the types of novelties addressed here are surely similar to the *ad hoc* ones we seek to exclude. If they do not 'do more' than old theories, if they do not predict something 'unknown' then surely they are likely candidates for falsity. Perhaps then, theories that are successful but not novelly so, are akin to *ad hoc*, massaged, and sometimes wild speculations which will likely fall short of truth.

9 See Psillos (1999, 106-107) for a full elaboration of *ad hoc* conditions.

We might buttress these ideas by considering an example I shall call *the lotto case*. Imagine that you buy a lottery ticket and win. Imagine, also, that this is your *tenth* consecutive win of the same lottery. Most, I think, would be highly suspicious of someone who wins ten times in a row, and would be therefore reluctant to ascribe these wins merely to a lucky streak. They would instead insist that the gambler is cheating.

Winning in the lottery case is like the theory that enjoys theoretical success: a proper prediction is like winning the prize money. The gambler cheating is akin to theoretical truth. Cheating gives the gambler control that allows him to successfully manipulate the lotto numbers drawn (or, adjust the numbers he plays to those he knows will be drawn), just as the truth of the theory give that theory the edge in predictions. The theory 'knows' the answers, and so 'guesses' the outcome correctly. It is a slightly unfortunate example, however. Truth is the noble goal of science; while cheating, the ignoble goal of (some) gamblers – but the case is clear nonetheless.

If the appeal to novel success of theories is not meant to capture truth, but to weed out *ad hoc* or false theories instead, then the appropriate analogue in the lotto case would be the restriction of gamblers to those not related to the organizers of the lottery itself (or

something similar). So we have two permutations for the lotto case: the first permutation has the gambler buying ten tickets, winning each time, while not being related to the organizers of the lottery. We think he is a cheater, but a *crafty* one, given that he doesn't have an "inside man". In the second permutation we have the ten time winner *with* an inside man as he is related to the lottery organizers. This gambler is a cheater, but a *lazy* one. Lazy cheaters are not the kind of cheaters that a gambler should want to be; the goal, instead, should be *crafty* cheating, because crafty cheaters will survive longer.

The question in the lotto case is, Which of the cheaters are the crafty ones? While the question for the theories is, Which are the true ones? We weed out the non-contenders, in the lotto case, by limiting ticket buyers to those who hold no familial relations to the lotto organizers. We weed out non-contenders in science by raising the bar to novel success (of mature theories). If this is coherent, then novel success matters for science not because it picks out true theories but because it eliminates false ones from contention.

1.2.4. Arguments Against Realism: The Bankruptcy of Science and PMI. One of the main attacks on realism and the NMA questions the link between successful prediction and truth. There are (perhaps) two routes

one may travel in this vein, the most common of which has gained the title *the pessimistic meta-induction* (PMI). The PMI claims that a theory can be successful while being thoroughly false. This attack provides a list of specific historical examples from science to make its case. While I shall not recount the list here (see, e.g., Psillos 1999, 101-2) we have seen two such examples already when we discussed luck and control. Before we examine the PMI, though, we should consider a less successful inductive version. I shall call this argument the '*bankruptcy of science*.'

The bankruptcy of science suggests that there are many theories that we now take to be false, but which we once took to be true. From this evidence, it seems reasonable to wonder the likelihood that our *current* theories are true. In fact, the argument suggests that we have very good reasons to expect that our current theories will be discarded. This is because every theory we have employed thus far has turned out to be false. If all the theories postulated thus far have been discarded, why expect anything different for the ones we hold currently? Inductively, the vast majority of theories have been discarded and replaced by radically different theories; thus, we can expect our current theories to suffer the same fate. So, realism is false.

If this were the only complaint against realism, then the realist would have little to worry about, because as it turns out the conclusion

that our current theories are (very likely) false actually depends on the *base rate fallacy*. It is best to consider an example which is removed from the realist debate in order to illuminate the fallacy.[10] Assume there is a disease, D, which can be reliably detected before any symptoms develop. Assume further that if someone has D she tests positive, P, all of the time; also assume that someone *without* the disease has a very small chance that he too will test positive (i.e., they produce a false-positive test result). In other words, assume

I) P(Px|Dx) = 1

II) P(Px|~Dx) = 0.05

(where Px is 'tests positive for the disease'; Dx is 'has the disease'; and "~" is the symbol for negation. Thus, (I) reads "the probability that x tests positive for the disease (Px) given that he has the disease (Dx) is 1").

We can ask: if someone tests positive for the disease, what's the probability that she actually has it? Given that there is a 0.05 probability that the test is mistaken, many are inclined to say that probability is quite high (around .95) that she has the disease when she tests positive. But, this is mistaken, because we have to consider the nature of the

10 Here, I follow Magnus and Callendar (2004, 324-5)

sample from which the person who tested positive was drawn. If the disease is *rare*, let's say "only 1 in 1000 people has the disease, then given the assumptions above [(I) and (II)] we should expect about 51 in 1000 to test positive. Of those 51 who test positive, only 1 will actually have the disease" (Magnus and Callendar 2004, 325). One out of 51, however is a mere 0.02 probability that she has the disease. This is dramatically different than the 0.95 probability that we assigned earlier! It is this assumption – thinking that the probability of having the disease is high, given that a reliable test deemed you to have the disease, while ignoring the frequency of the disease in the overall population – that is the base rate fallacy.

The applicability of this reasoning to the *bankruptcy of science* argument is straight forward. We are not permitted to conclude from the history of science that it is quite likely that our current scientific theories are false, unless we can determine the base rate of true theories to begin with. But how can we determine this? We can not figure out the base rate from a consideration of *past* theories: those theories *were* successful and false, but they could be false just because they were past theories. *W*hen it comes to current theories, it is perfectly compatible that these – in virtue of being current theories – are true, even when the previous set of theories are all false. Of course,

it would seem that we have no way to decide one way or the other: if we knew that some theory was drawn from mostly true theories, or mostly false theories, then realism would not be open for questioning. Regardless, *the bankruptcy of science* shouldn't be a compelling reason to reject realism.

The pessimistic meta-induction, on the other hand, promises something more for the anti-realist. Here the claim is not an induction from past falsity to the falsity of current theories. Instead, the objection focuses on the host of past false theories which, yet, were successful and suggests that these undermine the link that is claimed to exist, by realists, between success and truth. Recall: the NMA argued that *the best way* to explain the success of science was by the truth of the theories. This linked success with truthful representation of the world. The PMI questions this link: how can truth be the best explanation of success, when we have successful theories that have been false?

We could phrase the PMI, as just stated, in terms of a *reductio* (following Peter Lewis (2001, 373); and Saatsi (2005, 1089)):

1. Assume that success of a theory is a reliable test for its truth.
2. So most current successful scientific theories are

true.

3. Then most past scientific theories are false, since they differ from current successful theories in significant ways.
4. But, many of our past theories were also successful.
5. So, (1) is false: i.e., successfulness of a theory is not a reliable test for its truth (otherwise 3 and 4 contradict).[11]

How might the realist respond to such an argument? First, he needs to recognize that what is questioned here is the connection between success as a *reliable* indicator of truth. This argument is *not* an induction towards the falsity of our current theories despite the fact that prominent authors in the field have construed it that way (cf. Psillos 1999, Ch. 5). Thus, the PMI (as here formulated, at least) is not susceptible to the *base rate fallacy.* (So, calling it the pessimistic meta-*induction* is perhaps misleading: nevertheless, I will stick with tradition.)

The realist can gauge how successful this argument is, if she bears in mind the NMA's focus on the success of *mature*, *predictively*

11 I have closely followed Saatsi's formulation and wording here. Also, for Lewis, premise 3 is presented in two stages. The difference is inconsequential for the overall argument, however.

successful theories, yet again. Orienting ourselves this way will significantly narrow down the list of theories that one is able to give as examples supporting (4).[12] Still, this narrowing does not do away with the list entirely. We must contend with the Phlogiston theory, caloric theory of heat, and (more generally) some ether theories (like Fresnel's wave theory of light) which were all novelly predictively successful while false; they were novelly successful, as we have seen, because they account for phenomena that they i) were not constructed to handle or ii) were not theretofore known. And, they are false, of course, because they incorporate key ontological temrs (i.e., phlogiston, caloric, and ethers) which are (apparently) non-referential.

1.2.5. Realist Responses. If the PMI is correct, then we have no reason to think that the success of our current theories is any indication that they truthfully represent the way the world is. Of course, if the reader is anything like I am, the PMI will not have silenced the nagging voice that presented the NMA: *something* has to be going right for our theories to be successful. Recall that this intuition is roughly the idea that luck is a poor explanation when the theory is mature and affords novel success. Does the PMI, then, undermine the non-chancy explanations that are

12 For Laudan's initial list of theories that undermined the realist stance, see Laudan (1996); for a reduced list that respects the realist position, see Psillos (1999, ch. 5).

suggested by the evidence supporting the mature, novelly successful theories?

I think truth as an explanation of the successes of science is still viable. In fact, as many authors have noted (e.g., Chakravartty 2007; Psillos 1999; Worrall 1989) we can respect the claims of the PMI without undermining the realist intuition as a whole by recognizing the limitation of both what the PMI demonstrates, as well as what the NMA supports. I propose to follow the line taken by most realists who have faced these familiar challenges: admit that the PMI undermines only *some* claims to truth. Thus, a viable realist stance will restrict the realist commitment to *some* theoretical aspects of theories which avoid the grasp of the pessimistic meta-induction, but which nevertheless support the intuition that luck is not a reasonable explanation of a theory's success.

The current task is to provide a sketch of the possible routes one might take in trying to fulfill these desiderata. The options that are open seem to be three fold. The realist who wants to respect the PMI and the NMA can be committed only to:

I. Some of the *objects* postulated by theories. Call this Entity Realism (ER)[13];

13 I shall use 'ER' to refer to both entity realism as well as the entity realist as the context dictates. I will follow the same practice for other abbreviations as well (e.g., SR, ESR, OSR)

II. Some of the *structures* postulated by theories. Call this structural realism (SR); or

III. Some *entities*, and some *structural* aspects of theories. Call this 'Semirealism' (Chakravartty 2007).

At least *prima facie*, there do not seem to be good reasons to adopt ER. After all, it is the PMI's insight that we lose theoretical entities with theory change that stirs pessimistic concerns. Still, entity realists attempt to circumvent these problems by refining their commitments to only those entities that we can causally manipulate. Thus, as Mohamed Elsamahi (1994) characterizes the position, entity realists believe in an entity if there is a "relevant experiment that utilizes the entity" (175). The greater degree of manipulability we have over the entity, the greater degree of belief we can have in the entity itself. The characteristic account for ER, then, is Ian Hacking's position towards electrons: "so far as I am concerned, if you can spray them then they are real" (Hacking 1983, 23).

This focus on manipulation, or 'intervening', is a turn away from 'representing'. That is, the entity realist concerns herself more with the manipulation of entities rather than with the theory that describes those entities that we manipulate. The benefits of such a shift should be

obvious. First, it seems intuitive to say that if we can 'spray' the entities at one time then regardless of the pet scientific theory of the time, we should be able to 'spray' them in the future. Thus, it would seem that theory change should not raise pessimistic troubles for manipulated entities. Moreover, because ER refrains from commitment to the theories themselves, changes between theories should not be problematic.

As the focus of this dissertation is elsewhere, let me merely suggest a few problems which ER would have to solve, were it to count as a realist contender. To begin, it seems that ER needs to be especially careful in spelling out the manipulation requirement. After all, it seems possible to interpret the actions of scientists as the manipulation of entities, even though those entities do not actually exist. Thus, while no entity realist would want to assert its existence, there is a sense in which we can understand phlogiston as being manipulated. After all, we are privy to suggestive descriptions: "Calxes or ores, are normally poor in phlogiston, and they become lustrous, ductile and good heat conductors -- thus metallic -- when *impregnated* with it" (Kuhn 1983, 675; emphasis added). 'Impregnating' a calx with phlogiston sounds remarkably like *manipulating* phlogiston. But, if this can be understood as the manipulation of phlogiston then the connection that ER wants to draw between existence and manipulation becomes tenuous.

Naturally, we should be careful not to read too much into the use of 'impregnated' from this passage given that scientists can often be mistaken about what it is that they are doing in an experiment.[14] Nevertheless, the challenge is clear: for ER to be tenable it needs to establish a method for distinguishing the occurrence of the legitimate manipulation of an entity from the cases that only seem like we are manipulating entities. Worse, even if this issue can be handled the entity realist's insistence that we can mark a clear division between entities and entities *as described by theories* seems problematic. Is it really coherent, for example, to conceive of the electron independently of the theories and the theory laden experiments that describe the electron's behaviour (see, e.g. Elsamahi 1994; Chakravartty 1998)? This is especially troubling when we take into account the fact that "the meanings of entity terms are to some extent defined by the theories in which they occur" (Chakravartty 1998, 393). Thus, it is troublesome to suggest that we can be committed to an entity without, *ipso facto*, being committed to the theory that describes the entity. In light of these troubles, then, I propose to set ER aside in favour of exploring a structuralist approach.

Accordingly, I shall also set aside *Semirealism*. It is, of course,

14 In this light, see Carrier (1991) who reports on Antoine Lavoisier's experiments. Lavoisier, apparently, took himself to be 'manipulating' phlogiston: As Carrier says for Lavoisier, "the calx took up phlogiston thereby turning it into a metal" (32).

disingenuous (to Chakravartty at least) to lump together *all* realists who maintain that we can be committed to some of both the structure and objects that a theory describes, because the positions vary greatly. However, given that my focus is on ontological structuralism, let me just say here that it should be obvious that a general version of the first challenge raised for ER's account of manipulation can be raised for *Semirealism*: to maintain objects in some form, *Semirealism* will need to be very careful about which entities it admits.[15]

Furthermore, as we see in Chapter 2 section 2.3.1, I will reject the *Semirealist's* inference to underlying intrinsic properties, and then present metaphysical positions in the third and fourth chapters which can underpin this rejection. I take the coherence of each of these accounts to be a significant step in overcoming the suggestion that the *Semirealist* position is the best way to proceed for the realist. I out line that argument further in Chapter 3, section 3.4.2.[16]

The route I shall take here is the SR approach, for it promises to alleviate some of the pressure to which these views are subject by refocusing away from the objects. Thus, structural realism holds that

15 Those familiar with the literature know that the attempt to maintain at least some objects has lead some authors down troublesome roads when developing the criteria for realist commitment. One of the most prominent is Psillos' (1999) account which has us look to the *attitudes* of the scientists who worked with the theory.

16 Also, I think it is important to note that all theories that allow objects in their ontology will have to contend with the troubles raised in the next chapter regarding quantum physics underdetermination of individuality. Thus, both *Semirealism* and ER alike will have to address that trouble (see Chapter 2, section 2.2.1).

our theories correctly describe the way that the world is put together, and further that this is what supports the NMA intuition. That is, it is our theories' accurate account of the connections between things, rather than a theories' account of the things themselves, which can account for the idea that our theories are achieving more than luck. While I shall be exploring in more detail the accounts of structural realism in the coming chapters, it will be useful to discuss here what I intend when I say that a theory gets the structure of the world correct.

1.3 Structure

1.3.1. Structure: Concrete and Abstract. Informally, structure is a set of relations between elements. The (worn) examples in the literature are revealing: the painting's structure is composed of the brush strokes (the objects) beside, on top of, beneath, and around one another (the specific relations); A house's structure is composed of the materials (e.g., the wood and nails) relating in certain ways; or, the structure of the soccer team is made up of the the players – keeper, full backs, half backs, and strikers - on the pitch. These examples pick out *concrete* structures.

We can begin to identify *abstract* structures by a focusing on only the relations in concrete structures. Abstract away the specific players

on the pitch, putting 'placeholders' in their spot; abstract away the pitch itself: Neither the players' names, nor the green-ness of the pitch remains behind. What remains, instead, is the formal structure of the soccer team itself (e.g., 4-4-2, 5-3-2, 3-4-3, etc.). So too with the structure of the painting and the house: take away the nails and wood, take away the paint and the colors, and what remains are relations that hold between placeholders.

Abstracted structures like this will, some of the time, be identical to one another. The abstracted structure of the LRT line in Edmonton can be identical to the abstracted structure of a straight line-point drawing I can construct so long as the drawing I construct has the right number of "station" nodes. In this vein, then, we can actually *identify* a specific abstract structure with an equivalence class. Thus, an abstract structure is a set of isomorphisms on that structure, i.e., a set where each structure in the set has elements that can be mapped bijectively, one to one, onto another structure in the set while still preserving the relations between the elements.

Some (Chakravartty 2007) have insisted that the concrete-abstract distinction is highly important. Indeed, they have insisted that structural realists need to be committed to *concrete* structures, because realists "aspire to the knowledge of the concrete" (2007, 41). In reply, French

(2006), French and Ladyman (1999; 2003) and Ladyman and Ross (2008) have all argued that the distinction itself can be rejected, because of the blurring of the line by physics. The authors insist that the abstract mathematical structures *just* are the physical reality: What there are to the quantum objects really are just whatever the quantum physical equations can tell you. (And, as it turns out, what they 'tell you' is entirely structural information) (see, especially, French and Ladyman 2003). As we shall see presently, I support an account of (metaphysical) structure as *properties*. What this means for the distinction between concrete and abstract properties I leave of others to determine. My own thoughts are that the distinction can be rejected on the grounds offered above, but that the commitment to properties makes the distinction a non-issue.

1.3.2 Invariance. I left implicit in the development of the idea of abstract structure the crucial role of invariance which *identified* abstract structure. Recall: abstract structures are *sets* of isomorphic structures which *preserve the relations* (i.e., in which the relations are invariant) despite a change from entity to entity. The importance of invariance has been suggested by numerous authors, however, even outside the discussions of structural realism.[17]

17 Cf. Koslicki (2008) and North (2009).

Consider a simple geometric example to illustrate the usefulness of invariance for capturing structure. Take a specific square. Its four corners will have specific relations to one another which help to produce the squares 'structure'. If we rotate the square 180 degrees around a point in its center, we have changed some facts about the square – the corners that were on the 'left' are now on the 'right,' and vice versa; the 'top' points are now 'bottom' points, and vice versa; etc. But, the structure of the square remains invariant: rotations preserve the relations between corners.

We can also see invariance as central in other accounts of structure. Any piece of music is going to be structured such that each note will be related to the rest of the notes in crucial ways. These relations are what the performers must preserve between performances in order for separate instances to count as instances of the same piece. They can only be two performances of, e.g., Shostakovitch's 8th string quartet if all these relations are invariant between performances. Of course the notes in the two performances will be different *tokens,* played by different musicians, and the conductor may choose to change the tone/ pitch of the piece, but the crucial relations will have remained invariant across transformations.

As I made clear at the beginning of this section on structure, my

structural realism commits me to relations. We know, too, that relations can exist in both abstract and concrete structures (if there is such a distinction). I suggest that all the *invariant* relations/ properties will be candidates for realist belief. The task is to determine *which* of the relations and properties are invariant, and to which we have access.

1.3.3. Structure: Representation. It is important to keep clear the distinction between the *representation* of structure and a *metaphysical* account of structure. This distinction reminds us that there are ways of *talking about* structure as well as the structure itself.

Representation of scientific theories in the philosophy of science typically takes one of two forms, syntactic or semantic.[18] The syntactic view of theories understands a theory as a set of propositions and laws. The adaptation of the syntactic representation of theories to structuralist ends has seen some (e.g., Worrall 2007) propose that we capture the importance of 'structure' by taking the Ramsey sentence of the theory. This procedure takes the expression of theory,

T: $(T_1, T_2, \ldots T_n; O_1, O_2, \ldots O_n)$

18 There is also the 'category-theoretic' as proposed by Elaine Landry (2007), but I shall not address this modification.

(where the T_x's are the theoretical terms, and the O_x's are the observational terms) and replaces all the theoretical claims with a variable and a quantifier governing those variables. Thus, we get,

$$\mathbf{T^R}\text{: } \exists t_1, \exists t_2, \ldots \exists t_n \, (t_1, t_2, \ldots t_n; O_1, O_2, \ldots O_n)$$

which tells us, for each t_n that there is something-or-other that stands in some relation to the O('s). This syntactic approach to the structure of theories allows one to reduce the focus on the entities of the theory, emphasizing the structure between them because of this shift away from specific entities.

Two points to note: First, it is commonly (yet mistakenly) assumed that the Ramsey approach to representing structure *trivializes* our knowledge of the world. This is the well known Newman objection: because a Ramsey sentence tells us only of the higher-order properties among whatever objects there are, no unique structure will be picked out. It is a matter of second order logic that any structure can fit the Ramsey sentence, *so long as it has the right number of objects*. Thus, the objection runs, all the Ramsey sentence approach can really tell us about the world is the trivial fact of cardinality. Melia and Saatsi (2006), however, convincingly suggest that this conclusion in fact relies on a set

of assumptions that the structuralist need not, and should not, accept.[19]

Second, and more importantly, it is sometimes objected (Ladyman 1998; 2008) that the syntactic approach (via Ramseyfication) is not a viable approach for a successful structural realism because a Ramseyfied theory still admits that there are entities *of some kind*, even though it attempts to remain silent about just what those entities are like. This is because entities seem to be what the PMI grabs onto in its pessimistic move: the successful but false theories claimed that phlogiston, caloric, and ether exist even though we reject these now. If our approach keeps entities, even in a reduced form, it is likely going to leave itself open to the PMI complaints. This is the complaint in Ladyman (1998). Thus, while Ramseyfying a theory does seem to 'reduce' objects – it refers to no object *in particular* – it does not seem to get us far enough away from them to pay due respect to the pessimistic pull.

The semantic approach to representing structure suggests that theories, rather than being sets of propositions, employs non-linguistic entities like sets of models.[20] It has been argued that the semantic approach to theories is more apt for the structural realist's endeavors

19 I cannot, nor do I wish to, get into the discussion on this issue. See Melia and Saatsi (2006). See also French and Saatsi (2004).

20 These models, however, can be described in multiple ways. See French and Ladyman (1999), as well as French and Saatsi (2004) who give an account of the relationship between the linguistic and the model theoretic components of the semantic approach. The latter also argue that the semantic approach to theories can avoid the underlying issues to the Newman problem.

because the very nature of the view highlights structure. Models, after all, are structures. A toy example helps: Watson and Crick's DNA model made from tin and wire explicitly demonstrates that DNA is understood (by these two at least) as a double helix *structure*.

