4-27-2021 11:00 AM

Theories: Reconsidering Ramsey in the Philosophy of Science

John D. Lehmann, *The University of Western Ontario*

Supervisor: DiSalle, Robert, *The University of Western Ontario*

A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Philosophy

Abstract

This work is an analysis of F. P. Ramsey's philosophy of science. Twentieth-century philosophy of science was marked by attempts to consider the relation between scientific theories and our knowledge of the empirical world through considerations of abstract mathematical structure. Such considerations led Bertrand Russell to an account of the relation between our theoretical picture of the world and its real nature as a relation of structural similarity. Subsequently, Max Newman gave what has become a well-known logico-mathematical objection to this account. William Demopoulos recently showed that Newman's problem applied not only to Russell's realist account, but also to a variety of otherwise disparate accounts of theoretical knowledge. The common element underlying these accounts is a conception of theories as abstract formal structures. Many such accounts have incorporated key elements of Ramsey's views, most notably the Ramsey-sentence. Moreover, Demopoulos has interpreted Ramsey's own view of theories as sharing the essential features of those abstract views, and therefore their common problem. My analysis aims to show that this abstract conception of theories does not adequately characterize Ramsey's view. Namely, his account of theories was not an attempt to do the epistemology of science in the fashion of Russell or Eddington, or of subsequent structuralist views that have adopted the Ramsey-sentence. I show this by a broader exposition of Ramsey's work on the nature of theories, comparing his seminal paper with his many other remarks on the nature and purpose of theories. I begin by discussing the historical context of Newman's objection, and a generalization of it that shows its broad applicability to abstract characterizations of theoretical knowledge. I then reconstruct Ramsey's view of theories, to show how far it extends beyond the Ramsey-sentence picture. Finally, I discuss the relevance of this view to contemporary debates concerning realism and instrumentalism. I characterize Ramsey's view as focused not on grounding our theoretical knowledge in abstract structure, but instead on demystifying the role of theoretical language and concepts in a theory's application to the world.

Keywords: Ramsey; Ramsey-sentences; Newman's objection; Scientific Realism; Structural Realism; Theories, William Demopoulos.

Summary for Lay Audience

This work is an analysis of F.P. Ramsey's philosophy of science. When we think of a scientific theory, there is a plausible distinction in the vocabulary, or language, we use. On the one hand, there are statements that have to do with things we more or less directly observe; on the other hand, there are statements about theoretical entities and relations, e.g. electrons, forces, space–time curvature. This plausible distinction suggests another distinction between how we come to know or understand the two classes of statement. Theoretical knowledge seems inherently more problematical than our knowledge of things through direct observation.

Twentieth century philosophy of science was marked by attempts to consider the relation between scientific theories and our knowledge of the empirical world by appealing to abstract mathematical structures. In particular, Bertrand Russell believed that an adequate notion of structural similarity could explain the relation between what we experience, and the world beyond our experiences. Max Newman gave a mathematical objection to Russell's account. However, subsequent thinkers in the philosophy of science continued to develop accounts of theoretical knowledge that appealed to abstract mathematical structures. William Demopoulos has shown that Newman's objection generalizes beyond Russell's theory to oppose any view which shares specific features with Russell's.

Many such accounts have incorporated key elements of Ramsey's views. Demopoulos has interpreted Ramsey's work on theories as sharing the essential features of those views, and therefore their common problem. My analysis aims to show that this interpretation does not adequately characterize Ramsey's view. I reconstruct Ramsey's view of scientific theories from his various remarks on the nature and purpose of theories. Crucially, I argue that Ramsey's approach to theoretical knowledge does not share the problematical features that make it vulnerable to Newman's objection. Finally, I discuss the relevance of the reconstructed view I provide to some nearby issues in contemporary philosophy of science.

Acknowledgements

This project was funded by the Social Sciences and Humanities Research Council of Canada.

I have benefited continuously from the support and encouragement of my supervisor Robert DiSalle. He has been incredibly generous with his time, and I'm grateful for all the many happy hours we've discussed these, and other, topics. I consider myself fortunate to have had such an outstanding philosophic role model. I can't imagine a better mentor or supervisor.

I little expected that when I knocked on John Bell's door, looking for some help with set-theory, that he would turn into one of my dearest friends. His enthusiastic encouragement and support of my fledgling interest in mathematical logic and philosophy of mathematics has meant more than he surely realizes, not least for the confidence it fostered.

I dedicate this thesis to my parents, and my wife Kate. Their love and support has meant the world to me.

Contents

Abstract **ii**

Summary for Lay Audience **iii**

Acknowledgements **iv**

1 Introduction **1**
1.1 Context 1
1.2 Overview 4

2 The origins and applications of Newman's objection **6**
2.1 Newman's objection contra Russell 6
2.1.1 Russell on the external world 6
2.1.2 The objection 8
2.2 A mathematical interlude 11
2.2.1 Preliminaries 11
2.2.2 Isomorphisms 12
2.2.3 Push–Through 13
2.3 *Three Views of Theoretical Knowledge*: A critical exegesis 14
2.3.1 Context of the paper 15
2.3.2 Overview 16
2.3.3 Target of the analysis 17
2.3.4 All that business about toy models and Craig transcriptions 18
2.3.5 Demopoulos reading Russell 19
2.3.6 Demopoulos reading Ramsey 21
2.3.7 Demopoulos reading Carnap 24
2.3.8 Demopoulos' conclusion and suggestion 25
2.4 Newman's objection applied to Eddington 28
2.4.1 Summary of *The Philosophy of Physical Science* 28
2.4.2 Braithwaite and Solomon's criticism 32
2.5 Newman's objection applied to Ramsey-sentence structures 35
2.6 Summary 37

3 Ramsey and Theories **39**
3.1 *Theories* 40
3.1.1 Responding to Russell: What Physics Says 40

3.1.2 Exegesis of *Theories* . . . 43
Theories and Languages . . . 44
Question and Answer . . . 46
3.2 General Propositions, Causal Considerations . . . 55
3.2.1 "General Propositions and Causality" . . . 55
3.2.2 "Causal Qualities" . . . 59
3.2.3 Drawing Together . . . 60
3.3 Summary . . . 65

4 Structure, more broadly **67**
4.1