Of equal importance is the notion of invariance that re-enters with the semantic approach and the use of models. Both the specific model created by Watson and Crick, and an actual DNA strand have invariants in common. Independent of what specifically composes this double helix, tin and wire as in the model; or, nucleic acids and nucleotides as in actual DNA, the relations that compose the 'twisted ladder' remain constant across instantiations. Thus, the semantic approach seems suited to help pick out the important features of theories.

Other 'models' can be found by looking to graph theory. Graphs have nodes or vertices. These are connected to one-another (or themselves) via edges which can be directed or undirected. The vertices typically hold the place of objects, while the edges represent the relations between the objects. A trivial example of a graph can be produced by considering a seating order enforced over the holidays for dinner.

At a round table, 6 people are arranged at a circular table such

that they have the relation 'sitting next to' to two others at the table. In this case we can build a model of the situation which looks like Figure 1.1. *Structure* is clearly presented by this model: Each node is a 'seat holder', each edge a relation that captures the *constraints* of sitting beside someone else. The idea of a constraint is important: just who sits in which seat does not matter, *per se*. What is important is that each person sit beside two others.

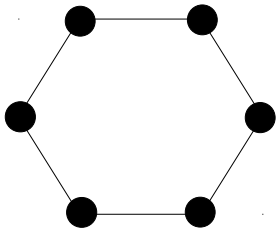


Figure 1.1

Of course, these examples make clear that the semantic view also relies on 'objects' somewhat, for one cannot construct a model without the nodes. Thus, it is perhaps fair to press the semantic view in a similar manner to how the Ramseyfied syntactic view was pressed: is the semantic view of theories suited for the structuralist aim if she chooses to move away from troublesome objects? While these questions are important, I will not answer them here. I am instead interested not in how we represent structure, but in defending a plausible account of a metaphysics of structure.

1.3.4. Structure: Metaphysics. Just what part (or parts) of the world count as its structure has historically been queued by the mathematics of scientific theories. Worrall's (1989) paper is one contemporary account that makes this kind of appeal. Still, we cannot merely point to the equations of the theories themselves and suggest that they indicate the 'structure' of the world for a couple of reasons. First, many non-realists are going to latch onto the mathematics of theories suggesting that it is the fact that these equations are correctly formulated which contributes to the theories' successfulness (even while concordantly denying that this success indicates the equations represent underlying reality). Thus, the realist has to offer a *realist* interpretation of these equations (cf. Chakravartty 2007; French 2003; Ladyman 1998). She has to say what it is about the equations about which we can be realists; and as a structural realist, what she says in this regard has to pick out what she takes the structure of the world to be.

The second issue deals with structuralism. If we want to give a structuralist account of all scientific theories then we cannot merely gesture to the mathematical formulae while suggesting that 'structure' is whatever these formulae represent, because not all scientific theories are formulated mathematically (see, Chakravartty 2007). Not only is this still too vague to be a useful account of which parts of the world are the

structural parts, but also this will not be helpful for those non-mathematized sciences. We need to say more.

As a first approximation of a metaphysics of structure then, we must move beyond the mathematics. I propose looking at three suggestions from a very recent paper (French 2010) which are only briefly canvassed. On one approach, structures are relations (or, n-adic properties). Construing structure as relations can have its advantages: relations seem to be what are captured by our theories. And, this seems to be compatible with both methods of representations of structure, semantic and syntactic. Moreover, relations seem to lie beneath appeals to mathematical formulae.

Of course, as both French (*ibid.*) and Chakravartty (2007) note, if we take structure to be (first and / or second-order) relations we (seem to) *need* relata (i.e., an intrinsic property or a property bearer), for it seems impossible to have something that *relates* without that which it relates. Yet, these relata look a lot like what the PMI might grab onto to make its attacks on the link between success and truth. As I have already said (mimicking Ladyman 1998), if our structural realism keeps too much of objects then 'going structural' will not have respected the pessimistic induction's force.

I'll more to say about this issue in the chapters to come, but let

me gesture briefly at those chapters now to help with the forgoing discussion. Ultimately, I shall claim that the most tenable version of structural realism will reject the object-oriented approach, adopting a wholly "structural" metaphysics. In its most basic formulation ontic structural realism (OSR) holds that there are only relations. Immediately we can sense a conflict. I claim that structure is best understood as relations, and that OSR is the best form of structuralism. But, some suggest, because OSR rejects the existence of relata (i.e., intrinsic properties or substrata), the structure cannot be the worldly relations.

To alleviate the tension here, one might employ French's second suggestion. Assume for the moment that relations require something to be related. Now the proposal is to equate structure with relations, but place relations on an ontological par with the things related. Michael Esfeld and Vincent Lam both defend this position, which they call moderate ontic realism (Esfeld 2003; Esfeld and Lam 2008), as one way to defend OSR. French hints that "it is not clear that [the position] is stable" (2010, 4). In the fourth chapter, I suggest that the position is not unstable, but that it makes commitments that run counter to the motivations for OSR itself. In light of this trouble, I develop an alternative way to defend OSR which moves away from the notion of fundamentality. (A full explanation of both of these points will have to

wait until the final, fourth, chapter.)

The last option to which French gestures is one which tries to monopolize on relations taken as *primitive*. With relations as primitive, the troubles of the first view (i.e., with the mere acceptance of relations) is overcome because, presumably, we no longer need relata in order to have the relations. Of course, French's account cannot be taken verbatim here: clearly, to have relations one *must* have relata (*qua* an entity related). Instead, what seems to be being suggested is that we take relations as primitive, and then demonstrate how they do not need any *non-relational* relata. Donald Mertz (2006) has developed a comprehensive account of relations as primitive in this sense. In chapter 3, I will suggest alternative motivations to Mertz's for taking relations as primitive. In short, I argue that scientific experiments give us cause to believe in relations because that is all of which we are 'directly' aware. We shall also find that a long entrenched metaphysical view – bundle theory – will be the perfect ground for this kind of an appeal to relations as primitive. For now, however, the important point to take away from the present discussion is that a successful account of structure will be in terms of relations – or so I contend.

1.4 Conclusion

1.4.1. Final Remarks. We now have a grasp of the arguments for an against the realist movement. We have seen that I take the most promising route of realism to be the structuralist one, where structure is understood as 'relations'. Our next task, then, will be to explore one way of fulfilling the structuralist requirement, Epistemic structural realism. I will offer what I take to be two good reasons to doubt that this approach to realism can be successful.

Chapter 2

Epistemic Structural Realism

2.1 Epistemic Structural Realism

2.1.1. Introduction. In the previous chapter I outlined the motivation for being a realist, viz., the no miracles argument. I also sketched one of the main objections to realism, the pessimistic meta-induction. I submitted that both of these arguments have legitimate force behind them. Despite this, I suggested that it is possible to respect both by adopting structural realism (SR).[21] A first approximation of SR will take ***Scientific Realism*** as its starting point, adjusting it with a structuralist constraint which I shall call ***Structuralism***. The first approximation of SR, then, consists of the following two theses:

> ***Scientific Realism*** - The world has mind-independent, objective features which are revealed to us (in approximate form) by scientific theories.

21 As in the previous chapter, I will use 'SR' rather loosely to mean both 'structural realism' as well as 'structural realist', according to the context. So too with the soon to be introduced 'ESR'.

Structuralism - Scientific theories reveal to us the structural features of the world.

Where we should go from here is a matter of much controversy, for it is unclear what status the putative theoretical *objects* are supposed to have. For, if ***Structuralism*** is correct, science reveals to us the relations in the world; but, this says nothing about the status of the objects which stand in those relations. Thus, a central question to any structural realism is, What about the objects – can we know these too? And if we can know them, how much about them can we know? Everything there is to know, or only some things? If we can only know some things, which?

In order to explore the answers to these queries, let us return briefly to the contemporary father of SR, John Worrall (1989). For Worrall, SR grows out of considerations of a case study: the theoretical shift from Fresnel's to Maxwell's theory of light. Peculiarly, this shift is often taken as a paradigmatic reason to be an *anti-realist* about science because despite the significant predictive success of both theories, they differed dramatically regarding the theoretical entities that they posited. For Fresnel, light was a disturbance in an ether; on Maxwell's

theory (in its final form), light was a disturbance in an electromagnetic field.[22] This shift was "a fundamental change in the accepted account of the basic structure of light... [for,] instead of vibrations carried through an elastic medium, it becomes a series of wave like changes in a disembodied electromagnetic field" (Worrall 1989, 108). Thus, because it is a stretch (to politely understate the issue) to assume that the ether and the electromagnetic field are really the same entity across theories, anti-realists suggest that this dramatic theoretical shift undermines any truth claims.

Yet, Worrall thinks the example is more promising for the realist than the anti-realist allows because of the underlying continuity of "*form* or *structure*, [even if] not of content" (1989, 117) between these theories. This shift, that is, exhibits *structural realism* because the behavior of light in the Maxwell's theory (the later), obeys formally similar laws to those that light in Fresnel's theory (the earlier) obey, despite the dramatic change in 'furniture' from an ether to an electromagnetic field. Thus, Worrall says, Fresnel was wrong about light's nature (i.e., wave-like), but right about light's structure (i.e., that it required oscillation of something at right angles to it) (Worrall

22 As Worrall (1989, 108) notes, Maxwell himself did believe in an ether through which light propagated. However, all his attempts to reduce the electromagnetic field to the ether failed; soon the electromagnetic field was taken as a primitive.

1989, 118).[23]

Despite the fact that Worrall's initial presentation of structuralism is generally regarded as dramatically underdeveloped[24], he is commonly read as committing to an epistemic formulation of structuralism. The hints of this *epistemic* variation comes from passages of his earlier work, as when he says:

> "From the standpoint of this superseding theory, Fresnel was quite wrong about the nature of light.... Nonetheless Fresnel was quite right not just about a whole range of optical phenomena but right that these phenomena depend on something or other that undergoes periodic change at right angles to the light." (Worrall 1989, 119-120)

Embedded in this passage is the suggestion that this epistemic approach can be fruitfully portrayed as making a *positive* and a *negative*

23 Worrall points out two other important features. First, we can find Fresnel's light equations adopted, in tact, into Maxwell's theory. This is indicative of the theories' grasp on the structure of the world – even in the face of radical ontological shift. Second, the 'carry over' of equations in exact form is an *atypical* occurrence. Normally equations are not held over in tact from theory to theory. Yet as Worrall also notes, one typical occurrence is to find the equations of superseded theories as the limiting cases of the equations of the superseding theories, as when we find Newton's equations appearing as the limiting cases of Einstein's.

24 This is no criticism, of course. Worrall notes that his remarks are introductory and need further development.

realist claim (cf. Chakravartty 2007). The positive claim is that we *can* know the structure of the world; the negative claim is that we *cannot* know the nature of the objects. Taking this as the basis for the construal of the epistemic form of structural realism, we might add the ***Epistemic*** thesis to the previous two realist theses, giving us Epistemic Structural Realism (ESR).

Epistemic - we cannot *know* the nature of objects,
but we can know the structure of the world.

Let's illuminate the positive and negative claims of ESR a little more. First the positive assertion: 1) Our mature scientific theories are predictively successful because they truthfully capture the structure (i.e., relations) of the world. Thus, all that we can reasonably expect to be carried over across theory change are the structural components and these are the components which ground our realist intuition, the NMA. While Worrall urges that these structures should be *whatever* are represented by the mathematical formalisms, I have proposed in chapter 1 that we understand structure explicitly as the world's relations instead.

The negative feature suggests that 2) we should refrain from 'all-

out' commitment to theories, at least in so far as objects or underlying natures are concerned, just because what makes our scientific theories successful is merely their capacity to capture *structural* features *and nothing else*; it is not the capacity to describe the nature of objects that contributes to a theory's success, so we should not be committed to those aspects.

ESR does justice to the NMA with (1). If we think that there is *nothing* true about our theories, then the fact that they are mature, well confirmed theories that are highly predictively successful can *only* be explained by invoking luck. ESR avoids luck by attributing the predictive success to the theory's (approximately) truthful representation of the world's actual relations. That is, because we have retained structure from past theories, we can expect to retain structure from current (and future) theories.

Yet, ESR respects the PMI with (2), the restraint from objects. The PMI requires (at least) that not everything about our theories can be true, or else the fact that the history of science is a graveyard for past theories will not be given its due regard. By restricting our commitment to structure (i.e., the relations) on the grounds that it is structure which contributes to the predictive success of theories, while refraining from commitment to fickle objects like the ether, phlogiston, and caloric, we

can have the best of both worlds: bits of the old theories *are* in the graveyard and these bits can be expected to be in the graveyard in the future. But the fact that these parts are discarded is not troublesome, for we never had good grounds to say we knew their natures anyways.

Let's return to the questions with which we began: What of objects? How much can we know, if anything? ESR councils a limited epistemic stance: we can know some, but not all there is to know about objects because this is the best way to respect the pressures with which the non-structural realisms have to deal. Not surprisingly, however, controversy still exists regarding whether or not ESR is the best form of structuralism to pay respect to both the NMA and the PMI. Indeed, a couple of problems with ESR have encouraged a growing number of people to find an alternative to the epistemic structuralist variant. The details of the alternative form of structuralism, known as ontological structural realism (OSR) will be spelled out in the next chapter. For now, we shall focus on two of the most telling objections to ESR. The objections center around crucial tenets of the view; if they are legitimate complaints, ESR cannot be a tenable version of realism.

2.2 Two Troubles for ESR.

2.2.1. Quantum Theory and the PII. One of the first problems that has

been used to suggest an ontological turn to structural realism, is the problem of underdetermination of individuals by quantum theory. This problem concerns quantum theory and the principle of the identity of indiscernibles (henceforth PII, or 'the principle'); it is well rehearsed in the literature, so I'll be brief in its presentation. The PII claims that if for any property P an object *x* has P if and only if an object *y* has P, then *x* and *y* are identical.[25] Alternatively, and more perspicuously, we might say that for different objects to be discernibly different, they must differ in some respect.[26]

Quantum particles (QPs) seem to violate the principle. Consider fermions: each has the same state independent properties – the same charge, half integer-spin, and same mass. And when they are entangled (i.e., in the singlet state) we cannot properly ascribe to them a position in space-time either, so even this cannot serve to distinguish them (Ladyman 1998). Thus, even though there are *two* fermions in the singlet state – the claim goes – the fermions have no properties which make them physically discernible: the two objects do *not*, after all, have *any* distinguishing properties. Thus, PII is violated.

Some (Ladyman 1998; French and Ladyman 2003) have suggested

25 Symbolically: $\forall x \forall y [\forall P(Px \leftrightarrow Py) \rightarrow x=y]$

26 This is to be distinguished from Leibniz's Law, sometimes also called the 'indiscernibility of identicals', which states that for any object x and any object y, if x is identical to y then for any property P, x has P if and only if y has P. Symbolically: $\forall x \forall y [(x=y) \rightarrow \forall P(Px \leftrightarrow Py)]$

that this leaves a dilemma. Because the QPs' individuality is violated, either the QPs are non-individuals or they are a *special* kind of individual: the kind that violates the PII. Worse, the obstacles that QPs pose for PII are heightened, for the decision between these two options is dramatically undermined; we have no good reasons to choose one option over the other. This is a pressing concern for scientific realists because the category of object-hood and individuality is fundamental to the realist's position. We might ask then, What kind of a realist can one really claim to be if one cannot even answer questions about the fundamental nature of reality.[27]

Of course this issue drops off if we do away with the object ontology altogether, which is a move we find exploited by ontological structural realism (see chapter 3). As ontological structural realists, we will not have to say whether QPs are special individuals or non-individuals because we will instead reject the underlying metaphysical framework that gives rise to the underdetermination. Replace object-metaphysics with structure-metaphysics and it no longer makes sense to ask what kind of objects these troublesome particles are. Of course, ESR does not propose to do this. Instead, that view is fully embedded in the metaphysical tradition which embraces object-hood. Thus, ESR – just as any other 'traditional' realism – has a very real dilemma on its hands

27 Cf., van Fraassen (1991).

which undercuts any impetus one might find to support the view.

This supposed underdetermination has not gone unchallenged, however. One of the most potentially damning responses comes from Simon Saunders (2006) who suggests that the impact of quantum theory and PII has been over-emphasized. There is no underdetermination, he claims, because QPs are actually distinguishable individuals. As I left the issue above there was good reason to believe that quantum theory produced a dilemma – QPs as *special* individuals or non-individuals – which motivates a shift away from a traditional object ontology. Yet Saunders (op. cit.), as well as Ladyman (2005) and Ladyman (2007), provide reasons to reject this dilemma.[28]

To see how these authors have tried to avoid the underdetermination dilemma, imagine there are two objects that stand in a two-place irreflexive relation to one-another. This is a condition Saunders calls *weak discernibility*. Any two objects any spatial distance apart will fulfill this condition; regardless of which other relations an object stands in, regardless of what properties each has independent of the other, spatially separate entities will be weakly discernible because each will be x units from the other other without being x units from itself. Thus, even entities which have all the same properties will be discernible, according to Saunders, just so long as they are *weakly*

28 Ladyman, with Bigaj, (2010) has since changed his tune yet again. See below.

discernible. Importantly, however, spatial separation is not the only relation that fits the weak discernibility bill.

Quantum particles, Saunders notes, are weakly discernible because there is an irreflexive relation that holds between two fermions which discerns them. That relation is *having the opposite spin of*. This relation discerns the individual QPs because each will have the opposite spin from the other, but not from itself. Thus, weak discernibility can (potentially) diffuse the underdetermination of individuality problem. Accordingly, the motivation to shift towards an ontological structuralism appears lost.

There are three responses available. First, we can accept Saunders' argument that fermions are objects because they can be weakly discerned, while nevertheless being able to take solace in two facts: 1) even for Saunders, some QPs are not objects. Thus we have bosons which cannot even be weakly discerned when they are in the singlet state. But, 2) further solace can be found in an observation due to Ladyman, who urges us to recognize an important feature of weak discernibility:

> "while Saunders' view vindicates an ontology of individuals in the context of Quantum Mechanics, it is a

> thoroughly structuralist one in so far as objects are not assumed to be individuated independently of the nexus of relations in which they stand. Rather they are contextually individuated." (Ladyman 2007, 31)

Even if Saunders is correct in defending the plausibility of weak discernibility - even if QPs are distinguishable objects - QPs are still very unlike the individuals which we encounter in everyday life. Quantum 'objects' have the special feature of being distinguishable *only* via their relations; they are not individuals *except* insofar as they enter into specific relations. This means that the quantum physical level is inextricably structural. Thus whatever relata we take there to be, we must take them to be characterizable *wholly* by relations alone.

Perhaps this is not enough. If so, those who want to maintain a non-traditional metaphysics (like structuralism) can adopt the second of our three response: an appeal to a recent argument presented by Muller (2011) which promises to flip the dependence relations between the 'intrinsic properties' and the relations of QPs. So, in a traditional metaphysics, relations depend upon intrinsic properties. Yet, Muller suggests that the intrinsic properties of fermions (e.g., charge, mass) are derivable from the structural (i.e., relational) aspects of theories

regarding QPs. As Muller says, "[mass and spin-magnitude] are thus determined by symmetry relations, which makes them acceptable for the structural realist" (Muller 2011, 232).

If this is the case, Saunders' weak discernibility proposal is actually turned into "an ally" of OSR (*ibid*.) because the supposed intrinsic properties of QPs actually depend upon the structural aspects of those QPs. If Muller is correct, he allows us to safely conclude that the lessons to be learned are nearly what James Ladyman first proposed them to be: accounting for our current scientific theories – especially quantum mechanics – requires taking a thoroughly structural turn in our realism about science. What is most fundamental about objects is not the intrinsic properties – as tradition would have it – but rather the relations of those objects. Thus objects are not eliminated, but they are taken down from their pedestal; they are nothing more than collections of structure.

The third and final response (to be considered here) to Saunders' weak discernibility claim is simply to deny that relations can discern entities (even weakly). In brief the response is that relations cannot individuate because they *presuppose* distinct individuals. This type of argument has been made by Edwin Allaire (1965) in his discussion on bare particulars. Here, Allaire wants to claim that two things which

agree in all their properties cannot be *two* things unless there is an individuating difference between them. For him, what individuates an entity is that entity's 'bare particular' i.e., a substance.

V.C. Chappell (1964) has objected, claiming that we need not have bare particulars to individuate two things even if they agree in all their properties: all we need is a difference in relations. So for instance, even if an entity has all the same properties as some other entity these two entities can be differentiated if, e.g., one is to the left of the other. The similarity with Saunders' suggestion is obvious, 'being to the left of' weakly discerns the two objects. Thus Chappell's response is analogous to the QP difference 'having the opposite spin of'.

And yet Allaire has a simple seemingly devastating response to Chappell:

> "Relations... *presuppose* numerical difference, they do not account for it. The *thisness* and the *thatness* of things is presupposed in saying that *the one* is left of *the other*. Were it not, then in at least some cases we would be forced to say what we all know to be false; namely that the same *thing* is left of itself." (1964, 261; original emphasis)

We can divorce this response from Allaire's metaphysical agenda of haecceitties, and still have a telling response to Saunders. To describe a relation is to presuppose two things from the beginning. Thus, we cannot use relations to distinguish the entities in question; their use begs the question. And because Allaire could just as easily have discussed how two fermions having opposite spins presuppose their individuality, Saunders seems open to Allaire's complaint. Accordingly Saunders' claim that two fermions instantiating the relation 'having the opposite spin of' begs the question: *this* entity cannot have the opposite spin of *that* entity unless we first presuppose that there is a *this* and *that*.

We might push this response to Saunders a little further by renewing our focus on the importance of PII – something which was lost in the previous dialogue between Allaire and Chappell. The principle of identity of indiscernibles concerns *physical discernibility* and this has empirical import: what matters is not that these objects are in principle *distinguishable,* but that they are actually *discernible*.[29]

Indeed, the empirical import of the PII is why we normally limit the types of properties that allowably fall under the principle's rubric. Hence, the so called 'impure' properties (e.g., 'being identical with *A*')

29 See Ladyman and Bigaj (2010) for an argument to this effect.

and the naming, or 'labeling', properties are barred from inclusion because they trivialize PII: no object except one, object *A* itself, will have the property 'being identical with *A*', just as no object except one can be picked out by 'Socrates' - so we should exclude these properties from the scope of *the principle*.

A focus on physical discernibility, however, potentially undercuts the *discerning* role that relations are supposed to play. Consider two objects that are absolutely indiscernible, A and B, but which can be *putatively* weakly discerned by the relation '*having the opposite spin of*'. *Pace* Saunders there is no way that we will be able to *physically* discern one from the other despite the spin difference, for if we were to subject the two-object system to a re-ordering – that is if we were to swap the places of the two fermions – there would be *no* way to tell that the swap had been made. Obviously they *would* be discernible if before and after the swap we were able to tell that *this* fermion had 'up' spin and *that one* 'down' spin; in this latter hypothetical case, the swap produces a discernible state because the switched locations of the 'up' and 'down' spin fermions would be noticeable: before 'up' spin was in quadrant 1, now it is in quadrant 2. Yet this is not the case with entangled fermions. We know that they have opposite spin from one another, but not which one has which spin, up or down. Thus, swapping of fermions does not

produce a discernible difference in the world – and so *weak discernibility* is insufficient to solve the underdetermination problem that arises with PII and QPs.[30]

Ladyman and Bigaj (2010) note this succinctly in a footnote: "when we consider the fact that an irreflexive relation between object A and B is perfectly compatible with the existence of an automorphism of the physical structure containing the object that maps A to B [it is clear that] the complete structure remains the same under the exchange of objects" (2010, 130 fn). Given this, we are pressed to explain how these putative objects are *discernible*. Thus I conclude that despite Saunders' claims to the contrary, QPs are not discernible entities and that the individuality of these particles is underdetermined.

* * * * *

The dialectic here has been long and arduous; let me recap. We started with the claim that the nature of QPs undermined the realist stance because individuality is central to the realist project, and this is underdetermined. I suggested that a shift to the thoroughgoing structuralism of OSR serves as a panacea to the problem. But Saunders was quick to retort with a suggestion that QPs are objects after all,

30 Ladyman and Bigaj (2010) accept that weak discernibility establishes numerical distinctness – even if it falls short of discernibility. Michael Esfeld defends a version of OSR that adopts numerical distinction of metaphysically reduced objects; I shall discuss his account in Chapter 4.

because they are weakly discernible. Three responses were then offered. The first and second could work in tandem. First, we could accept Saunders' claims and argue that this is still in the ontological structuralist's favour because objects are still fundamentally structural (à lá Ladyman); second, we could support this by suggesting that all of the properties of QPs are derivable from their structural properties anyways (à lá Muller). Finally, the third response was to undermine the whole discussion prompted by Saunders, suggesting that weak discernibility begs the question. Thus, I suggested that that weak discernibility is actually insufficient to *discern* individual QPs despite Saunders' initially plausible argument to the contrary.

Regardless of the option pursued, however, ESR seems ill equipped to deal with the underdetermination of the individuality of QPs. Even if we accept that Saunders' proposal is (somewhat) correct (as I am inclined to do), we still get objects that are at the fundamental level structural entities. This raises an issue for ESR's claim that we know the 'underlying natures' of objects. 1) If we can know the structure of the world but we cannot know the nature of the underlying objects (according to ESR); and, 2) objects are *fundamentally* structural (i.e., characterized solely in terms of relations); then 3) what is left to the realm of the unknown, as ESR requires? There is no reason, as far as I

can see, to accept that there is an unknowable realm of natures given that we can describe objects entirely in structural terms.

Of course to pursue the above line is to accept the weakest of options available to those who reject ESR. The strongest response rejects that weak discernibility can establish the individuality of QPs. To take this line is to defend the original position from Ladyman (1998) where the individuality of objects is underdetermined; this underdetermination requires some response from the realist position. Taking an ontological turn in one's structuralism is that response, as we shall see in chapter 3.

2.2.2. ESR's Central Thesis. Now I want to turn our attention towards ESR's central thesis: the epistemic commitment to structures coupled with an epistemic abstinence from objects. ESR's very conceptual tenability hinges on this distinction, hence, it has been called ESR's "central thesis" (Chakravartty 2007, 42). I shall expand the potential readings of the central thesis momentarily. For now, I want to anticipate the conclusions that I hope to reach. My conclusion will be disjunctive: in trying to get a clear interpretation of the central thesis we shall find that either there is nothing more to ESR than is asserted by scientific realism, or that ESR accepts an idleness – i.e., that there are

metaphysically idle entities - which is highly objectionable. Let us see how these conclusions can be reached.

The central thesis derives from Worrall's assertion that ESR "insists that it is a mistake to think that we can ever 'understand' the *nature* of the basic furniture of the universe" (1989, 122) even though we *can* understand the universe's structure. It is a matter of some uncertainty how exactly we are to understand 'nature' in this passage. In concert with other authors, I suggest that 'nature' is best understood as 'objects', which in turn has two readings: property bearers (i.e., substrata); or intrinsic properties. This provides three possible readings of the central thesis (Psillos 2001, S19):

1. We can know everything except the property bearers that instantiate a definite structure;
2. We can know everything except the property bearers and their intrinsic properties;
3. We can know everything except the property bearers, their intrinsic properties, and their relations.

We can begin by noting that (3) *cannot* be what epistemic structural realists intend by the central thesis. Given the commitment to

knowledge of structure, and given that 'structure' is to be cashed out as relations, (3)'s denial of the knowledge of relations makes it explicitly *non-structuralist*. (Indeed, I am unsure just what is left if we deny knowledge of relations, intrinsic properties, and bearers.) So, the central thesis must be understood as either (1) or (2). We shall address each of these in turn.

Is ESR tenable if we deny knowledge of the bearers of properties (i.e., if we formulate the central thesis as (1))? No, for the mere denial of knowledge of the bearers is not enough to distinguish ESR from problematic forms of scientific realism. Consider why. One common form of scientific realism accepts that there are no underlying property bearers. That is, it accepts the bundle theoretic approach to objects. On such an approach, because there are no underlying bearers it is impossible to know them; thus if *this* is the denial that ESR hopes to maintain, then it is nothing more than a version of scientific realism.

We find something like this bundle theoretic approach to scientific realism in Psillos (1999), at least as I interpret him. He says:

> "[T]o say what an entity *is* is to show *how this entity is structured:* what are its properties, in what relations it stands to other objects, etc. An exhaustive specification

> of this set of properties leaves nothing left out. Any talk of something else remaining uncaptured when this specification is made is, I think, obscure." (1999, 156-7)

It is possible, however, that Psillos supports the so called 'traditional metaphysics' in this passage. Thus we could, on the basis of this passage, ascribe to Psillos the view that there *are* bearers of properties, but that in virtue of the fact that we can know both intrinsic and relational properties of those bearers *we can know something about the bearers themselves*. On this interpretation, we can understand Psillos as claiming that ESR is false: there is no epistemic divide between structure and nature when 'nature' is understood as property bearers because knowledge of intrinsic properties and relations *entails* knowledge of the bearers themselves.[31]

On either interpretation of (1) then, ESR collapses into scientific realism. Scientists provide a list of properties and at least some of those properties tell us what relations the objects stand in. But this leaves nothing to be agnostic about: if there are *bearers* we get to know them through our knowledge of properties; and if there are only properties

31 We might reject this implication. If we do then bearers of properties are taken to be fundamentally unknowable. For this to be true, bearers turn out to be fundamentally causally idle. After all, if they were causally efficacious then these bearers would not be *fundamentally* unknowable, just coincidentally unknown. I address this form of idleness below.

(because the bundle theory is true), there is nothing to be agnostic about because nothing else exists. In either case, there is no epistemic divide between structure and nature so the central thesis falls through.

What if we interpret the central thesis as (2), the claim that we know neither the bearers nor the intrinsic properties? A focus on nature *qua* intrinsic properties seems like the obvious watering hole for ESR. After all, this would create the clear divide that the position requires: 'nature' includes all the intrinsic properties and the bearers, and structure includes the relations between those properties. If so, we might understand (2) colloquially as claiming that we can know the "relation descriptions" of objects. This is surely less than the property descriptions of objects that we would get from (1), because relation descriptions tell us only what relations the objects stand in; thus, this prevents ESR from slipping into scientific realism, and provides the humility that the new position requires. We can know, for instance, that "A *is the father of* B" but nothing more about the intrinsic properties of A and B.

The success here is only superficial, however. Just as knowledge of intrinsic properties and relations gives us knowledge of bearers, so too will knowledge of relations give us knowledge of intrinsic properties. That is, as Psillos (2001, S20) rightly notes, if (2) is the correct

formulation of the central thesis of ESR then structure and nature actually form an epistemic continuum: we cannot know relations without knowing something about intrinsic properties; and we cannot know intrinsic properties without knowing some relations. Thus, this watering hole *cannot* provide the unknowability constraint that the central thesis requires, despite initial appearances.

Anjan Chakravartty (2007) presents a very similar case against ESR. He accepts that 'structure' refers to relations and that 'nature' refers to intrinsic properties. He also accepts that the most plausible form of ESR will adopt (2). But he notes in chorus with Psillos that this distinction between structure and nature results in a blurring of that distinguishing line. So both authors admit, to use Psillos' example, that knowledge of the "is the father of" relation holding between A and B entails knowledge that, e.g., A *is male - and this is an intrinsic property*. Thus, the epistemic distinction between structure and nature *cannot* be maintained.

One might try to maintain the epistemic distinction by suggesting that while science presents to us what relations there are it never directly gives us access to the intrinsic properties. Instead, we only ever infer the intrinsic properties from the contact that we actually have with relations. This inference to specific intrinsic properties could then

be coupled with the claim that those specific intrinsic properties are not the ones that we *necessarily* had to infer from the relations captured by science. For example, if for the time being we construe the relations to which we have access as 'causal relations', then we might say that the grounding (or underlying) intrinsic properties of causal relations are underdetermined. Then, many intrinsic properties could fill the role as grounding properties without changing the causal layout to which we have contact. If this were true then our knowledge of intrinsic properties is underdetermined, which strongly suggests – say the epistemic structural realists – that we should be humble in our assertions that we know the intrinsic properties. So we see again an attempt to maintain an epistemically unaccessible realm.

We find this in one very similar argument pushed by Frank Jackson (1998).

> "When physicists tell us about the properties they take to be fundamental, they tell us about what these properties *do*. This is no accident. We know about what things are like essentially through the way that they impinge on us and our measuring instruments. It does not follow from this that the fundamental properties of

> current physics, or of 'completed' physics, are causal *cum* relational ones. ... However, it does suggest the possibility that (i) there are two quite different intrinsic properties, *P* and *P**, which are exactly alike in the causal relations they enter into, (ii) sometimes one is possessed and sometimes the other, and (iii) we mistakenly think that there is just one property because the difference does not make a difference (as the point is put in information theory). An obvious extension of this possibility leads to the uncomfortable idea that we may know next to nothing about the intrinsic nature of our world." (Jackson 1998, 23-4)

If I understand Jackson correctly, he presents tools amenable to ESR. We reject the possibility that the fundamental properties as revealed by physics are "causal *cum* relational" and suggest that our relational properties 'pick out' some intrinsic properties, even though we can never be sure which specific properties of the latter type are picked out. Of course, 'pick out' here cannot be much more than a colloquial expression. No intrinsic properties are ever properly known; they are merely implied.

While we are humble about the intrinsic properties, we can nevertheless have knowledge of relations. One consequence of this is that "there are worlds that are different because they differ in the distribution of the intrinsic properties that are instantiated in them, although there is no difference in causal and nomological relations and thus no discernible difference between them" (Esfeld 2009, 3).

If this is where ESR is headed, then there is a worse objection to be raised. Ultimately I would suggest that independently of how we cash out 'nature', we should question the spirit behind the central thesis itself. Recall that ESR's stance towards natures has to be of a very special form: ESR must take natures to be unknowable *in principle* or else the reason for adopting ESR (i.e., accommodating the PMI) is undermined. This *in principle* limitation requires that ESR maintain that even with vast technological and theoretical advancements we will never be able to know these natures; they are, by their very nature, unknowable.

There is something very off-putting about such a stipulation. In trying to find the best of both worlds between the PMI and the NMA, ESR has quite literally created two worlds, one accessible the other not. Yet, ESR still wants to allow that this *inaccessible* world exists. But why? Should we be agnostic about the existence of objects or should we

disavow them? Who must bear the burden of proof (cf. Ladyman and Ross 2008, 131)?

We can explore both sides of this putative burden. ESR councils agnosticism about objects' natures. It affirms, that is, that objects have intrinsic properties but that we cannot know what these are because we lack contact with them. This *might* seem reasonable. Consider a putative analogy: It *is* reasonable to believe that beings biologically differently than us will experience the world differently than we do. As such, biologically different beings could have access to entities that are inaccessible to us. Thus cats may see at wave lengths of light that we cannot; or, extra-terrestrial beings may see significantly 'smaller' entities without the aid of any further apparatus. In both these cases, it would seem *unwarranted* to suggest that those parts of the universe do not exist just because *we* cannot access them. Analogously, ESR might hold that the mere fact that we cannot access either the property bearers or the underlying intrinsic properties should not lead us to assume that those bearers or properties do not exist.[32]

The cases are importantly dis-analogous from the case against ESR, however. All of the above cases do not involve entities which are inaccessible *in principle*, only in practice. Indeed, the natures of the potential analogies rely on the fact that the objects and properties are

32 Thanks to Adam Morton for making me take this objection seriously.

accessible *somehow* – by cats and aliens. We might illuminate the dis-analogy in the following way: 'natures' for ESR are, while the entities accessible to cats and aliens are *not*, idle posits. For ESR, that which is beyond our grasp turns out to do no *causal* work about which we could ever be aware; they are differences that make no real difference. Any proposal that wants to adopt idleness of this form, I suggest, must bear the burden of proof. How ESR could meet this burden is an important question: given the idleness of the objects, in what other way might ESR fill the justificatory lacuna?

This burden is even heavier than I have intimated, for one could appeal to the (admittedly vague) principle of Occam's Razor in support of their non-existence. This familiar principle, demanding that we not populate the world superfluously, is a call for simplicity that at the very least cuts *idle* posits when nothing is lost in their removal. In fact, some in the field who argue against ESR have made just this appeal to Occam's razor. Thus, Ladyman and Ross claim that if we should not cut the idle posits in which we have *no* reason to believe, then we "ought to be agnostic about a literal infinity of matters – whatever anyone can conceive without contradicting physics." They ask, tongue in cheek, "Should we be agnostic about the existence, somewhere, of two headed gerbils that sing the blues?" (2008, 131): I think not.

Perhaps the burden of proof can be shifted back to the non-believers. Though I am personally not moved by the line about to be presented (for reasons found in the coming chapters), I present it because it is often adopted in the literature. ESR might try to shift the burden by suggesting the following: 'The real justification for my agnosticism towards property bearers (or their intrinsic natures) comes from one line of thought, deriving from the conceptual dependence between relations and relata. We know there are relations and these require relata. Either we cash out relata as property bearers, or we cash them out as groupings of intrinsic properties. Either way, we can know *that* there are relata even though we cannot know *what* they are like, just because we know there are relations. The latter (conceptually) *require* the former.'

Here the burden of proof, putatively, shifts. Now it is the task of the deniers to demonstrate that we can be rid of the “idle” objects and intrinsic properties while leaving behind no conceptual or metaphysical residue. If this can be demonstrated, then the posits will be truly idle and thereby expendable. This thesis hopes to show that no such residue remains after the elimination of the underlying objects and that there is a coherent metaphysical system that does not employ these underlying posits. But, this shall have to wait until later chapters 3 and 4.

2.2.3. Incoherence. There is one final problem that I shall mention regarding ESR. This problem arises only when we couple ESR with a commitment to physicalism. As such, this section is not meant to undermine ESR – unless the commitment to physicalism is too precious to give up (as I think it is). The problem, in brief, is that a commitment to physicalism undermines the epistemic division within the central thesis.

Consider two closely related cousins of ESR: Rae Langton's (1998) *Kantian Humility* and David Lewis' (2007) *Ramseyan Humility*. These cousins, both humble like ESR, suggest that we ought to remain agnostic about both the nature of objects (as property bearers) and of intrinsic properties, even though we can know the way the world impinges on us – even though we can know the relations of the world. Yet, they make these claims only because their position is a conglomeration of *metaphysical commitments* (similar to those found in ESR) with *physicalism*. Strong physicalism is the belief that a complete list of the fundamental properties of the world will contain only those which are determined by science. If one prefers to avoid formulations that include reference to the fundamental level, we can say that strong physicalism is the view that "only the physical sciences have the ontological authority to tell us on their own terms what the world contains" (Ney

2007, 44).

Now, the turn towards *humility* in Langton's and Lewis' positions, just like the *epistemic* turn toward humility in ESR, is founded on the idea that there are solely metaphysical (i.e., non-scientifically founded) reasons to believe that the relations discovered by science have underlying intrinsic properties. But, *assuming* that the complete list of properties given by science comes out as consisting of entirely extrinsic properties – as both Langton and Lewis assume - the metaphysical motivations towards humility are undermined: If we accept that science is to determine the complete list of fundamental properties,[33] and none of those turn out to be intrinsic, then there is neither room nor reason for metaphysics to add intrinsic properties (*ibid.*, 49).

Clearly the forgoing is not a problem for ESR *per se*, as realism is the view that science truthfully represents the world. Yet, my physicalist leanings provide even more reason to look for realism's refuge elsewhere. With this is in mind, let me close this chapter by suggesting a few lessons that should be learned from the two main problems with ESR, the quantum physics quandary and the troubles with the central thesis.

33 If we are inclined to deny that science will ever get to the fundamental level, we will perhaps need to rephrase this requirement to something like 'science is to determine the properties of entities at each level', or 'science is to determine the list of properties that are candidates for belief at each level'.

2.3 Two Potential Routes and Concluding Remarks

2.3.1. A Solution: Structuralized 'Objects'. I propose that there are two ways forward which would adequately deal with the aforementioned problems. Both of these ways forward are based in one main assertion: that objects are *entirely* structural – i.e., they have no non-relational parts. Such an assertion can be realized, I think, in two ways each one of which gives rise to a distinct metaphysics which would make OSR plausible. I shall merely propose an outline for each one of these ways, with the intent of fully discussing and defending each of the positions in the next two chapters.

Let's consider the first way to satisfy the clause “objects are entirely structural entities”. 'Structure' refers to relations. Entirely structural entities, then, would refer to entities which consist solely of relations. However, we suggested earlier that there are some who believe that relations imply relata. The structural realist sensitive to the foregoing troubles, I suggest, should reject this implication, if it is to be understood in terms of either intrinsic properties (if those properties are non-relational) or property bearers. This, I think, sufficiently respects the PMI; Angelo Cei (2005) agrees:

> "It can be the case, for instance that from a relational description of electromagnetic forces we can infer properties like the mass or the charge of the electron. But the whole point of PMI is that there is nonetheless room to doubt [the existence of these properties] when the properties and the entity have been replaced so frequently in the past. In other words, which electron is the bearer of the values of mass and charge we inferred?" (2005, 1388)

Cei goes on to recall that SR was offered initially as a response to the PMI and that to allow inference from relations to intrinsic properties is to undercut the motivations behind SR itself. Thus, we need to address the PMI by taking 'structure' to refer not merely to relations, but to "relational, *extrinsic* properties, properties that are not intrinsic to the entities" (*ibid.*). So we have a new refined account of structure: 'structure' refers to the ungrounded relations – on pain of failing to avoid the PMI. Of course we know that all relations discussed so far *imply* intrinsic properties. But, we need to deny this implication. Doing so gives us 'objects' which are composed of properties, all of which are relations. How we are to fill-out and defend such a position is the topic

of the next chapter, chapter 3.

The second way to fill out the "objects are entirely structural entities" clause is *not* to deny the implication to non-relational underlying intrinsic properties, but instead to *allow* this inference while simultaneously adopting a special stance towards whatever properties are inferred. The special stance, in short, is to suggest that the inferred non-relational intrinsic properties can ultimately be "structuralized" themselves. As we shall see, this will mean allowing the inference to intrinsic properties only on the grounds that those inferred properties can be decomposed, at a different level, into more relations. Ultimately then, this view embraces substrata and bundles, but on different levels of consideration. I shall explore this idea fully in chapter 4.

2.3.2. Conclusion: The Intelligibility Question. As is apparent, in the pending final two chapters I present two distinct coherent metaphysical accounts for the position known in the literature as Ontological Structural Realism. This is the position that, on the face of it, accepts that there are only relations, or 'relations without relata' - to utilize Ladyman's (1998) phrase. Yet, we are now at the point where we can see one of the perennial objections to this *ontological* form of structural realism – an objection I call the *Intelligibility Question*.

This objection is perspicuously presented as follows: According to this view, if the world consists only of structure, where 'structure' means relations, then we are driven, *prima facie,* to incoherence. After all, if the world consists of relations then there is a *conceptual* need for relata; a world without relata is incoherent. (We saw this objection in brief at the end of *section 2.2.2* above.) We simply cannot have relata-less relations, so the solution suggested in the previous section which results in ontological structural realism, is not feasible because it is unintelligible.

In fact, I think this objection is mistaken which is surprising given that it is still one of the oft most cited objections to the ontological turn to structural realism. Indeed even when authors (e.g., Chakravartty 2003a) dismiss the intelligibility objection – despite the fact that they do *not* support the ontological turn – the intelligibility objection is often dismissed for reasons *weaker* than those that are available to the ontological structural realist. Usually, that is, these thinkers suggest that it is not fair to raise the intelligibility objection because of the ontological structural realist's desire to shift her ontology towards a thoroughly structuralist stance; such a shift undercuts the cry of unintelligibility, because OSR rejects the grounds on which the intelligibility objection is raised.

The problem with dispensing the *intelligibility question* in this manner is that communication between ontological and non-ontological realists quickly becomes impossible for the two groups have rescinded the common ground that they once shared. And, while I support such a structuralist shift I want also to defend the claim (in the next two chapters) that there are metaphysical accounts which can face the *intelligibility question head on* while at the same time preserving some of the common ground from which both parties can communicate.

As I have said, I shall use the next two chapters to develop these positions. However, as I develop the first option in the next chapter, I will also take the liberty to build – at the same time – the stance of ontological structural realism. It is important to keep separate the formulation of OSR and the denial of intrinsic properties, for that denial will only be a feature of the first proposal (which we find in Chapter 3). OSR, that is, will be explicated as containing three theses, none of which requires the rejection of intrinsic properties. Thus, I shall use similar theses to ground my second response to the *intelligibility question*, found in Chapter 4. Let's turn to the first response now.

Chapter 3

Ontic Structural Realism and Bundle Theory

3.1 Introduction

3.1.1. Origins. In this chapter, I turn towards the view that is central to the topic of this dissertation: Ontological Structural Realism (OSR). Our task in this chapter is two-fold. First, I shall develop OSR under the guise of a longstanding metaphysical position, bundle theory of objects. Second, I will critically assess one argument (from an alternative realist position) which, if correct, undercuts OSR.

I begin the chapter with a quick reminder of the lessons that we should have learned from the forgoing discussion. I culminate these into an ontic postulate. I explore the consequence of the postulate, as expressed in two distinct formulations. For clarity, I focus on the second formulation, which I call ***Ontic*$_2$**. This postulate is meant to capture the ontological structural realist's position, when coupled with the ***Realist*** and ***Structuralist*** postulates from chapter 2. The new postulate reminds us of the *intelligibility question*, but I propose to temporarily set aside

this difficulty in order to examine how a bundle theoretic approach to objects is implied by ***Ontic₂***.

Bundle theory (BT) is a metaphysics of objects under which those objects are, in some sense, nothing more than the properties that compose them; objects are really just those properties, 'bundled' together. Of course, the previous lessons of structural realism will weigh heavily on this view, and so much of this discussion will be a demonstration of how bundle theory must bend in order to accommodate the structuralist burden. Even still, the accommodation of structuralism by BT will not yet satisfy the calls that James Ladyman has made in defense of ontological structural realism; work remains to be done with respect to squaring these two, and I complete that work here.

The broad strokes of the chapter are as follows: First, after having outlined how the ontic postulate suggests bundle theory, I shall present a generic account of bundle theory. This will include an explication of the position primarily as it opposes its competitor, substratum theory. This presentation highlights the important metaphysically *revisionary* features of the view which make it a true alternative to substratum theory.

Following this, I shall turn to the task of fitting the bundle theory of objects into the structuralist schema. Thus, I shall outline the

necessary changes that must be made to bundle theory in order for the view to be amenable to OSR. We shall find that the change required is the limitation of the properties - those which make up bundles – to relations alone; this, of course, is also motivated by the new ontic postulate. I coin the title *bundle of relations theory* (BRT) to refer to bundle theory under this modification. The third task will be to increase the plausibility of the claim that entities could be identified entirely, or solely, in relational terms as is required by BRT; only then will the combination of bundle theory and OSR begin to be feasible.

The final task of wedding BRT to OSR is to address the *intelligibility question* which we set aside in order to fully appreciate how bundle theory was implied by the discussion of the previous chapter. In this section of the paper, I will suggest that we continue with the revisionary nature of BT by suggesting that BRT *refuse* to justify the *intelligibility question* with a response. I explore the consequences of this denial by considering the analogous denial made by (regular) bundle theory with respect to the questions about the 'support' of properties. One consequence, as we shall see, is that BRT must contend with one question, what I call the *occurrence question*, which asks why there are certain relations rather than others. I suggest that in light of the revisionary nature of bundle theory, the bundle of relations theory

should employ the compresence relation in response to this new concern.

At this point we will have seen enough of OSR to realize that a BRT account of OSR is plausible. Two tasks remain. First, I shall address one argument from within an alternative metaphysical account which promises to avoid the strictures of OSR, while nevertheless remaining a realist position. This position is proffered by Anjan Chakravartty, and is entitled *Semirealism*. I focus on *Semirealism's* abductive argument for keeping objects in form more robust than the objects of the BRT position as defended herein. I explore this suggestion, clarifying exactly what Chakravartty might intend by his abductive argument. We shall see that in the light of the currently adumbrated version of OSR, Chakravartty's suggestion loses its status as the “best explanation”.

The final task of the paper will be to explore some potential problems with the acceptance of a metaphysics that admits only relations. There are two substantial objections: the identity objection and the causation objection. To clarify these objections, I rely on discussion about the nature of properties, specifically the discussion addressing dispositional essentialism. There we find an analogous position to the one defended herein. I explore those objections, draw out the analogues for OSR, and respond to them. We shall find none of

them to be particularly threatening.

3.2 Ontic Structural Realism and Bundle Theory

3.2.1. Reminder of Lessons to be Learned and a View of the Way Forward. As I have said, our first task is to determine the possible formulations of ontological structural realism. We can see one potential route for OSR by returning to the motivations outlined in the last two chapters. Thus, chapter 1 demonstrated that if we allow that our scientific theories get the *structure* of the world correct then we have the means to keep the intuition behind the 'no miracles' argument, while still respecting the pessimistic pull generated by the history of science. Chapter 2 explored ESR, one possible way to pursue that structuralist line. We noted however that *that* account of structuralism suffered from two problems: 1) an unacceptable idleness inherent in ESR's central thesis; and 2) the quantum physics quandary which under-determined the nature of quantum objects.

I have already suggested (Chapter 2) that one way to relieve the pressures from both of these troubles is to appeal to 'ungrounded relations'; that is, we should reject the inference from relational properties to underlying intrinsic properties. This move rids us of at least some of the objectionable idleness inherent in ESR's central thesis. Such

a move, if correct, dictates that the realist should embrace more fully her structuralist credo, giving greater ontological weight to relations. Thus, she should adopt the ***Scientific Realism*** and ***Structuralism*** theses developed in the first chapter, and add to it a third thesis which I shall call ***Ontic$_1$***:

Ontic$_1$ - There is only structure, i.e., relational properties.

Of course, this formulation brings to light why many are "up in arms" with OSR for if there are naught but relations, then relata seem to have been eliminated. What exactly one means by 'relata' however requires careful clarification: as I have said, what seems to be required by the forgoing is not the elimination of relata qua entities which are related; but rather the elimination of relata qua particulars, where by 'particular' I shall mean an entity which instantiates properties and relations. We should understand the ontic postulate, then, as claiming that there *are* relata *qua* entities related; but there are not relata *qua* particulars. OSR, then, is committed not to the elimination of relata *per se*, but to the elimination of *objects as particulars*.

With the discussion stemming as it does from the previous chapter's criticism of ESR, however, this consequence – the elimination

of objects - seems unavoidable. Certainly, objects and their intrinsic properties appear to be a residue in ESR: they are the unknowable bits which lead us to the aforementioned undesirable consequences. ***Ontic*$_1$** proposes to eliminate that troublesome residue, which leaves us to wonder what more – if anything – there is left to be related by relations.

Nevertheless, both naysayers and defenders of OSR (e.g., Chakravartty *manuscript;* Esfeld and Lam 2008) have suggested that we can reformulate this ontic thesis to be less *prima facie* objectionable than one which suggests that there are no relata. If we bear in mind that we want to eliminate relata *qua* particular bearers of properties while placing increased ontological importance on relations, then we can derive a second ontic postulate. I propose we formulate it in terms of *fundamentality*:

***Ontic*$_2$** – Relations are more fundamental than relata.

Crucially, this reformulation does not necessitate that there are no relata (qua entity related); nor does it necessitate that there are no objects. Yet, we know that objects *(qua* particular bearers of properties) need to be eliminated, so we must read this postulate accordingly. Nevertheless, it is compatible with ***Ontic*$_2$** that there be some relata:

they can exist just so long as relations are more fundamental than relata. (Just what 'more fundamental' means is to be discussed shortly.) We shall understand ***Ontic₂*** in this strictest sense – viz., as claiming that there are no objects (particular bearers of properties) at all. (Henceforth, by 'object' I shall mean particular bearer of properties, unless otherwise indicated.)

If we are going to be eliminating objects we need to know what this means. We can find a useful contrast to 'elimination' in the notion of 'reduction'. We might capture the distinction in this way: an entity X is *eliminated* if there is no reduction of X-talk into talk about accepted (or proper) entities. An entity is eliminated if when speaking strictly, it falls out of contention as an appropriate object of discussion. On the other hand, X-talk is *reduced* if there is a mapping of X-talk onto talk about proper entities. Reduced entities, comparatively, do not fall out of contention as appropriate entities of discussion. Thus under the current interpretation of OSR, when we take the philosophical pressures seriously we need to recognize that strictly speaking there are no such things as objects; there are only relations.

Obviously, adopting the eliminativist interpretation of ***Ontic₂*** returns us to the questions that plagued ***Ontic₁***: to properly respect the lessons of chapter 2 we must be rid of relata (qua objects) entirely; but

if objects are eliminated, then we begin to press the grounds of intelligibility. Thus, the interpretation of ***Ontic₂*** in terms of the elimination of objects leads us to ask: If we have relations do we not *need* some relata?

3.2.2. 'Fundamentality'. Before we can spell out the consequences of this 'eliminativist' reading of ***Ontic₂***, let us briefly consider what it would mean to say that some thing is 'more fundamental than' some other thing. One way to spell out this notion is in terms of ontological dependence.[34] There are at least two ontological readings that we can give to "x depends upon y": *essential dependence*, which is dependence for identity; and *existential dependence*, dependence for existence.

It is hard to find clear 'everyday' examples of these two types of dependence. Even still, we can clarify this distinction by making an appeal to a metaphysical entity, the bare particular. Everyday objects (e.g., chairs, tables, bicycles) are commonly understood to be composed of (at least) bare particulars. Moreover, those everyday objects are commonly taken to be *existentially* dependent on their bare particulars: no bare particular, no object. Yet, everyday objects are not *essentially* dependent upon their bare particulars: the identity of an object is

34 This follows much of the recent literature on OSR: e.g., Chakravartty *manuscript*; French (2010); Ainsworth (2010); Esfeld and Lam (2008). The distinction between existential and essential dependence is drawn from Lowe (2005).

determined by properties, and not by the bare particular.

Sometimes these two types of dependence are run together, other times they are kept separate; this typically depends on how essential dependence is further explained (via supervenience, constitution, etc.). Nevertheless, many in the OSR literature (e.g., Ladyman and Ross 2008; Chakravartty *manuscript*; French *manuscript*) suggest that the most appropriate account of dependence for the structuralist is essential dependence, and I shall follow suit.[35]

We can say that if y *essentially depends* on x, then y depends on x for the determination of its identity. That is, if y essentially depends on x, then y's identity is determined by x. Making explicit the inherent notions of *fundamentality* in this definition, we can understand essential dependence as follows: x is more fundamental than y, if y depends on x for the determination of its identity, and not vice versa (again, cf. Chakravartty *manuscript*).

3.2.3. The Bundle Theory of Objects. Return now to ***Ontic*$_2$**. Remember, I have suggested that we understand this as strictly as possible; thus, this postulate tells us that there are no objects (i.e., particulars). This, I

35 The main justification for this is that we are in need of an asymmetric relation, and it is not clear that existential dependence is, uncontroversially at least, such a relation (see Lowe 2005). To my knowledge, using essential dependence in the definition of OSR's central postulate was first proposed by Chakravartty (*manuscript*).

have said, reinvigorates the *intelligibility* question, pressing at the coherence of our realism. Still, setting those concerns aside for the time being it would seem that the considerations thus far adumbrated lead us directly into the old metaphysical view of the bundle theory of objects (though, obviously, modifications to the original theory are necessary). Let us explore the 'original' view to see what resources there are for the structural realist, remembering that we are placing the *intelligibility question* to one side for the time being.

First, we shall explicate what is entailed by the *bundle theory of objects* (henceforth BT). Obviously, there are many ways to fill out the specifics of BT, so I shall need to be rather general in my formulation of BT.[36] The lack of these specifics, however, should not prevent us from seeing how OSR and BT might be conjoined. BT is a metaphysical view whereby there is *nothing more* to an object than a collection of properties. The revisionary scope of this approach is plainly obvious when it is compared to its competitor, what I'll call *substratum theory*. According to substratum theory, a complete account of an object's properties no matter how complex will always leave out a crucial part of that object, viz., its substratum (a particular bearer of properties).

An object without a substratum, thus, is an *incomplete* entity.

36 I do this, despite the fact that the responses that one offers to objections to BT vary *greatly* with respect to the details of one's bundle theoretic approach.

According to substratum theory, objects without substrata are incomplete because properties are not the kinds of entities that can 'stand alone': they must be *instantiated* and instantiation requires instantiation *in* something. Properties, then, are dependent entities. Conceived in this way, their existence raises the question which I shall henceforth call the *support question* – "What underlies, or supports properties?". The substratum theorist responds to this question by employing the metaphysical entity substratum, one of whose jobs is to support properties. (We saw talk of this notion in the previous chapter, cf., chapter 2, section 2.2.2.; its other roles will be discussed shortly.)

The postulation of substrata in response to the support question contrasts starkly with BT's response to that same query, however. When faced with this query, BT suggests that properties are not such that they need to be supported. This revisions highlights some key differences in the two views. For instance, while substratum theorists are driven to include substrata (along with properties) among the denizens of the world, BT's view regarding those denizens is arguably more economical: there are merely properties. After all, for BT properties are not dependent entities.

Substratum theorists complain that BT's response to the support question is too revisionary to be defensible. Typically the objectors try

to find some role that substrata play but for which BT cannot account. One such suggested role comes from the complaint that without substrata we cannot explain the unification of properties as a distinct entity. For example, we regularly claim that some object consists of a collection of properties and not others; this fact calls for an explanation: we need to explain why all three properties X, Y, and Z, for example, are properties of *one* entity rather than X and Y being properties of one entity, while Z is a property of another. How can we do this without substrata? We can put the concern more generically by asking, "On what grounds can we say properties are properties of the same entity?" Call this the *coincidence question*. Substrata allow an easy response to the coincidence question of course: X, Y, and Z are instantiated by the same substratum and so are properties of one entity, rather than of two distinct entities.

The initial tenability of BT hinges on its capability to respond to the coincidence question, and this task falls at the feet of the novel relation *compresence*.[37] With compresence in mind, reconsider the coincidence question: Why are these properties all properties of *one* object? BT has an answer: because this collection of properties is that

37 A glance at the literature on BT shows that the commitment to 'compresence' is not universal among defenders of BT. Others utilize 'concurrence', 'consubstantiation', 'co-location', or 'fusion'. For a brief overview of these, see Paul (*forthcoming*), where the merits of employing 'fusion' are explored.

between which the compresence relation holds. So, just as substrata for the substratum theorist answers the coincidence question, BT silences it with compresence. Compresence is that relation which bundles groups of properties together; it is the tie that binds the collection of properties into an object.[38] Compresence is a primitive relation which holds between properties (of any *adicity*) but no other type of entity (like a substratum). BT, then, asserts a property ontology.[39]

38 Thus, we can dispense with the objections which suggest that BT's account of objects is too broad, given that any collection (set) of properties can be considered an object, for this arises from the mistaken interpretation that for BT objects are *nothing more than* a set of properties. No: they are bundles of compresent properties; they are not simply any set of properties. See, e.g., van Cleve (1998).

39 We should, before we return to how BT fits with OSR, explore the nature of compresence a bit more. First, compresence is a property (specifically a relation) so the bundle theoretic claim that there is nothing more to the world than its properties, remains fulfilled. Second, we should note that just as each object has its own substratum (according to substratum theory), so too with BT does each object have its own compresence relation. This fact deserves special attention, for it implies that compresence has a unique nature, unlike other relations.

Briefly, because every object has a unique compresence relation, compresence will vary in *adicity* across objects. That is, according to BT an object will have some number of properties which compose it. But, not all objects will have the same number of properties. Because each object has its own compresence relation, and each has a differing number of properties, each compresence relation will have to have a varying number of 'argument places', one for each property of the object. For an object with only two properties, compresence will be b*inary:* A and B are compresent (where A and B are properties); For an object with *n* number of properties, compresence will be more complex: A, B, C, ... n are compresent. We can say then that compresence is *multigrade* (cf., Morton (1975)).

The result is that compresence does not seem much like some relations with which we are immediately acquainted. After all, it would seem that every other relation we know of has a *set* adicity, not a variable one. Consider *is to the left of*, which is obviously of 2-adicity. Even though it is possible to say "X is to the left of Y, Z, and Q" we are not here suggesting that *to the left of* has an adicity of four. No; here we are compounding the binary relation *to the left of* over three items. Thus, what we *really* mean is that there are three instances of *to the left of:* one between X and Y; one between X and Z; and one between X and Q.

Still not all relations are akin to *is to the left of*. Indeed, there are many examples of multigrade relations besides *compresence*. Consider *had an orgy with*, *shares his cake with, are brothers, are compatriots, built the bridge* (see, again, Morton (*ibid.*)). All of these relations are multigrade in the way just described.

3.2.4. Bundle Theory and OSR. What does all this have to do with structural realism - and more specifically - OSR? The traditional bundle theoretic account of objects insists that objects are collections or 'compresences' of *properties,* including especially intrinsic properties. The position that our realist considerations have brought us is something very much like BT given the rejection of substrata. But the ontic structural realist's further rejection of intrinsic properties, limiting properties to relational properties, means that the version of bundle theory is even more revisionary than the original, for it is a *bundle of relations theory* (BRT).

BRT appears to be the ideal framework for the Ontic Structural Realist.[40] Here is why: for BT there are no 'irreducible' objects. That is, any putative entity is really just a bundle of properties. I take this cue from Micheal Loux, who says "the bundle theorist wants to claim that particularity is a derived feature of the world. At the most fundamental level, there are no particulars or individuals" (1998, 234).[41] This

40 Chakravartty (*manuscript*) discusses the potential combination of OSR and bundle theory; he rejects it as unfeasible. He suggests that if OSR is eliminative (i.e., a position that suggests there are no objects), then the central dependence relation of OSR will be violated because bundle theory *needs* intrinsic properties, and presence of intrinsic properties undercuts the claim that structures are more fundamental than properties/ objects.

I reject this reasoning. First, Ainsworth (2010) demonstrates how some versions of (a bundle theoretic account of) OSR are in fact compatible with intrinsic properties just so long as those latter do not determine the identity of objects. Strengthening this claim are the arguments in this chapter which suggest that identity can be determined solely by the relations of objects; if this is true, then the bundle theory does not need intrinsic properties at all.

41 This needs qualification for it is true only if we assume that properties are *universals.* If properties are *tropes* Loux must be mistaken, for on all accounts, tropes are particulars. In this case we should rephrase the statement to (something like): "For the bundle theorist, at the most

requirement fits perfectly with the strict reading of ***Ontic₂***, according to which there can be nothing but structure (i.e., relations). Consider:

1. By *bundle theoretic* constraints objects are nothing more than bundles of properties;
2. By *structuralist* constraints properties are restricted to relations;
3. Thus, objects are nothing more than bundles of relations.

So, BRT seems to follow directly from the coupling of BT with Ontic Structural Realism as captured by the strictest reading of ***Ontic₂***.

The harmony between BRT and OSR hinges on the possibility that bundles could be entirely relational. Establishing that a bundle can be 'entirely relational' requires fulfilling two related desiderata. The first desideratum is for a clear demonstration of how the identity of entities can be established in relational terms alone; the second desideratum is for a defense of the claim that relations can relate relations (i.e., a defense of the claim that relations can themselves be relata). The first desideratum, of paramount importance, might be called the "identifying by" task, for our concern is the capacity to identify putative relata *by*

fundamental level there are no particulars which are not also tropes." The crux of the bundle theoretic position remains essentially unchanged, however.

their relations alone; while the second desideratum could be called the "identifying with" task, for we are concerned to identify relata *with*, or as, relations alone. We shall address these in turn.

3.2.5. Desidertum (1): Relational Identity. The first desideratum stems from the rejection of intrinsic properties which was championed in the previous chapter. Before we address this desideratum, however, we need to explore, briefly, what I mean by 'intrinsic'. Following Angelo Cei (2005) - who adopts the definition introduced by Rae Langton and David Lewis - I suggest that 'intrinsic' be understood as those properties which are 1) independent of accompaniment and loneliness; 2) not disjunctive properties; and 3) not negations of disjunctive properties (Langton and Lewis 1998, 336).[42] A property is independent of accompaniment and loneliness, loosely speaking, if an object can have that property regardless of what else is going on around the object. Thus, if the property F is independent of accompaniment and loneliness then it is possible for a lonely object to have *or* lack F, and it is possible for an accompanied object to have *or* lack F. (A lonely object is the sole occupant of a world; an accompanied object is not the sole occupant of a world.)

42 In concert with Cei, I do not wish to suggest that this definition is sufficient to capture all intrinsic properties; instead, it focuses on the 'basic' ones. See Cei (2005); Langton and Lewis (1998).

Importantly, under this interpretation of 'intrinsic' it would seem like we cannot be too quick to reject *all* intrinsic properties as Angelo Cei (2005) would have us do. For Cei, as I have said, the PMI concerns suggest that we rid ourselves of the intrinsic, and focus on the extrinsic, relational properties. However, it is not obvious whether the distinction between intrinsic and extrinsic properties maps cleanly onto the distinction between non-relational and relational properties. Indeed, there seem to be good candidates for relational intrinsic properties. For instance, it is an intrinsic property of an atom that its nucleus is larger than one of its electrons; just as it seems to be one of my intrinsic properties that I have longer legs than I do arms (see, e.g., Humberstone 1996). Both of these properties (having a larger nucleus than an electron, having longer legs than arms) seem to be relational despite being intrinsic, thus structural realism should allow room for their inclusion, should these properties turn out to be central to the predictive success of the theory in question. The result is that the structural realist should not reject intrinsic properties out of hand. They should only reject non-relational intrinsic properties. Relational intrinsic properties should remain viable candidates for commitment, should they meet the required standards.[43]

43 Chakravartty (1998; 2007), offers a useful distinction between *detection* and auxiliary properties which helps to clarify to which properties we should be committed. If a relational intrinsic property turns out to be the kind of property we can detect, then OSR should allow for

With this out of the way, we can consider the role of non-relational intrinsic properties (henceforth, I'll use *intrinsic properties* to refer only to the non-relational intrinsic properties, unless otherwise stated). Normally the role of intrinsic properties is to establish the identity of entities. As Lewis (1986) puts it, any putative exact duplicates of an entity must have all the intrinsic properties which establish the identity of the entity in question. The worry with the elimination of intrinsic properties, then, is that it will be impossible to establish the identity of any entity. While this worry is somewhat attenuated by the recognition that we can have some intrinsic properties after all – namely those that are intrinsic *and* relational – it is not clear that the inclusion of the relational properties will be enough to establish an entity's identity. (Surely, the two properties listed above would be insufficient on their own.) Moreover, given the central role of *essential* dependence in our account of 'fundamentality', BRT had better be able to say something about the identity of a bundle of relations; if it cannot, then OSR is untenable.

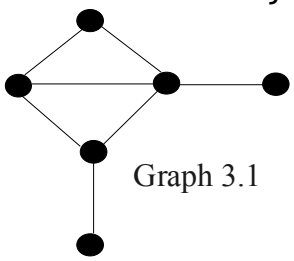
Luckily for BRT, it can appeal to graph theory.[44] Graph 3.1 (below)

commitment to it.

It is also important to note that Chakravartty, who rejects OSR, would be inclined to infer from the existence of relational properties some non-relational intrinsic properties, while I deny this inference. I take this to be the source of key differences between our positions.

44 Much of what I say here has already been said by others, e.g., Bird (2007); Ladyman (2005). One important limitation of appealing to graph theory as an example of relational identity is that the procedure only works for graphs which are asymmetrical (see Dipert 1997; Bird *op. cit.*; Ladyman *op. cit.*). It is not clear how this consequence affects the application to issues in

consists of 'nodes' (the dots or circles) and 'edges' (the connecting lines between nodes). The edges represent relations between the nodes which themselves are 'place holders' for 'entities' or 'objects'. Here the edges



Graph 3.1

are 'undirected', meaning the relations they represent hold in no specific order between the entities represented by the nodes; but, graphs may also have directed edges, which would be indicated by arrows. In all the graphs I shall consider the relations are symmetric, given that they are undirected, but one could also represent asymmetric relations. The relations represented by the edges may, or may not indicate the same relation. Importantly, however, each relation in this graph (and all those to which I shall make reference) are binary relations.[45]

Crucially, the nodes of graphs are *featureless* entities according to graph theory: they are entirely dependent upon the relations in which they stand.[46] Thus according to graph theory, nodes are identified by the

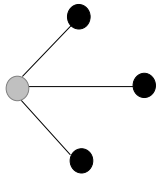
quantum mechanics, or other areas where exact symmetry seems to be a feature (as with bosons). If it turns out that, according to our best theories, some feature of the universe is highly symmetrical, then structuralism would have a problem with this.

45 Bird (2008) discusses graphs in much greater detail. I direct the reader to that work (especially Ch. 6) for further clarification. The discussion there is especially important for it preempts many complaints of what is to follow here. For instance, as we shall see, establishing the identity of nodes in a graph hinges on the graph being asymmetric. Moreover, the reliance on binary relations seems troublesome, given that there are relations which hold between triples and quadruples, etc., of relata. Still, what I present here justifies (in broad strokes) the possibility of my project, which is all that is required in the current context.

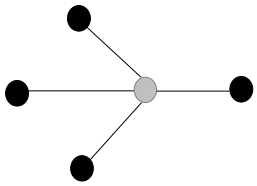
46 This is true, at least in so far as we consider 'unlabeled graphs' as opposed to 'labeled graphs'.

relations in which each stands and nothing more. Let's consider one node to see how we might establish its identity; take the top node of Graph 3.1. We can see that there are two relations in which it stands, each represented by an edge in the graph. One way to establish the identity of the top node is to derive an identity through these two relations.

So, the top node is related to two other nodes, a node to the lower left, and a node to the lower right. Examining the connected nodes will help us to determine the identify of the top node; Thus, we need to simply count the number of relations in which these connected nodes stand to establish the identity of the top node. Graph 3.1', and Graph 3.1" aid in these considerations, as they are partial graphs of Graph 3.1.



Graph 3.1'



Graph 3.1"

What I have been calling the 'connected nodes' have been represented as light gray, as a matter of convention; the top node – about whose identity we are concerned – remains 'at the top' of both

As Ladyman (2007) clarifies these, "labeled graphs are unlabeled graphs that come with an additional assignment of linguistic or numerical labels to their nodes, by which nodes become distinguishable by means of their labels even if taken in isolation. However, it should be noted that if the labels of two nodes in a labeled graph with no edges are permuted the result is regarded as the same graph" (33). Moreover, the labeling of nodes in a graph provides no way to empirically distinguish the nodes from one another.

graphs. To determine the identity of the top node, we merely count the edges of the light gray node. Take Graph 3.1' first: there we can see that the gray node has three edges connected to it. Thus, *part* of the identity of the top node is {3}.

Now, consider Graph 3.1": we can see that gray node is related to four nodes. Thus part of the identity of the top node is the set of relations {4}. Accordingly, the identity of the top-most node in Graph 3.1 can be fixed as the complete set of its relations, {3,4}. And this procedure clearly fulfills the first desiderata, the 'identifying by' task of an entity, given that we have used no intrinsic properties – only relations - to establish the identity of the top most node.[47]

Of note is the fact that the {3,4} node has *no* identity independent of Graph 3.1: it is not something more than this set of relations {3,4}. That is to say, that node would not exist were the relations in which it stands not to exist (or, even, to change). It is nothing more than this set of relations; hence, we see how it is possible that an entity might be identified by its relations.

Moreover, we can see this feature demonstrated *twice* at different scales, as it were. We find the 'completely relational' feature of the nodes as a feature of the whole of Graph 3.1 itself. After all, we can identify all the nodes of Graph 3.1 by their relations just as we have

47 Again, it is crucial to note that this is successful only because the graph is asymmetric.

done with the top node; then, we can compile these identities into a set of relations which identifies the whole graph. Completing this description, Graph 3.1 consists of the set of relations **G1**:

G1: {{3}, {4}, {3,4}, {1,3,4}, {2,3,4}, {1,2,3,3}}

This, too, is clearly an account of an entirely relational entity for the set is composed only of relations which characterize the whole graph. Thus, we see generally that it is possible to identify an entity by its relations, and thereby showing that entirely relationally specified entities are possible.[48]

3.3 Intelligibility and Bundle of Relations Theory – The Final Stroke

3.3.1. Desideratum (2): Relations as Relata. We need now to turn to the second desideratum which, the reader shall recall, is to establish that relations can relate relations – that is, to establish that relations can be relata. Indeed, BRT's claim has to be even stronger, for it must claim not only that relations relate other relations, but also that relations *only* relate relations – and nothing else (i.e., relations do not relate any non-

48 What if there were another graph, Graph 3.2 that was identical to Graph 3.1? In this case it would seem that Graph 3.2 would be indistinguishable from Graph 3.1, given that for any node of either graph, we would find a relationally identical one in the alternative graph. This is a problem similar to Max Black's (1952) 'Two Spheres' problem for BT; I suggest that whatever solution one adopts for the two spheres problem for BT will be equally a solution for the problem as applied to BRT.

relational relata because there are no such things). How is BRT to go about fulfilling this task?

Defenders of BRT might begin by pointing out the fact that it is *obvious* that relations can relate other relations. Some higher-order relations, like *has more argument places than*, for instance, hold between relations - as when we affirm that the relation *between* has more argument places than *beside*. Still, a persistent objector might insist that this is the case for the higher order relations but not for relations at the first level. Thus, there is still the question of how BRT is to be fleshed out with respect to these lower level relations: if it is not demonstrated as initially possible for relations to relate other relations, then BRT will not be a convincing metaphysics.

So again, the plausibility of a coherent metaphysics for OSR has returned to (something like) the *intelligibility question*, for we are pressed with trying to explain how relations can relate relations, given that relations need some relata or other. And thus, we can see that a central concern for BRT is to address – in some manner - the *intelligibility question*: if there are only relations, then relations must relate those entities, given that relations require some kind of relata or other. Yet, it is just not clear how relations serve this role.

In response, I think BRT should take a page from the dialectic

surrounding BT, recounted earlier, by suggesting that the view is *revisionary*. That is BRT should *refuse* to respond to the question of how relations can relate relations; it should refuse to (try to) satisfy the second desideratum. Accordingly, just as BT was revisionary in its denial that properties are the kinds of entities that require support - so too BRT should embrace a revisionary nature by *refusing* to respond to the *intelligibility question*. This is a consequence, it seems, of the rejection of the support question: because properties and relations are not the kinds of entities that require support, we need not accept the intelligibility question as legitimate. Thus, just as properties in BT have a non-dependent nature, so too do relations have a (heretofore unappreciated) "related" nature.

To grasp what this entails, recall that when BT rejected the suggestion that properties required support the opposition, substratum theorists, suggested that such a refusal gave rise to the *coincidence question,* viz., "How can we explain the constant coincidences of properties?" BT then makes its (in)famous appeal to the primitive relation of compresence as an explanation of these coincidences.

For the bundle of relations theorist who refuses to respond to the *intelligibility question*, one might wonder whether some analogous question to the coincidence question arises. That is, just as the

coincidence question comes to the forefront once the support question is rejected, so too we might ask whether any further questions arise once the *intelligibility question* is ignored. One issue that seems to arise with the rejection of this concern is the task of explaining why certain relations exist. Thus, we might wonder why there are specific relations rather than others; why, that is, there is this relation R_1, rather than some other relation R_2? Call this the *occurrence question*.[49]

We should note how easily this question would be to answer if we had recourse to intrinsic properties or substrata. After all, for substratum theorists it is the presence of the substratum - or an intrinsic property - which explains the occurrence of a specific relation. Thus, we can 'point to' that entity (substratum, intrinsic property) to explain the *occurrence* of the specific relations to which we are committed. Cut relata (i.e., intrinsic properties, substrata) from our ontology, however, and this explanatory ease is lost. Thus, it might be easy to explain why the relation *fatherhood* (rather than *motherhood*) holds between two entities x and y, if we could make reference to the (intrinsic property) *maleness* (rather than *femaleness*) of x. Yet, we have rid ourselves of

49 One important note: our response to this question should be phrased in terms of *universals*, rather than *tropes.* Importantly, I see no *prima facie* barriers to defending BRT as coupled with a trope ontology; Esfeld and Lam (2010) defend this position. In fact, I believe that one of the more successful ways to circumvent a number of bundle theoretic problems is to adopt a trope ontology. I merely avoid it here because I want to make the current case for BRT as appealing as possible.

intrinsic properties.[50] Thus, BRT seems to need another response.[51]

If we look closely at the nature of the occurrence question, not only is there a strong parallel between the it and the coincidence question, but also we can see that there is really nothing more to this question than was contained in the *intelligibility question*. All of this indicates that we need only to return to the original appeals of BT as a wholesale response.[52] Recall that the coincidence question asked what grounds we have to say that some property was a property of some entity; without a substratum it was hard to see why might identify some property as belonging to an object. Compresence was the relation to which we appealed in response: this relation, a primitive, unifies all the properties of an object as properties of that object.

Now we are pressed with the occurrence question – *Why R_1 instead of R_2? - w*hich arises because of the structuralist's disavowal of intrinsic properties and substrata; the question comes to the fore because of a concern with the lack of an 'anchor' for the relations and, it

50 Again, as I have said, we have not cut all intrinsic properties from our ontology but only those that are non-relational. Yet, again, it is not clear how much work, if any, relational intrinsic properties can do in response to this question; I should think that there will be some (indeed, many) relations to which we will be committed which cannot be explained via appeal to these relational intrinsic properties.

51 Alternatively, we might respond by suggesting that the existence of R_1 can be explained by making an appeal to R_1 as primitive. That is, we might suggest that the only way to answer the question "Why does R_1 exist (rather than R_2)?" is by appeal to other theories like the laws of nature. Adam Morton (personal communication) has suggested to me that this is *the only* appeal that we would need to make. I am sympathetic to this defense, but hope to say slightly more about the issue as well.

52 What I say here holds for whichever substitute for compresence (like the *fusing* relation) that one might employ, if one prefers to avoid compresence.

threatens to undermine the bundle of relations approach, just as the coincidence question did: the claim is that the substrata theorist's view is a better metaphysical account because the bundle of relations view cannot address these concerns.

Still, the appeal to compresence provides adequate response to the new concern. Once we recall that objects are bundles of *compresent* properties, the impetus behind the occurrence question falls away. After all, for BRT objects are *compresent* relations; R_1 is compresent with the other relations in that bundle. We say that R_1 occurs in the bundle *because* it is compresent with other relations that serve as its relata – and that is all there is to say. Compresence is a relation which binds relations to other relations *because* these relations are the relata for the other relations to which they are bound. It is to say that the relations occur with the others *in virtue of* the compresence relation holding. Nothing more can be gained by posing the occurrence question, Why R_1 rather than R_2? R_1 occurs because it is part of the bundle; the other relations require it. Period.[53]

An example: assume R_1 is binary. Accordingly, we would know that compresence binds two other relations, R_2 and R_3, to R_1. In total, then,

53 Shades of Adam Morton's view (see nt. 51) can be seen here, yet this response has a more metaphysical flavour. We make an appeal to the *metaphysical* relation, compresence, in order to explain why there are certain relations. Thus, the occurrence of R_1 is not (just) a brute nomological fact.

we know that (at least) three relations are compresent: R_1 and two other relations, R_2 and R_3. Moreover, we know that *in virtue of being compresent*, if these three comprise the bundle then R_2 and R_3 are the relata for R_1. Thus compresence's nature as unifying explains how relations can relate relations, as well as why there are relations at all.

3.3.2. Stopping a Regress. A concern has yet to be addressed however. Briefly, the trouble with accepting an ontology of relations – even relations that can serve as relata - is that we may have to allow that there are an infinite number of relations in the world. Consider why: if relations take other relations as their relata, then these 'relata-relations' will also need their own relata-relations, in virtue of being relations themselves; but these too, in virtue of being relations, will need their own relata-relations, and so on.

First, I should make one clarifying remark: this regress could be viewed as deriving from our concern with *existential dependence* rather than our concern with *essential* dependence. Thus, the regress that concerns us here is not one where we need further relata in order to establish the identity of the relations at hand; instead, the regress is one that arises because each relation takes another as relata and so implies that other relations exist. Still, this regress need not be

understood as one which goes infinitely *downward* - where the implied relations exist at lower levels of reality.[54]

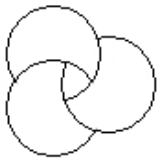
Must we permit that there are an infinite number relations because each relation essentially depends on some other relations for relata? We could; we might think that the world is infinitely relationally rich. Indeed, in the next chapter we will come to a view that can respond to the *intelligibility question*, but at the cost of accepting an infinite (downward) regress of relations. So we might choose to allow this consequence. Yet we need not accept an infinite number of relations: we can also accept BRT and avoid the regress by embracing the possibility of what I shall call *inner-reaching entities*.

The suggestion is subtle, but can be stated easily: if an entity were to consist solely of relations, but those relations did not "reach outside" the entity, then that entity would not require further relations to 'fill in' as relata. Consider a toy example: entity E consists of three two-placed relations. Each relation within E takes the other two relations as its relata; none take any relata which are outside E itself. Thus, relation 1 takes as its relata both relation 2 and relation 3; relation 2 takes as its relata relations 1 and 3; and relation 3 takes relation 2 and relation 1. And, there are no relations which are part of E

54 The downward directed regress is addressed in the next chapter where we see that, for BRT, it is not a threat

which take some relata outside of E: the relations form an inter-dependent loop.

Entities like E are what I call *inner-reaching* entities. We can adopt one successful visual representation of an inner-reaching entity from Donald Mertz (2006)[55] where relations are represented by the 'crescent-moon' shaped objects, of which there are three (Graph 3.2). We identify the relata of each of these relations by examining the 'points' or 'tips' of the crescent-moon shapes to find what touches them. Considering the 'top' relation, we can see that it has the bottom two relations as its relata because they are at its 'tips'. Similar remarks can be made about the other two relations. Thus we can provide relata for the three relations, without appealing to non-relational relata, and without always needing to cite a new relation.



One should note that there is nothing special about the fact that I have limited my discussion to bundles which consist of two placed relations. Though the cases would likely be harder to present pictorially, the possibility of mutually sustaining relations can be extended to

55 Mertz calls these *closed systems* (2006, 154).

entities which contain *any* number of relations of any adicity just so long as each 'relata place' is filled with a relation within the same entity (cf., Mertz 2006, 154-5). So, for example, it would be legitimate to claim that Graph 3.1 is itself an inner-reaching entity. We can see that the possibility of inner-reachers, in general, makes it clear that we need not accept the infinite population of relations.[56]

3.3.3. Summary of OSR's BRT. We have now come to the full explication of OSR under the guise of BRT. First, OSR is the view which accepts ***Scientific Realism***, ***Structuralism***, and ***Ontic$_2$***, as follows:

> ***Scientific Realism*** - The world has mind-independent, objective features which are revealed to us (in approximate form) by scientific theories.
>
> ***Structuralism*** **-** Scientific theories reveal to us the structural features of the world.

56 Another general remark: it would seem that all eliminativist or reductionist accounts of OSR face this choice: accept an infinitely rich world of relations, or allow that there are inner-reaching entities. This means that French (2006) and some of the earlier Ladyman positions (e.g., 1998) must make this choice. Of course it would seem that they tend toward the first disjunct, after all they are quite fond of stating that the world consists of relations "all the way down" (Ladyman 1998; French 2003).

Ontic₂ – Relations are more fundamental than relata.

The acceptance of ***Ontic₂*** (under its strictest reading, which rids us of objects, but not all relata) when coupled with ***Structuralism***, ushers in the bundle theoretic approach where relations play all the roles: thus, these two theses give us the bundle of relations theory, BRT. Following the revisionary flavour of BT, BRT denies that the *intelligibility question* needs a response: BRT insists that there is no need to respond to the query "How can we have relations without relata?". Finally, BRT can avoid the potential problem explaining the occurrence of relations by (re)appealing to the compresence relation for an explanation. Compresence is then understood as the relation that not only unifies the bundle of relations into an object, but it also allows the unified relations to serve as relata for one another.

3.4 An Alternative Argument for the Realist

3.4.1. Preliminary Remarks. We have seen the consequences that OSR has for our conception of objects and individuals if we strictly adhere to the lessons from the previous chapter: relata can be maintained only as relational entities; they are but bundles of relations. Some authors are not happy with this proposal. Indeed, they suggest that this ontic claim

(i.e., that there are relations with relational relata) is too troublesome to tolerate. While we can see now that this is not entirely compelling – allowing that relations can be relata is perfectly acceptable – it will pay to consider one argument from another realist position which hopes to avoid the ontic structuralist alternative.

3.4.2. Semirealism. Anjan Chakravartty (1998, 2007) suggests that there is a compromise to be found between ESR, OSR, and realism; he calls it *Semirealism*. There are two main components to *Semirealism*. First, *Semirealism* claims that though science gives us causal contact only to relations, we *must* infer from these the existence of underlying intrinsic properties. Second, it defends an inference to objects; that is, it claims that the best explanation for the fact that groups of properties regularly cohere is that there are objects. Given that I deny the inference to intrinsic properties, let's consider the abduction towards objects.

As Chakravartty says, "*Semirealism* is a realism about properties and their relations in the first instance" (2007, 65). Of course, *Semirealism* would be foolish not to recognize all the troubles that previous realisms have faced, especially the PMI. Thus, Chakravartty draws a distinction between detection properties (and relations) and auxiliary properties, suggesting that a wise *Semirealist* should commit

only to the former and not the latter. Briefly, detection properties are "the causal properties one knows, or in other words, the properties in whose existence one most reasonably believes on the basis of our causal contact with the world" (2007, 47),[57] while the latter are "any other putative properties attributed to particulars by theories" (*ibid.*).

From the commitment to detection properties, and from the recognition that many properties cohere much of the time, *Semirealists* move towards objects which they "identif[y] with *cohering sets* of detection properties" (*ibid.*, 65). This move is supported by one line of argument, so far as I can tell: "A particular set of properties come together as a package to constitute an electron.... These sets of properties seem to like each other's company; they are always detected together. *Coincidence or object*?" (ibid., 79; emphasis added).

This is an abductive argument, much like the NMA which supports realism. Still, in order to see if postulating objects really does best explain the consistent coherence of properties, we need to explore first what 'object' could mean. It seems to me there are three potential readings: objects as substrata; objects as bundles of properties; and, (an

57 I should mention that there is good reason to believe that we cannot merely limit detection properties to causal properties, however. There are some relations that we *need* to exist for our theories to be as successful as they are, even though we do not strictly speaking 'detect' those relations. Symmetry within quantum theory, I am told, is just one of these. We do not ever detect symmetry but we *need* it to make the kinds of predictions that make those theories highly successful (see Roberts 2010). Even still, we can broaden slightly the definition of 'detection property' to include those relations *necessary* to make successful predictions, without undermining the distinction that Chakravartty wants to maintain. See Roberts (*ibid*.).

unorthodox reading of) objects as intrinsic properties.

We already know that there are generally serious troubles with inferring substrata. However, Chakravartty's "coincidence or object" line might be seen as giving new lease to substrata. How? We rejected substrata before because they have no role to play in our metaphysics and are, thus, idle. However if substrata are needed to explain why we seem to have cohering sets of properties, then no longer are they idle. Of course, as the discussion in this chapter has shown we do *not* need substrata to explain cohering sets of properties; BRT can do so perfectly well, without having to make the *extra* stipulation that there is some entity about which we can know nothing.

However, as I read Chakravartty's *Semirealism* substrata are not a part of his metaphysics. Hence his statement that *Semirealism* is a realism about properties and their relations in the first place (2007, 65). Of course, this means that we should read him as a bundle theorist. Under this reading, however, it is not clear what the 'coincidence or object' argument provides unless we take it as an inference to the identity of objects and properties (or, the supervenience of objects on properties). This *is* coherent, but it is not clear that it is a *better* explanation than the BRT approach especially if we are also inclined to reject intrinsic properties (as the PMI seems to require).

This brings us to our final reading of 'object' as intrinsic properties.[58] While the admittance of intrinsic properties does mark a significant difference between *Semirealism* and OSR as defended here, it seems clear that allowing intrinsic properties is not justified by the 'coincidence or object' argument. The task posed by that argument is the explanation of constantly cohering sets of relations. But, intrinsic properties do not explain this; at best they *might* explain the presence of some single relation or other - whichever relation (supposedly) warrants their inference – but this is far from best explaining the coherence of the group of properties. Besides, as we have seen, BRT can appeal to compresence to account for the cohering group of relations.

Nor do I think it is feasible to cite *groups* of intrinsic properties as a *best explanation* for cohering collections of relations,[59] for this merely pushes the discussion back a level. How might a *group* of intrinsic properties explain the fact that some group of relations regularly coincide? The mere assumed presence of this grouping cries out for an explanation of its own without explaining why the relations themselves cohere. Indeed, it would explain this only if there were some 'special connection' between both the group of intrinsic properties as well as the

58 To be clear, Chakravartty never makes this suggestion. In fact, the reason Chakravartty infers intrinsic properties from relations is because he thinks that knowledge of the one entails knowledge of the other. I deny this inference: it is too troublesome (as suggested at the close of chapter 2), given the PMI.

59 Again, this is not Chakravartty's suggestion. I make it merely to explore how we might understand the 'coincidence or object' argument.

group of associated relations. But, traditionally all of this is explained by employing substrata or the compresence relation. So, employing intrinsic properties to *best* explain (or even merely explain) the coherence of relations does not seem to be a winning strategy. (My previous arguments, on the other hand, suggest that BRT can handle this task.)

We have seen then Chakravartty's *Semirealism* is similar to the position which I defend, BRT, given that the only tenable way to interpret 'object' in the 'coincidence or object' argument is in terms of a bundle of properties. Of course there is the matter, upon which we differ: the inference to intrinsic properties. However my bundle (of relations) theoretic account goes a long way to demonstrating how the inference to intrinsic properties is unnecessary baggage.

3.5 Objections Diffused.

3.5.1. Diffusing Troubles Concerning the Ontology of 'Mere' Relations. It shall be my current task to address some of the concerns that arise with the acceptance of an ontology of 'mere' relations as a (potential) metaphysical system for OSR. I have tried to address one of these concerns already with my discussion of the identity of relational entities, but there are other concerns as well. I suggest that these problems, as well as their solutions, can be grasped best if we consider

an analogous position in the metaphysics of properties known as dispositional essentialism (DE).[60] I shall give a cursory account of DE, and then outline two key objections that have been raised to it (as canvassed by Bird 2007).

3.5.2. Identity Concerns. Consider the debate for the dispositional essentialist: DE holds that *all* properties whatsoever are dispositions. For a property to be a disposition is for it to "give some characteristic manifestation in response to a certain kind of stimulus" (Bird 2007, 3); this makes a disposition essentially relational.[61] The pending objection is that if all properties are dispositions, and if dispositions are essentially relational, then we will not be able to establish the identity of any disposition whatsoever. Consider: if the essence of a disposition is relational, then we can describe it only in terms of its relations to other properties; it is X when in condition(s) Y. Yet, because X and Y are both properties themselves, and because all properties are dispositional (according to DE), both X and Y will be relational as well; thus, these too will be identified relationally with respect to *other* manifestation and

60 In fact, I shall return briefly (in section 3.5.3.1) to an outline of a position, drawn from Esfeld (2009), which couples DE and OSR. I shall not defend that position in this work, but it should be clear that I think this line has promise.

61 But, for a dissenting view, see Heil (2005). I do not think he, nor others who make a similar denial, need to do so; it seems to me that the impetus behind such a denial is the belief that intrinsic properties cannot be relational. But, as I have already suggested, I think there is good reason to be suspicious of that claim that all relational properties are extrinsic. See section 3.2.5, above.

stimulus conditions which themselves will be dispositional; and, so on *ad infinitum*. Thus, the objection runs, DE makes it impossible to establish the identity of any disposition.

The analogous objection to OSR (under the BRT interpretation) has already been suggested: the identity of entities will be indeterminate if we take them to be entirely relational things because we will always look to further entities, themselves relational, in our attempt to give the identities of any entity; and so on *ad infinitum*. So it appears that the identity of entities can never be fixed or determined because we will forever be searching for it in more relations.

While the analogy should be clear, we know that the objection has no bite (in either the DE or OSR case): in the discussion of graph theory we saw that relational entities can establish the identities of entities even if there are no intrinsic properties.[62] Indeed, it would seem that the objection hinges on the claim that identity can be established only if there is (are) some non-relational constituent(s) to which we can refer. (In the case of DE, this would be categorical properties; in the case of OSR, this would be non-relational intrinsic properties.) But, of course, the graph examples show that *prima facie* there is no reason to accept such a strict limitation.

62 For another, similar account, see Ladyman (2005). For the response on behalf of DE, see Bird (2007).

3.5.3. Too Little Actuality. The literature on DE offers other objections against an ontology of relations, however. In brief, an analogous trouble in the literature on DE is called the 'too little actuality' argument (TLA) (Bird 2007); it suggests that an appeal to merely relational properties will not be sufficient for accounting for causation. I shall canvass this trouble for DE, and then present what I take to be the most threatening analogue for OSR. Finally, I shall say why this analogous argument is not persuasive.

The TLA argument against DE runs as follows. All properties cannot be mere potencies because potencies lack 'sufficient reality' to be all that there is to objects of the world. So if all properties were potencies, there would not be "enough actual being in the system" (Bird 2007, 100-1). In other words, there cannot be merely relational properties; there has to be at least one non-dispositional (i.e., categorical) property for there to be something other than merely *potential* – i.e., for there to be *act* - in the world.[63] If all properties are potencies then each potency merely leads to another potency; that is, each potency is just a potency for a potency for a potency, etc., without ever being a potency for *something* (Bird *ibid.*).

The analogous argument against OSR is (probably) best expressed

63 Armstrong (1997, 80) suggests something similar.

in terms of BRT's inability to account for the causal nature of the world because of its adherence to (mere) relations. So: OSR claims that every thing that exists is a structure. But if there is only structure, then there are not enough 'existent things' for there to be causation. Causation requires objects or intrinsic properties.

As Chakravartty (2003a) has noted, objections to OSR which focus on causation seem to be appropriate. Commonly, reality or existence is said to depend on having causal influence or power. This is known as Alexander's Dictum: "to be is to have causal power."[64] If this is true – if we accept Alexander's Dictum – then we can understand how the complaint might arise that the elimination of relata (qua objects or intrinsic properties) is, *ipso facto*, an elimination of causation.[65]

This objection depends on two commitments. First is the commitment to Alexander's dictum – existence depends on having causal powers; I shall not dispute this claim.[66] The second commitment is that causal powers *necessarily presuppose* relata as something non-relational

64 See Jaegwon Kim (1995).

65 Ladyman and Ross (2008) suggest that there is no need to take this objection seriously because 1) OSR applies only to realism about quantum physics, and 2) quantum physics is not appropriately understood in terms of causation. (Why (2)? Briefly, because causation is a *directed asymmetric* relationship, while the relations we find in quantum mechanics are not – at least as far as the important equations let on.) While (2) might be true, I think that OSR applies more broadly than merely to quantum physics (as we saw from the discussion in Ch. 2), so Ladyman and Ross' response is insufficient.

66 An interesting point: if fn. 65 is correct, then Ladyman and Ross would have to deny Alexander's Dictum. They think there is a quantum realm, but that it is not causal in nature. So, to be is *not* to have causal powers, *pace* Alexander's Dictum.

(i.e., intrinsic properties or substrata). This second commitment can be understood in two ways: (i) causal powers are *only* in objects qua entities with intrinsic properties, which are the 'nexus of change'; or (ii) causation (at least partially) *depends* on objects: causation requires both objects and structure but neither is sufficient for causation (cf. Chakravartty 2003a).

The objection that OSR is incompatible with causation is not compatible, however, with the claim that (iii) structures are sufficiently causal in nature. This view deserves a brief discussion, for if defensible it undercuts any force this line of objection might have. We'll (very) briefly discuss this third issue, before moving on to the first two questions, which can be dealt with in tandem.

3.5.3.1. Necessary Connections? One feature of OSR that I have left in the background until now is that relations are sometimes understood to have 'primitive modality' to them (as in Ladyman 1998; Ladyman and Ross 2007; French 2006). There has been little discussion in the literature about how we ought to understand this appeal to modality. But, as Esfeld (2009) points out, if we were to understand these relations as primitively causal then the objection from causation loses its bite.

Consider a brief sketch of the position that takes relations to be primitively causal. According to Esfeld, for structures to be causal is for them to be composed of dispositional rather than categorical properties. That is, a commitment to primitive modality can be spelled out as a commitment to the claim that properties are *not* anything more than the nomological or causal relations in which they stand. Thus, the position that structures are causal is the rejection of the claim that there is a *quiddity* to properties, an identity of those properties independent of the relations in which they stand. This is a commitment, in other words, to dispositional essentialism.[67]

There seem to be similar grounds for accepting this view of properties as there are for accepting the Ontic Structural Realist's position: if we commit ourselves to categorical properties – the view that properties have identities independently of the causal roles that they play in a world –, then it is possible that there are two causally identical worlds but where the causal relations are played by many very different properties (cf., Chapter 2, section 2.2.2). Thus, there could be no manifest discernible difference between worlds W and W* even though in W the property 'mass' plays causal role C, while in W* causal role C is played by the property 'charge' (Esfeld 2009, 4-5).

67 Hawthorne (2001) outlines this position; he calls it 'casual structuralism'. See, also, Shoemaker (1980) and Bird (2007).

The consequence of accepting dispositional essentialism is that properties are defined by the causal roles that they play. Thus, causal connections are necessary and primitive.[68] But, the further consequence is that OSR is after all compatible with causation just because the properties to which it is committed are causal properties.

I am inclined, however, to leave open the possibility that the arguments for causal properties might be mistaken. Thus, we should concern ourselves with how we might account for causation under a defense of properties as categorical. That is, I want now to consider whether one can account for causation without having to take on the dispositional essentialist's view of properties. Thus, I turn now to the objection in (i) and (ii), where objects were taken to play some crucial role in causation.

3.5.3.2. Connectionist Theories and Conserved Quantities. How might we reply to (i) – that causal powers are only in objects - and (ii) – that causation depends on objects? The trouble, to be clear, is that we need an account of causation which does not depend on any entity that OSR has eliminated. Thus, we need to examine accounts of causation to determine if they rely, fundamentally, on troublesome non-relational

68 Although, see Handfield (2008) who argues that we can be committed to dispositions without *ipso facto* being committed to necessary primitive connections.

entities like intrinsic properties or substrata; if we find that they do, then we will have to find an alternative to OSR. Not surprisingly, I think we shall find that this is not the case. I shall argue that of the ways found in the literature which hope to account for causation, all of them are compatible with OSR; each approach is perfectly amenable to the ontic structural realist's position, understood under the guise of BRT.

There are two broad approaches which attempt to account for the causal relation, each of which utilize different causal relata. Broadly, these accounts can be labeled *local* and *global*. The former suggest that the causal relation can be best captured solely by looking at the casual situation itself; what goes on around the casual interaction is irrelevant to the causal situation. The latter, global theories, suggest that in order to properly account for the causal relation we must consider not only the specific causal interactions, but also what is going on outside or around it in order to adequately capture the relation. We shall consider each of these in turn.

Consider, first, the local theories of causation which include Wesley Salmon's (1984) 'mark transference' theory, David Fair's (1979) 'connectionist' account, as well as Phil Dowe's (1995; 2000) conserved quantity approach.[69] The latter of these is the most developed (and was

69 As both Fair (1979) and Dowe (2000) recognize, local theories fail to account for causation by omission. (Examples of this kind of causation are ubiquitous in the literature on causation; see, e.g., Dowe 1995) To my mind, this shortcoming is a culling blow to the local approaches.

ultimately adopted – though in a slightly different form - by Salmon 1997), so we shall focus our attention there.

According to Dowe, we can analyze the causal relation as follows:

> "CQ_1 – A *causal interaction* is an intersection of world lines which involves exchange of a conserved quantity.
>
> CQ_2 – A *causal process* is a world line of an object which possesses a conserved quantity" (Dowe 1995: 323)

As should be obvious, the relata of causal relations are world lines of objects, where a "world line" is a "collection of points on a space-time (Minkowski) diagram which represents the history of an object" (Dowe, 2008); these objects possess conserved quantities, where a conserved quantity is "any quantity which is universally conserved, and current scientific theory is our best guide as to what these are" (*ibid.*). As Dowe goes on to note, our current theories would seem to suggest that mass-energy, linear momentum, and charge are our best candidates for conserved quantities.

As far as these conserved quantities are concerned, there is no obvious incompatibility with OSR's "structure only" commitments. In

Dowe, however, tends the other way: because this kind of causation cannot be accounted for by the conserved quantity approach, he takes omissions (and preventions) to be only instances of *ersatz-causation.* I will not address this issue here.

virtue of the fact that the appropriate conserved quantities are to be determined by our successful scientific theories, these quantities will be relations. Accordingly, when OSR insists on a metaphysics of relations only, they do not exclude Dowe's theory. Indeed, these quantities (mass-energy, linear momentum, and charge) seem to be the kind of property which is captured by the mathematical equations that I take to describe the structure of the world; and, thus, they seem to be relations. So, it would seem that these at least are no trouble for the OSR.

Objects, which make up 'world lines', might be a different story however. In fact, CQ_1 and CQ_2 seem to place these objects as the true relata of the causal relation. If this is correct, then the commitment to (world lines of) objects as the relata for the causal relation might be trouble for OSR. Here is the trouble put into different words: If Dowe intends (world lines of) "objects" to track something robustly non-relational (e.g., a reference to a substratum) then because OSR under the strictest, BRT, interpretation rids us of these OSR's account of causation could be in trouble.[70]

Thankfully, Dowe's theory is not committed to any particular interpretation of objects *qua* substrata; indeed there is nothing preventing us from considering 'object' as a reference to the bundle theoretic collection of relations. Accordingly, a world line would not be

70 Cf., Chakravartty (*manuscript*); and, this chapter, *section 3.2.4.*

the history of an object *qua* substratum, but the history of the bundle. The conserved quantity would then not be 'localized' by a substratum, but rather it will be compresent with other properties.

Though this is obviously non-conventional, it is not incoherent. After all, what is crucial in CQ_1 and CQ_2 is that there is a 'possession' and 'exchange' of conserved quantities; and this feature can be preserved even when non-relational entities are cut from our ontology. Consider a prototypical causal process: the cue ball on a pool table strikes the eight ball, moving it away from us. According to CQ_1 and CQ_2, this process is causal because the cue ball possesses a conserved quantity which is exchanged; contact with the eight ball sees the conserved quantity exchanged between the two balls. Thus, we have two world lines of objects which intersect. A conserved quantity is first at a space time point which is part of one world line, and then at a space time point that is part of another world line. Obviously, the intersecting world lines here are to be cashed out as compresent bundles of properties. Pre-intersection, the first bundle has a (relational) conserved quantity, and so does the second. After the intersection, both bundles see a proportional change to the conserved quantity in the bundle. There is no trouble for OSR.

3.5.3.3. Counterfactual Accounts and Events. Consider now, the global candidates for a theory of causation. Almost every version of these theories owes something or other to David Lewis' (1973) counterfactual theory of causation. Accordingly, I shall focus my discussion there – with the recognition that there are obvious shortcomings which ultimately need to be addressed in order for this account to be successful.[71]

The central relata for the counterfactual account of causation are typically taken to be *events*. How and whether events are amenable to a structuralist account of causation will depend just on what we take events to be like. Yet, it seems like there are acceptable accounts of events that can be adopted which do not rely on objects or intrinsic properties. I shall canvas two such accounts, one from Lewis (1986) another from Jaegwon Kim (1996).

According to Lewis (1986) events occur in regions, and being unrepeated, occur in no more than *one* region of a world. For each event, there is a corresponding property which belongs to the region in which the event occurs. Events are not *natural* properties though; they are instead 'metaphysically innocent': for a region to have a property corresponding to an event, says Lewis, is merely for it to belonging to a

71 There is a litany of literature to this effect. For one example, see Schaffer (2001). On the plus side, the strength of the global account is that it can very easily and (often) non-controversially handle the omission and prevention cases which are (in my opinion) terminal problems for the local accounts (cf., nt. 69).

class or set; "*All* things that have the property, whether actual or merely possible, belong [to that class]. ... The property that corresponds to an event, then, is the class of all regions – at most one per world – where that event occurs" (Lewis 1986: 243). The collision of the cue ball with the eight ball, for instance, is an event to which there corresponds a property of a spatio-temporal region. This region is (somehow) cross-world identified.[72]

It should be obvious that there is nothing incompatible with this account of events and the requirements of OSR. The class that are events can be a class of regions containing *structures* (i.e., bundles of relations), just as easily as a class or regions containing intrinsic properties or substrata; after all, Lewis is not explicitly committed to an event containing a non-relational object or an individual. So, Lewis' account seems amenable to the ontological structural realist's aims.[73]

72 While there is only one token event per world, the class of events – the property – will need to be robust across the changes in times of occurrence for at least (some) events. As Lewis notes (1986, 249-50), if we allow any (counterfactual) change in time to constitute a new event then we will have far too many undesirable consequences: Imagine I am poisoned and will die at 10:30. The application of the imperfect antidote prevents my death at 10:30, but fails to nullify the poison fully; I die at 10:45. If the event of my death at 10:30 is a different event from the event of my death at 10:45, then the latter event counterfactual depends on the event of the doctor administering the antidote. Without the antidote-event, the 10:45-death event wouldn't have occurred. Accordingly, the doctor is causally responsible for my death, despite trying to save me. An unacceptable consequence; one which any account of the identity of events must avoid. (We shouldn't say, however, that time plays no significance: I could die many different poisoning deaths surely; it's just that the only difference between those poisoning deaths cannot be merely temporal.)

73 Nor is Lewis committed to events as individuals themselves. This is due, I think, to the fact that Lewis wanted to avoid the conclusion that events have 'counterparts'. So, for example, one role that his modal realism was meant to fulfill was explication of his counterpart theory; for Lewis, only individuals have counterparts; if events were individuals then they too would have counterparts. But, events are not individuals – they are classes.

Kim (1976) offers an alternative to Lewis' claim that events are classes. For Kim, an event is the "exemplification of a property" by "concrete objects" at a time (226). That is, events are a complex structure (i.e., a relation) represented by [E, P, t]: E is the 'concrete object'; P the property exemplified; and t the time at which the property is exemplified.

Prima facie, this would seem to conflict with the structuralist approach given the inclusion of 'concrete objects'. Yet, perhaps not surprisingly, 'concrete objects' can just as easily be seen as a reference to a wholly relational bundle of relations, rather than a troublesome reference to substrata (or intrinsic properties).[74] Most certainly, though, 'concrete object' need *not* be understood as a reference to intrinsic properties. And, as long as we can avoid substrata and intrinsic properties, we can account for causation without violating the strictures of ***Ontic₂***.

3.5.3.4. General Remarks on Causal Concerns. At least with these preliminary considerations, one begins to wonder what the trouble with

74 In fact, there are OSR-independent grounds for questioning Kim's reliance on "concrete objects". Some entities that should count as events seem lack 'concrete objects' – even understood very loosely – and so would be excluded on Kim's account. For example, the lights going out seems like a good candidate for an event; but where is the concrete object for this event? Perhaps it is the room; I think this is a stretch, but never mind. What about the event of the weather changing: what's the object here? The whole world seems like too big an object to count, but any less seems too little (cf., Brand 1977).

employing 'events' might be? The initial presentation of OSR, in Ladyman (1998), suggested that the proper construal of OSR would move away from *individuals* and *particulars*. If this is taken to be the source of the trouble from causation, then perhaps this is understandable (even if ultimately ungrounded). After all, even a preliminary exploration of the literature on events reveals a number of potentially troublesome aspects. For instance, it is common to describe events as *individuals* in many of the ways which coincide with how *objects* are taken to be individuals: for instance, they "both appear to be concrete, temporally and spatially located entities organized into part-whole hierarchies" (Casati and Varzi 2010). Coupling events with objects in this way, while adding to it the label 'individual' directly conflicts with the seminal presentation of OSR.

Yet, none of these above understandings of 'individual' are accounts that OSR actually needs to avoid. Indeed, as we see in chapter 2, the ways for understanding 'individual' that OSR *must* reject are those which require non-relational aspects. Thus, OSR should reject events only if *the only* plausible account that can be given of them is one which implicitly or explicitly embraces something like these commitments. But, of course, there is *no* reason to believe that events absolutely *must* endorse an approach embedded in these traditions, as we have seen

with the brief discussion in this section.

3.6 Conclusion

3.6.1. Concluding Remarks: What Next? This chapter saw the development of a novel account of bundle theory: a bundle of relations theory. At first glance, BRT seemed to follow directly from the conclusions we drew in the previous chapter. I clarified how these implications ought best to be spelled out. Crucially, I suggested that BRT should embrace the revisionary nature of its kin, bundle theory, by suggesting that the *intelligibility question* – the question which drives the discussion of this *entire thesis* – can go unanswered. Moreover, I tried to anticipate objections from the conservative type who would suggest that the refusal to answer the *intelligibility question* only leads to further troubles. As it turns out, those troubles are easily avoided so long as we are able to fully appreciate the role of compresence under BRT where compresence is the relation which holds between other relations just in case those relations are also capable of being relata for the relations to which they are bound.

One might wonder, however, why the discussion does not stop at this point if BRT is as successful as I suggest it is. That is, if OSR can adopt BRT and thereby refuse to answer the *intelligibility question* why

do I insist on carrying on the discussion into a fourth chapter? The answer is relatively simple: for some the BRT proposal is too costly. Just as bundle theory is too high a price to pay - given its refusal to respond to the support question (which substratum theory supposedly answers succinctly) - for the putatively metaphysical homogeneity, so too is BRT's refusal to respond to the *intelligibility question* too high a price to pay for the accommodation of OSR's central claim that there are only relations. For these folk, another option needs to be presented. The next chapter is such an option. There we will find that we can accommodate the strictures of OSR within a more palatable metaphysics. Accordingly, we shall find in the next chapter that there is space to accept a 'substratum theory-esque' approach, so long as we accept a few caveats and alternative metaphysical consequences. Let's explore these issues.

Chapter 4

OSR and Infinitism

4.1 Introduction

4.1.1. Preliminary Remarks. In this chapter I present and defend a second metaphysical account for ontological structural realism. This alternative metaphysical account enjoys a few key benefits. First, it can partially avoid the revisionary bundle theoretic metaphysics championed in the previous chapter in exchange for a more traditional metaphysics involving intrinsic properties or substrata, so long as the existence of these non-relational relata is constrained to levels. Such a shift allows the ontic structural realist's position to be more easily squared with the position adopted by the traditional metaphysician. The second, related, advantage of the current account is its capacity to respond to the *intelligibility question*, given the inclusion of these traditionalist ontological features. The advantage here is obvious for the entire purpose of this discussion is to satisfy the traditional metaphysician's desire for a response to this question. Both of these advantages are afforded OSR by a rejection of the formulation of the ontic postulate in terms of fundamentality. Instead, I suggest that we shift the ontic postulate towards the two notions of dependence outlined in the

previous chapter. This shift is completed while bearing in mind the broader metaphysical desire to account for the world in terms of levels of reality.

These benefits, however, have a cost. This cost is something I call *metaphysical infinitism*[75] (or *infinitism*, for short) which is the view that there are an infinite number of hierarchical levels which make up the world. Thus, under this new alternative approach, the structuralist is committed to defending the claim that there is no lowest fundamental level of reality. While this might seem *prima facie* troubling, I shall argue that there is no reason to view this consequence as too costly. Thus, part of my task to close out the discussion of the current chapter will be to legitimate this metaphysical implication.

4.1.2. Modus Operandi. The previous chapter demonstrated how the ontological structural realist can ignore the *intelligibility question* just so long as she is willing to make two metaphysical concessions, viz., that objects are mere bundles of relations and that these relations do not imply underlying intrinsic properties. The result was a bundle of relations theory. We saw, too, that BRT would be subject to an infinitely rich level of relations unless the possibility of what I called 'inner-

75 The title "*metaphysical infinitism*" distinguishes this discussion from *epistemic infinitism*. The latter, as defended by Peter Klein (2005), is the view that a belief can be justified by an infinite number of supporting beliefs.

reaching entities' is accepted: entities, fully composed of relations, each relation of which took (some of) the other composing relations as relata.

I want to begin by making two points. First, I want to suggest that the BRT version of OSR is able to accommodate the desire to give a metaphysical account of the levels of reality. Second, I want to turn our attentions, very briefly, to the plausibility of avoiding the infinite relations consequence with an appeal to inner-reaching entities.

I shall draw two conclusions regarding inner-reachers. First, I shall argue that the appeal to inner-reaching entities is potentially tenuous; and, accordingly, that BRT may have to allow that there are an infinite number of relations at a level. This brings us to my second suggestion, which also introduces us to the body of this chapter: I shall argue that if one is amenable to the infinite regress then there is a (partially) more traditional metaphysics to which one can appeal that carries with it all the aforementioned benefits.

Thus, one of the main goals of this chapter will be reconciling the traditional metaphysician (henceforth, the *traditionalist*) and the structuralist on metaphysical grounds; I shall search for a position which gives both parties what they want (at least partially); we shall find it comes at the cost of *infinitism*.

4.2 OSR: Bundle of Relations Theory, A New *Ontic*, and an Alternative

4.2.1.Levels and BRT. The previous chapter focused on ***Ontic₂***; the resulting metaphysics was bundle theoretic. I was careful to present that position in terms which were free of talk of levels of reality. So, I spoke of the world just as it consists solely of relations. However, the bundle theoretic account of OSR – and thus, ***Ontic₂*** – is also compatible with an account of reality in terms of levels. Indeed, this is one reason why I insisted on presenting ***Ontic₂*** in terms of 'fundamentality'. Let's see a brief presentation of BRT combined with levels.

Recall that ***Ontic₂*** states that relations are more fundamental than relata. We clarified this notion of "more fundamental than" in the previous chapter by making an appeal to the work completed by Anjan Chakravartty (*manuscript*), where "more fundamental than" was understood 'essentially': x is more fundamental than y, if y depends on x for the determination of its identity.

This notion of fundamentality strongly suggests a concept of levels; and, the BRT ontic structuralist can embrace this just so long as each level is understood under the guise of the BRT structuralist's conception, in contrast to the traditionalist's conception of levels. What is the traditionalist's conception of levels? The traditionalist accepts a mereological account of the world: she is committed to the fact that the

world is composed of parts which stand in some relations to one another. Typically these parts are taken to be *parts of a level* of the world. Thus we say that objects (i.e., a number of 'parts') exist at levels, and that these objects depend for their identity on (the objects of) lower levels which compose them.

Levels are typically picked out by considering the scientific theory which accounts for the entities at that level; thus, entities play a crucial role in the determination of a level. So we can talk about, for example, the astronomical level because at that level there are astronomical objects (e.g., planets, stars, nebulae) which stand in certain relations (e.g., gravitational fields, orbits, etc.); or, we can talk about the quantum level because at that level there are quantum objects (e.g., electrons) which stand in certain relations (e.g., entanglement); etc.

The ordering relation of these levels is, again, mereological. What makes one level, e.g. the quantum level, lower than other levels, e.g. the astronomical level, is the fact that the objects at lower levels are taken to be parts of the higher level, and not vice versa. Quantum objects are parts of the objects that exist at the astronomical level, but the astronomical objects are not part of the quantum objects.

From this mereological levels approach, we can derive an account of what it means for some object to depend on other objects for its

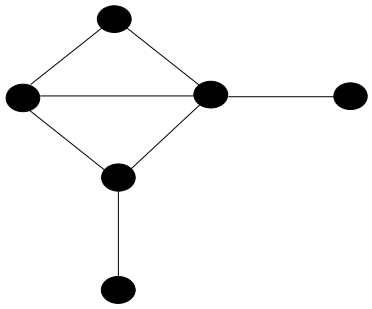
identity: an entity E_1, downwardly depends[76] on some entity or entities $E_2...E_n$ if: 1) E_1 exists at a higher level than $E_2...E_n$; and 2) if the identity of E_1 is determined by $E_2...E_n$. Thus, e.g., the traditional metaphysician will hold that the identity of my body depends upon the lower level cells which compose it; just as the identity of the atom will depend upon the lower level electrons and protons which are parts of the atom.

The structuralist, *qua* BRT, can quite simply accept all of these facets of the traditionalist conception of levels. Thus, she embraces the mereological account of the world: she embraces the fact that each level will be determined by the relata for that level. However, she insists that for all non-relational relata there will be a re-conceptualization such that the non-relational relata are eliminated. Keeping with the BRT stance, all objects will be relational.

We might return to the graph examples to see how this can be understood. Recall Graph 3.1: each node represents an object, but we understood objects not as having non-relational identity conditions, but rather as having relational identity conditions. The top node, then, has an identity which is {3,4}, as determined by the relations in which it stands: it is related to one node which has relations to three nodes (left); and it is related to another, which has relations to four nodes

76 The 'downwards' distinguishes this idea from the ontology of mathematics, where 'upwards' dependence has been discussed (see Linnebo 2008).

(right). Or, taking the right-most node, we can see that it is identified as the set {4}, because of the relation it stands in to the one connected node.



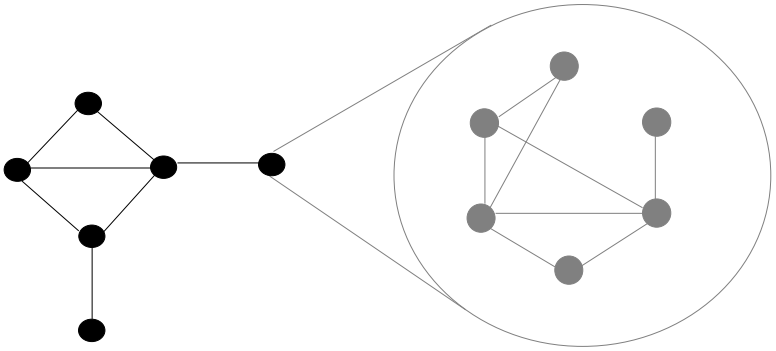
Graph 3.1

Imagine that Graph 3.1 captures a level of reality, that is taken to be the lowest level of reality. If it turns out after further experiments that there is a still lower level, BRT can allow for this. This new lower level will be picked out, initially, by the 'objects' that are detected during experimentation. Thus, that level can be initially presented in traditionalist terms, viz., as levels with relations and relata. This new lower level, typically, will be sought in an attempt to further characterize the entities at that higher levels; the lower level will give an account of the higher level entities.[77] BRT can allow for this further explanatory step (as prompted by scientific investigation) just so long as

77 The emphasis on science driving the search for lower levels is important. On the traditionalist account, we introduce a new level because there is scientific need to do so: without the lower level there is some explanatory loss which is unacceptable. It is crucial to bear this in mind because in the new metaphysical account that is to be presented in this chapter, the drive to find lower levels to account for the identity of higher level objects is entirely derived from the needs of the ontological structural realist. See section 4.3.2 for further detail.

BRT simultaneously insists that these new lower level relata can themselves be structurally understood. The bundle of relations theorist, that is, will insist that the new lower level entities will be characterizable in terms of relations entirely.[78]

Thus, consider Graph 4.1:



Graph 4.1

Conventions are as follows: The nodes and edges of structure in Graph 4.1 which are black occur at one level; the nodes and edges in gray occur at a lower level than those in black. Thus, the lower level entity includes the edges and nodes that form the (near-)hexagonal shape. I attempt to capture the idea that the node in black is composed of further entities by including the lower level (gray) relations as encased in a gray circle. Thus, the higher level is the collection of black nodes

78 Is this compatible with the essential dependence relations defended in the previous chapter? It would seem so. Relata at one level will essentially depend on the relations that compose them. If these composing relations turn out to be reducible to lower level relations, this would be another link in the chain of essential dependence. Relata at L_1 essentially depend on the relations at L_1. But if those relations are reducible to L_2 relations, then the L_1 relations actually will essentially depend on L_2 relations.

and relations; the lower level is consists of the gray nodes and relations. This gray circle indicates that *all* of the relations and nodes which are gray are constituents of the nodes at the higher level.[79] We can, of course, apply the same procedure that was applied to Graph 3.1, to get the relational identities of the nodes that exist at this lower (gray) level. The entire structure can be identified as the set of relations: {{4},{3,4}, {4,4},{2,4,4},{1,2,3,4},{2,2,3,4}}.

4.2.2. Potential Problems with BRT and Levels. One point to bear in mind with the construal of BRT in terms of the hierarchy of levels is that it is still a *refusal* to respond to the *intelligibility question*. This, coupled with the other problem that I shall canvass presently, might make one wish there were an alternative to BRT. First, though, what is this second concern?

In the previous chapter I outlined the possibility of inner-reaching entities. These were meant to prevent the requirement that there be an infinite collection of relations; after all, without inner-reaching entities, we would have to stipulate that there are an infinite number of relations because each relation takes another relation as its relata.

The potential trouble with relying on inner-reaching entities is

79 Something similar is presented in Mertz (2006), though his graphical conventions differ distinctly from those used here.

that our reliance on them is mere speculation, unless we can provide a real world example of such an entity. Yet, no example is forthcoming. Accordingly defenders of BRT, who do not want to accept infinitely many relations, seem at best able to say that inner-reaching entities seem *logically* possible (as the graph examples from the previous chapter demonstrated). Yet, logical possibility is a long way from the required actually existent; one ought to be tentative with one's commitment to these entities given that there are *no* forthcoming scientifically acceptable examples of such entities.

In fact, one might think that such entities *are* appealed to by one theory; but appealing to this theory as evidence for inner-reachers will not help the scientific realist. Here is why: in the 1960's scientists supported a theory called S-Matrix theory. This theory held that all quantum particles were made up of other quantum particles. Consider Cushing's (1985) simplified explanation:

> "there are particles – call them A – which can interact to form another type of particle, say B.... For simplicity let us assume that the forces between A and B are such that they do not form a new particle. Suppose though, that two B's can form another particle C.... In general we

> would expect particle C to be a type distinct from both A and B. However, since the mass of a 'bound' state is typically less than the sum of the masses of the particles producing it, the mass of C could be the same as that of A. In such a case we would have [A's producing B's, and B's producing A's]." (Cushing 1985, 40)

The requisite 'inner-reaching' circularity is obvious: subatomic particles of one type make up another type of subatomic particle; and, this latter type of subatomic particle make up the former. Thus, each sub-atomic particle is identified in terms of the other. (Potentially, the circularity here is not *exactly* that required to be an inner-reaching entity: inner-reachers require that their identity be determined by their relations, and it is not clear whether the *only* way to identify quantum particles under S-matrix theory is via *relations* to other particles. Still the circularity is sufficiently analogous, given that one type of particle can be understood in terms of another type (and vice versa), that one might hope S-Matrix theory could be appealed to as a way of providing an example of inner-reachers.)

S-Matrix theory might lead one to believe that we can find a physical realization for inner-reaching entities - and thus a sort of

refuge for OSR (qua BRT) in that theory; but, we cannot. Even if we forget that this may not be a perfect account of an inner-reaching entity, the real problem is apparent: OSR cannot appeal to this theory for examples of inner-reachers because the theory is now generally regarded as false. No rejected theory, even if it employs inner-reachers, can lend credence to the possibility of such entities; thus, BRT's central examples lack license.[80]

Still we should be careful for we are in danger of throwing the baby out with the bath water. Just because we have no legitimate examples of inner-reaching entities does not mean that we have to reject BRT *tout court*. The true consequence arising from the rejection of inner-reachers is that BRT must accept that there is an infinite regress of relations at each level: BRT must accept (a version of) what I call *infinitism* (another version of this *infinitism* will be outlined for the alternative metaphysics yet to presented). Indeed, I see no incompatibility between BRT and infinite hierarchies, *per se*.

However, I want to stress that if one is willing to accept an infinity within one's metaphysics as plausible, then one can accept OSR under a different interpretation besides the BRT construal. The benefit

80 A reminder is in order. As mentioned in Chapter 3, fn. 44, there is the problem (for structuralism) in general that the identification of nodes can only occur in asymmetric graphs. If each level is to be relational described as OSR requires, then each level would have to be representable by an asymmetric graph. It is not clear if this is possible.

of making this shift is that the alternative metaphysics is more traditional, rather than radically revisionary. To see how this alternative position arises, however, we need to re-examine the ontic postulate.

4.2.3. A New Ontic Postulate? Recall that the ontic postulates introduced in the third chapter are

***Ontic*$_1$** - There is only structure, i.e., relational properties.

***Ontic*$_2$** – Relations are more fundamental than relata

***Ontic*$_1$** clearly rids us of the non-relational; when we reformulated it as ***Ontic*$_2$**, we kept the restrictive sense of the original postulate. We saw that the restrictive reading lead to BRT, and was compatible with the metaphysical need to account for levels. But the cost is that the *intelligibility question* has no answer. We might then keep ***Ontic*$_2$** but adopt a less strict understanding of it. Accordingly, ***Ontic*$_2$** is compatible with the claim that relata exist, but are (somehow) less fundamental than relations.

It should be pretty clear though that this version of the ontic postulate will not provide the means for OSR to respond to the

intelligibility question in a way which diverges from the bundle theoretic approach. If we look back to the discussion in chapter 3, section 3.2.3, we can see why: our candidates for relata are substrata, intrinsic properties, and relations. Only relata of the first type will respond to the *intelligibility question* without an appeal to bundle theory. Yet, we know that if we admit substrata into our ontology as a means for responding to the *intelligibility question* then relations lose their status as fundamental, and this undermines OSR. So, ***Ontic₂*** cannot be the postulate that the OSR of this chapter accepts.

We might be inclined, then, to relax the ontic postulate even further if we want to appeal to some entity other than relations. How might we formulate the ontic postulate in such a way that is compatible with keeping relata, yet simultaneously keeping an increased emphasis on relations? ***Ontic₃*** is one formulation which tries to achieve this.

Ontic₃ - Relations are *as fundamental as* relata.

Like ***Ontic₂***, ***Ontic₃*** suggests that the traditionalist's pride of place for relata needs to be attenuated; it replaces the traditionalist's emphasis with a structuralist emphasis on relations. Thus, like ***Ontic₂***, this third version of the postulate emphasizes fundamentality (rather than merely

what exists), which allows for the existence of relata. We can say, then, that both these postulates reduce relata, rather than eliminate them as did ***Ontic*$_1$** and some interpretations of ***Ontic*$_2$** (cf. Chapter 3). To see how this third version of the ontic postulate fairs, we should turn to Esfeld's and Lam's (2008) 'moderate' Ontic Structural Realism, which endorses ***Ontic*$_3$**.

4.2.4. 'Moderate OSR' and Bare Particulars. Esfeld and Lam recognize the realist as well as the anti-realist motivations canvassed in the first two chapters; and, they suggest that these problems can be avoided by adopting some form of OSR. Moreover, they are troubled by the *intelligibility question*. They propose 'Moderate OSR' to try to accommodate all these concerns without yielding to the claim that relata are wholly relational (i.e., bundle theoretic). We find the core of Moderate OSR expressed as follows:

> "[W]hen it comes to the physical world, the point at issue are concrete relations that are instantiated in the physical world and that hence are particulars in contrast to universals.[81] For the relations to be instantiated,

81 This wording seems to suggest that Esfeld and Lam take properties to be tropes, particular instances, rather than universals. I leave this feature aside in the interest of being as impartial as possible about the nature of properties; although, I do think this position is amenable to

> there has to be something that instantiates them, that is, something that stands in the relations.[82] ...[Yet, for our position] it makes no sense to assign an ontological priority to objects, because instead of having fundamental intrinsic properties, they are only the relations in which they stand. In other words, an object as such is nothing but that what bears the relations. ... In sum, as far as the physical world is concerned, there is a mutual ontological as well as conceptual dependence between objects and structure (relations): objects can neither exist nor be conceived without relations in which they stand, and relations can neither exist in the physical world nor be conceived as the structure of the physical world without objects that stand in the relations." (Esfeld and Lam 2008, 31-2)

From this, we can derive three theses which are at the core of Moderate OSR:

Intelligibility - Relations require relata;

OSR.

82 This is clearly a recognition of the force of the *intelligibility question*; it has been raised by many others: e.g., Cao (2003); Chakravartty (2003a); Busch (2003); and Psillos (2004).

> ***Relationality*** - Relata do not have intrinsic properties over and above the relations that they bear to one another; and
>
> ***Ontic₃*** - Relations are as fundamental as relata (Esfeld and Lam 2008, 31).[83]

Obviously, the crucial difference between Moderate OSR and BRT is that the former insists on finding a response to the *intelligibility question*. Thus, while ***Relationality*** is merely a restatement of the structuralist postulate from Chapter 2, the acceptance of ***Intelligibility*** marks a real difference between the two positions. Indeed, this thesis is an explicit rejection of BRT's ontic postulate, ***Ontic₁***. Moreover, ***Intelligibility*** motivates the adoption of ***Ontic₃***, 'equal ontological dependence' between relations and some non-relational relata. Thus, in so far as Moderate OSR admits these non-relational entities, it is committed to more than relations.

Crucial to this view is the understanding of ***Ontic₃***. As the above quote suggests, Esfeld and Lam take relata and relations to be *existentially* co-dependent: objects cannot exist without relations;

83 For ease of reference, I have labeled these theses; Esfeld and Lam do not suggest these labels.

relations cannot exist without objects. Accordingly, we might cash out their view in terms of *existential* dependence, which was introduced in the previous chapter, where if x existentially depends on y, then x depends on y for its *existence*. (In the third chapter, we add the clause "and not vice versa" to capture the notion of fundamentality. Here we have to leave this clause aside to express co-dependence.)

Taking Esfeld and Lam at their word, then, we can understand ***Ontic₃*** as saying that relations and relata are existentially co-dependent:

i) Relations depend for their existence on relata; and

ii) Relata depend for their existence on relations.

Obviously these two statements require a special understanding of 'relata'. After all, Moderate OSR needs (1) an account of relata strong enough to support relations but (2) weak enough to allow that relata existentially depend on relations. Traditionally, neither substrata nor bundles allow for this; substrata fail on account (2) for, in virtue of being the support of properties, substrata are existentially more fundamental. And, bundle theory fails on both counts (1) and (2): after all, bundles do not *instantiate* properties; properties exist and the bundle is constituted by them; properties then are prior to objects in bundle theory. In

Esfeld's and Lam's words "[a] bundle theory of objects accords ontological priority to intrinsic properties or relations over objects: objects are constituted by intrinsic properties or relations on that theory" (2008, 33).

For Esfeld and Lam relata are merely brutely numerically distinct. As they say, this account arises from the presence of relations themselves: to say that we can know there is a numerical distinction between objects is to say that we know "that there is a number of objects that is greater than one ... and that is all that it tells us" (2008, 33).[84] Crucially, then, relata are nothing more than things between which there is a numerical distinction.

The trouble with the Moderate OSR approach seems to be that the natural interpretation that arises from our existential reading of ***Ontic*$_3$** is inconsistent: to fulfill (i), a *substance* (or 'bare particular') view of relata is required. After all, (i) is a statement that coincides with the traditional metaphysician's view of the world. Moreover, it is only by way of substrata or bare particulars that properties can be instantiated. However, to fulfill (ii), a bundle theoretic view of relata seems to be required. For relata to existentially depend on relations, there cannot be substrata at the most fundamental level; relations have to be ontologically more fundamental than relata for relata to depend for

84 Importantly, this numerical distinction is not a primitive *thisness* (Esfeld and Lam 2008, 33-4).

their existence on relations. Thus, as far as I can determine these two results are inconsistent. In light of these troubles, I suggest that we turn to an alternative view which can diffuse the inconsistency that arises with existential dependence.[85]

4.3 A Metaphysics for the Intelligibility Question

4.3.1. Structuralist Metaphysics: The Proposal. We have seen the apparent incoherence of Esfeld and Lam's position when we interpret ***Ontic₃*** in terms of existential dependence. I want to suggest, now, that we can alleviate these concerns - while nevertheless responding to the *intelligibility question* - if we incorporate an account of levels into structuralist position. We should understand this account as constituent of a renewed ontic postulate, ***Ontic₄***.

To begin, consider the relations of dependence that exist at a level, L_n. We can satisfy the intelligibility concern immediately by stipulating that the relations at a level depend existentially on the

85 One might wonder whether we can avoid these troubles by understanding equal ontological dependence in essential rather than existential terms. If we do, then Esfeld and Lam would be committed to the claims that i) relations depend for their identity on relata, and ii) relata depend for their identity on relations. If one is a trope theorist - as Esfeld and Lam claim to be - then (i) makes sense; after all, for trope theorists relations (and properties) are resemblance classes, the members of which are all the objects that instantiate the relation in question. And, of course the identity of a class *does* depend on its members, so the identity of a relation will depend on the objects that stand in that relation. (ii) could also be satisfied, but only if Esfeld and Lam insist that relata do not have a primitive identity that normally accompanies the commitment to bare particulars. This is atypical, but not incoherent or problematic. It seems that the real problem here, in so far as my project is concerned, is that (i) really only makes sense if one is a trope theorist; yet, I want to present a version of OSR amenable to a wider base of theorists than merely trope theorists.

relata of that level.

> ***O_4-1*** - relata at L_n are not existentially dependent on relations at L_n;
>
> ***O_4-2*** - relations at L_n are existentially dependent on relata at L_n;

However, as I have suggested, to properly respect the structuralist position while diffusing the incoherence that arises within Moderate OSR we need to supplement these postulates with additional ones which take different levels into account. Thus, that is, these additional postulates should help diffuse the need to be committed to both bare particulars and bundles of properties at the same time. The way that I suggest we do this is to limit the commitment to bare particular to a level. Thus, we should maintain the traditionalist's metaphysics for *intra-level* considerations; while, with respect to *inter*-level considerations we should defend the metaphysics of the structuralist. Two postulates that one can employ to fill this role come to mind:

> ***O_4-3*** - relata at L_n are existentially dependent on

relations at L_{n-1};

O_4-4 - relations at L_{n-1} are not existentially dependent on relata at L_n;

It seems obvious that by coupling ***O_4-1*** through ***O_4-4*** we would be able to diffuse the inconsistency that arises from Esfeld and Lam's understanding of ***Ontic$_3$***: no longer do we need both bundles and bare particulars at any one level. Instead, we can be committed to bare particulars alone, at that level.

However, it should also be clear that by understanding the inter-level dependencies in *existential* terms we are still thereby committed to the bundle theoretic view of objects that was espoused in the previous chapter. After all, when relata depend for their existence on relations, as we have already seen, what follows is that they are nothing more than bundles of those relations. And, while the entire purpose of this fourth chapter was to explore a unique way to fulfill the needs of the ontic structural realist while nevertheless trying to avoid wholehearted commitment to a bundle theoretic approach, it should be clear by now that concessions need to be made by both parties. Thus, while the structuralist allows bare particulars which are limited to intra-

level considerations, the traditionalist – in taking the structuralist seriously – will have to make some bundle theoretic concessions. The traditionalist, then, must admit that relata – when multiple levels are concerned – are entirely relational. These structuralist concessions, after all, are those that we glean from the lessons of science. Theorists, then, can find the middle ground they both need by defending the position outlined here.

As we noted in the third chapter, however, even if we can capture the inter-level dependencies as existential dependence, the real task for the bundle theorist is to explain how *essential* dependence of relata on relations is possible. In this spirit, I suggest that we reformulate the inter-level account, in terms of *essential* dependence instead of the current existential formulation. Such a shift is compatible with the existential claims of ***O_4-3*** and ***O_4-4***; yet, the shift also reminds us that dependence for identity of higher level relata on lower level relations is *paramount* for the structuralist. Thus, structuralists need to defend the claim that relata at level *n* essentially depend on relations at the lower level *n-1*. Thus, the revised inter-level constituents of the ontic postulate should read:

O_4-5 - relata at L_n are essentially dependent on relations

at L_{n-1};

O_4-6 - relations at L_{n-1} are not essentially dependent on relata at L_n.[86]

Coupling these two with ***O_4-1*** and ***O_4-2*** gives us a *mixed* dependence account. This, I suggest, solves the incoherence problem arising from Esfeld and Lam's Moderate OSR. Again, it is important to note that this solution hinges on the acceptance of relata as existent in a traditional sense *at that level*; while also defending the claim that bundles exist when we consider the picture of the world from the inter-level perspective. These four postulates (***O_4-1***, ***O_4-2***, ***O_4-5***, and ***O_4-6***) can be summarized as the constituents of ***Ontic$_4$***.

Ontic$_4$ - Relations are *intra*-level existentially dependent on relata, but not vice versa; and relata are *inter*-level

86 Whether or not this really is a significant thesis will depend on the stance that one takes towards properties. For those who accept universals, it might seem trivially true: if we accept that universals can exist uninstantiated then ***O_4-6*** is fulfilled because the existence of relations are necessary features of the world, and their identities are primitive; if we are immanent universalists, then even though a universal's existence depends on being instantiated, it could be instantiated by some other than the object in which it is actually instantiated while nevertheless being the same universal. So, the relation has a primitive identity again. Thus, in both these cases ***O_4-6*** is true because properties have primitive identities. I have already discussed this issue with respect to tropes; see nt. 85, above. I should add that if one has good reason to accept tropes, then I do not see a barrier to adopting Moderate OSR or adapting the current proposal to reflect these distinct features of tropes.

essentially dependent on relations, but not vice versa.

We can capture the metaphysical picture being suggested here in terms of a dialectic between the traditionalist and the structuralist. Begin with the traditionalist: some level L_n is picked out by the relata found at that level, as given by our theories. Our theories also give us a grasp on the relations between these entities. The structuralist allows both of these steps, but insists that in light of the hierarchy the relata at L_n will be identified by *relations* at a lower level (L_{n-1}) – for these are the relations on which those relata depend *essentially*. Accordingly, L_n's relata are dependent on L_{n-1}'s relations. However, as is the traditionalist procedure, L_{n-1} is picked out in the same way as L_n, viz., by picking out the relata at L_{n-1}. Of course, the structuralist will *insist* that these L_{n-1}-relata will be identified by relations at a still further level, L_{n-2}, because the L_{n-1} relata are essentially dependent on that lower level.[87]

We can find a helpful illustration of this proposal if we look in mineralogy, which studies crystal structures and their properties.[88] Of specific interest are the allotropes of carbon, diamond and graphite. Though both crystals are composed entirely of carbon, what

87 Those familiar with the literature might recognize a similarity to Steven French's (e.g., 2001) popular saying that relata are mere 'heuristic devices' – ladders – that we use to get to the relations; once we have the relations in hand, we can 'kick away' those entities. Perhaps, this account might be what French intends; his (2006) hints that this is so.

88 Special thanks to Graham Mah who walked me through the features of crystals.

distinguishes these crystalline solids from one another is how the atoms of carbon are bonded together. For graphite, each carbon atom is bonded to three other carbon atoms to form a hexagonal lattice structure. A consequence of the bonding is that the atoms remain in the same plane; they form a two-dimensional lattice. These layers stack to form the soft macroscopic object, graphite.

In contrast, even though diamond is also composed of carbon, its properties differ as a consequence of its different structure. Thus the carbon atoms which compose diamond are bound to 4 other carbon atoms, rather than only three carbon atoms. Accordingly, the lattice differs significantly forming a tetrahedral structure which extends out of a plane to form a three-dimensional lattice. The structure formed is referred to as 'diamond cubic'. The macroscopic object we know as diamond consists of a multitude of these units joined in a specific lattice.

The types of bonds allowed between the carbon atoms are ultimately what distinguishes one lattice from the other; the bonds between carbon atoms dictate whether a crystal is hexagonal or diamond cubic. These bonds are a consequence of the electronic structure of the atoms in the material. Thus the number of electrons that each composing carbon atom has available for bonding, the kinds of

orbitals in which the outermost electrons reside, etc., directly affect the relationship that the carbons atoms hold to other carbon atoms. That is, the relations that the electrons hold to other entities directly affects whether a crystal displays a graphite or diamond structure.

Of course, the identity of a carbon atom itself is reducible to the relations at the lower level which compose it. To begin, we need to take into account the relations that the nucleus has to its electrons, as these determine the kinds of relations that the atom enters into. But, obviously, the features of the nucleus are important as well. Thus, carbon *is* carbon because of the number of protons and neutrons that compose the nucleus; if it had more or less of either, it would be some other element (or isotope).

Importantly we ought to recognize that the composition of the nucleus depends on the *strong nuclear force* relating those entities in such a way that allows the nucleus to be stable. Those forces which hold between the six protons and neutrons of carbon's nucleus will distinguish a carbon's nucleus from other nuclei. Thus, the relations composing the carbon atom will differ from those that hold between the single proton and neutron of the hydrogen atom: just because the nucleus of hydrogen contains one proton and neutron bound by the strong nuclear force, the relational structure bonding those two together will be distinct and

distinguishable from that binding the nucleus of carbon.

It is easy to see how this discussion conforms to the proposal required by ***Ontic₄***. Consider the level of the hexagonal lattices or the diamond cubic structures. These, let us say, exist at level L_1. At this level there are both the carbon atoms as well as the relations between those carbon atoms. And (in accordance with ***O₄-1*** and ***O₄-2***) without the L_1-carbon atoms the L_1-relations between those entities would not exist. Thus, the carbon atoms' relations are existentially dependent on the carbon atoms themselves. Thus, these relations are intra-level existentially dependent on relata.

However, the carbon atoms are inter-level *essentially* dependent on the relations (e.g., the strong nuclear force) between the constituents at the next lower level, L_0. That is, (in accordance with ***O₄-5*** and ***O₄-6***) the L_1-carbon atoms are essentially dependent on the relations which hold between the L_0-protons and L_0-neutrons (in the nucleus) as well as those between the L_0-nucleus and the surrounding L_0-electrons. Thus, at one level we have relations existentially depending on objects at the same level; while we also have those higher level objects *essentially* depending on the relations at lower levels.

4.3.2. Infinitism. The above dialectic firmly establishes the mixed

fundamentality view required by ***Ontic₄***. The traditionalist insistence on the existence of relata must be taken seriously to establish at which level the all important relations exist. Yet, the structuralist will insist on a structuralization of these relata: they are to be identified by lower level relations. Getting to these lower level relations requires determining which are the lower level relata. Once we determine this lower level, the relations can be employed to 'dissolve' the higher relata. Yet, if the structuralist were to leave the dialectic at this stage she would be giving up her position. After all, her central insistence is that relations play a more central role than the traditionalist ontology allows; thus, her failure to structuralize these *newly* introduced relata would undermine her structuralist approach. Accordingly, the defender of OSR under this new metaphysics will insist that for *any* level there will be a structuralization process which dissolves the relata of that level into lower level relations.[89]

That the structuralist can never be satisfied to leave the discussion at the stage where the traditionalist has reintroduced relata, coupled with the fact that the traditionalist's procedure for picking out levels must be embraced, is a source of potential trouble: these facts seems to give rise to an infinite regress. Consider: under ***Ontic₄***, OSR

89 And so we can now see why the 'mixed fundamentality' label is a bit of a misnomer: given the infinite hierarchy there is no real answer to whether relations are more fundamental than relata.

insists that we establish the identity of relata with lower level relations. This means that for all relata, one can only establish a relatum's nature by looking at the lower level relations into which it is structuralized. But, whenever we perform the structuralization process to establish identity, the structuralist must pick out levels using new lower level relata. Thus, to structuralize any level, we must infer a lower level that has further relata, the identity of which must be determined via a further structuralization process.

We can see the regress lurking. After all, to determine the nature of some relatum we look at the lower level structure. The structure at the lower level accounts for the identity of the higher level relatum, but the lower level structure will also have its own relata; to avoid the commitment to relata at this lower level, we identify *those* by looking to still lower level structures; and then we can ask the same question about the inferred relata at this even lower level; and this pushes lower yet again; and so on, *ad infinitum*. Thus, if this 'infer-relata-then-structuralize-*those*-relata' process were ever to stop then the structuralist would not be satisfied, as the spirit behind the central postulate would be undermined. Thus, the structuralist who accepts this fourth version of the postulate must insist that there is always a lower level for OSR. This is a consequence that I call (*metaphysical*) *infinitism*,

and it follows directly from the desire to fulfill both the structuralist desire to give relations more 'fundamentality' as well as the requirements of the traditionalist.

4.3.3. Ontic$_4$ and the Final Formulation of OSR. Now that we have a full account of the metaphysical position which responds to the *intelligibility question*, we can also see another reason why ***Ontic$_2$*** must be rejected: the suggestion that OSR *must* accept *infinitism* undermines the possibility of endorsing such a postulate. The claim made by that version of the postulate is that relations are *more fundamental than* relata. Yet, when we take into account the current metaphysical dialectic it is hard to see how this might be fulfilled. Because of our desire to accommodate the traditionalist, we will never arrive at a level which we is entirely relational, i.e., which does not require relata. If we are always inferring relata from the relations introduced via the structuralization process, then relations are not more fundamental than relata; how could they be? But, the reverse is true as well; relata are not more fundamental than relations because the structuralist will always be ridding each level of its relations through the structuralization process.[90]

90 As I have said, the structuralist drives the dialectic to lower and lower levels; thus, unlike with BRT, it is not science that suggests any relata can be structuralized, but instead the structuralist position.

Ultimately, then, we must replace ***Ontic₂*** and the talk of *fundamentality* with ***Ontic₄*** and the talk of *dependence*. The final formulation of the Ontic Structural Realist position, then, can be captured by the following three theses:

> ***Scientific Realism*** - The world has mind-independent, objective features which are revealed to us (in approximate form) by scientific theories.
>
> ***Structuralism*** - Scientific theories reveal to us the structural features of the world.
>
> ***Ontic₄*** - Relations are *intra*-level existentially dependent on relata, but not vice versa; and relata are *inter*-level essentially dependent on relations, but not vice versa.

Thus, it is really ***Ontic₄*** – viewed in light of the dialectic sketched above - which can begin to give the traditionalist the means to communicate with the structuralist in a meaningful way. Yet, the satisfaction of the

traditionalist by the structuralist comes at the price of the commitment to an infinite number of levels, for only in this way can the structuralist retain her structuralist stripes.

4.3.4. OSR and Intelligibility. The point of this chapter was to provide a means for OSR to respond to the *intelligibility* question. Before we can defend OSR's commitment to *infinitism*, then, we need to see the means that OSR has to respond to that question. Bearing in mind the dialectic that is endorsed by ***Ontic₄***, we can readily grasp the response.

Recall that on the new account, each level still has relations and the relata, when the level is considered in isolation. Relata exist at each level as (something like) a primitive, just so long as we do not consider the hierarchy of levels. Yet, when we ask about the nature of any relatum we will have to look to a lower level to make this determination. Such a perspective brings the relatum's 'relationality' back into light; that is, we find that upon examination the *putative* non-relationality of the relatum dissolves with inter-level concerns: it is again re-defined in relational terms at a lower level, while its non-relationality was an intra-level feature only.

Nevertheless, each level in isolation contains relata which can be considered (at that level) to be non-relational. Thus, this dialectic opens

the door to the traditionalist's *non-bundle theoretic* metaphysics. For, even though these non-relational parts *must* remain a feature of 'intra-level' considerations, at each level there will still be relata for our relations. Thus under ***Ontic₄***, OSR has a ready response to the *intelligibility question* because at each level the question does not arise: there is no ground for raising the question "How can we have relations without relata?" because OSR allows relata.

4.4 In Defense of OSR and the Infinite Hierarchy

4.4.1. Troubles on the Horizon? One might wonder whether the above dialectic is just too much to allow in order to find a solution to the realist dilemma. The potentially troublesome commitments rose to the surface when we considered the dialectic: is it not too much to allow that we will always be able to structuralize entities at a lower level? The result is an infinite hierarchy; surely that is too heavy a burden to bear! *Prima facie*, it seems it *is* too much to bear; so, unless something can be said in defense of infinite hierarchies we shall have to admit some form of anti-realism about science. As far as I am concerned this alternative is unacceptable; something must be said to defend infinite hierarchies. I shall take up this task now.[91]

91 There are two versions of infinitism: the first is the suggestion that we need an infinite number of levels in our hierarchy, which arises under ***Ontic₄***. The second is that we have an infinite number of relations (at one level), which arises under ***Ontic₂***.

4.4.2. Schaffer and Finitism. The concern about *infinitism* is that such a consequence is too much of a burden for a view to harbour. Objections which focus on infinities can take various forms, so it is often hard to narrow down what the real objection or problem is which calls for an explanation. I propose to examine a number of different versions of this objection, responding to each in turn.

We can start by dealing with what might be called the "Aristotelean repulsion" to infinities (Nolan 2001). To accept this objection is to accept that an infinite non-terminating regress is impossible, and that any postulation of such a regress is a *reductio* of the position. Like Daniel Nolan, I take this to be "an unqualifiedly bad reason to take an infinite regress as a *reductio*" (Nolan 2001, 532). The mere presence of an infinite hierarchy, is not sufficient grounds to reject the position; after all some infinities are acceptable "benign" occurrences, as when the Tarski scheme can be used to show that there are an infinite number of truths that correspond to each truth; or, as when the Peano axioms lead to a non-stop regress of counting numbers (*ibid.*, 523-4). If we are to reject OSR under the current presentation, we need some reason to believe this instance of an infinite regress is different from the kinds that Tarski or Peano allowed. The burden,

therefore, is on the objector to say what it is about the current infinite hierarchy that is vicious.

One way for an infinite hierarchy to be vicious is for it to occur with(in) a theory that deals with a domain that is known to be finite (*ibid*. 527-533).[92] The domain of OSR (under ***Ontic₄***) is levels; call the view that there is a lowest level to reality, *downward finitism*. The truth of downward finitism is commonly assumed in metaphysics, even if we do not yet know which level is the lowest; yet, we have just seen that downward finitism is incompatible with OSR under ***Ontic₄***. Here, then, is where one tension might arise: OSR conflicts with a common metaphysical assumption about reality, downward finitism.

Jonathan Schaffer (2003b) has recently argued that *assuming* that downward finitism is true is untenable.[93] Thus, he challenges this common metaphysical assumption. If he is right, then his arguments might begin to add plausibility to my claim that OSR's metaphysics can tenably defend the rejection of downward finitism; let's consider his

92 This objection can be modified to apply to the ***Ontic₂*** OSR position: that position implies that there are an infinite number of relations (at any one level). But, we know that there are *not* an infinite number of relations at a level; we know levels are finite. Therefore, we can reject OSR under ***Ontic₂*** because it commits us to something which is false.

First, it should be pointed out that this objection only has force if we reject the plausibility of inner-reaching entities; and, I have suggested that there are no ready examples of such entities. But of course this does not mean there are no such entities. It just means that we cannot provide any examples. Second, even if there are no such entities, I think the objection is innocuous because it is not clear what grounds we have for believing that there are a finite number of relations (at any one level). Why ought we to believe this? Reasons – to which I am not privy – need to be provided before we can take this version of the objection seriously.

93 To be clear, Schaffer does not say that downward finitism is false; instead, he concludes that we are not justified in assuming downward finitism is true without further arguments.

position. Schaffer suggests that there are actually no good reasons to believe that there is a fundamental level of reality. His arguments focus primarily on the *a posteriori* claims that science will (or has) demonstrate(d) that there is a fundamental level.[94] Schaffer suggests that past theories have claimed the status of being complete and fundamental, but they were wrong. Moreover, we are in no different an epistemic position regarding our current theories as we were with our past theories. So, we are not justified in assuming that our current theories are correct in making claims about the fundamentality of any one level (2003b, 503). This is obviously a version of the PMI (though, Schaffer does not phrase the objection in these terms); the argument suggests that we exercise caution – more specifically *agnosticism* - with respect to our theoretical commitments towards downward finitism. I urge that we heed Schaffer's suggestion.

The trouble with inferring downward finitism from our theories is exacerbated by the fact that we are committed to structural realism about science. Given this commitment, it would seem that we would *have* to be able to account for fundamentality as a *structural* (i.e., relational) feature that our theories reliably capture. After all, only if fundamentality meets these features can we justifiably be committed to

94 He rejects, fairly quickly, any claims that we can show this via *a priori* means. I agree with him on these points and will not present them here.

that feature as a 'real' account of the world. The trouble, of course, is that it is not clear that *fundamentality* is a property that we will be able to detect (cf., Chapter 2).

There is further reason to reject downward finitism: doing so brings with it certain advantages that any opposing argument – any argument for finitism – must face. Assume that downward finitism is true. Now consider the fact that some metaphysicians have defended the claim that all higher levels can be reduced to the lowest, most fundamental level. Accordingly, the 'real' level is that which is the lowest level; the rest are 'ersatz'. Yet, the rejection of downward finitism reinvigorates the reality of all levels. After all, if there is no lowest level, then the reductionist project fails. Accordingly, all the levels that were to be reduced regain a kind of robustness that finitism promised to remove (Schaffer 2003b, 510).

Obviously, the further advantage that the rejection of downward finitism provides is the coherence with a metaphysical picture that meshes with a philosophy of science that is able to address many of the central concerns in the field, like the PMI. Accordingly, those who wish to accept finitism *must* argue for it; and the deck is stacked against them, for the rejection of downward finitism carries with it powerful advantages.

4.5 Conclusions and Ramifications

4.5.1. Ramifications. Though potentially off-putting, the claim that reality consists of an infinite hierarchy of levels is not – after examination – solid enough grounds to reject the metaphysics proposed here. Thus, it seems as though I have built up support for my larger claim that the ontic structural realist can make sense of the *intelligibility question* – that is, the question of how relations can exist without relata – by supposing that every level of the world is solely structure, but that we can pick out relata so long as we recognize that relata are essentially reduced at lower levels.

What are the ramifications of a proposal of this kind? First, we can see that it relies heavily on the notion that there is no good reason, provided by science, to accept that there is a lowest level. That means that my position hangs primarily on the results of current science, specifically whether it can offer good reasons for finitism. Thus, this metaphysical background for OSR has the peculiar feature of being empirically falsifiable.[95] Should any scientific theory be able to establish that the level it describes actually is the fundamental level to reality, this proposal would be defeated (and, so far as OSR depends on this

95 I think this should be a consequence that Ladyman and Ross, at least, are perfectly willing to accept.

proposal, it too would be defeated. Of course, even in that instance, all would not be lost for we would still have a plausible metaphysical background for OSR in the BRT proposal of the third chapter.

There is another scenario which would undermine the current presentation of OSR. If scientists could ever reach a level that was structural, but was such that we could not in any reasonable way say that there were objects, then we would be stuck again with an unanswerable *intelligibility question*. It is important to remember why a structural level that cannot be described in terms of objects undermines the current proposal. The overall task is to reconcile the traditionalist with the ontic structuralist. So we need to demonstrate how each level can be seen to have relata, even though they really do not have relata. Any level of reality that blocks re-description (for whatever reason) will undercut any attempt to reconcile the two stances.

First, we can simply note that if this possibility is seen by both parties as legitimate, then this is just another way that my current proposal could be empirically falsified. But, I doubt whether this is an option that the traditionalist metaphysician would deem possible. As I have just reminded us, the entire dialectic until now has been an attempt to moderate between the traditionalist and the structuralist. If, however, the traditionalist is willing from the outset to accept that

there could be a level which is describable only in terms of object-less structure, then the whole attempt at reconciliation is unnecessary; both parties will then have accepted that a level of relations alone is possible – both will have accepted a BRT account of the world

Indeed if scientists actually do discover a level that can be described only in structural terms, then this is grist to the ontic structural realist's mill, as I would suggest that it would be a ready example of intertwined relations (which would be very close to the inner-reaching entities of Chapter 3). Indeed, it would make the BRT version of the OSR project all the more palpable by providing an empirical example of what a purely structural ontology might look like. No longer would the cry of the traditionalist, which calls for a 'demonstration of such an ontology', be unanswered. Indeed, in this case science would show us that levels are strictly structural, so we would be better asking, What is so useful about a traditionalist ontology anyways?

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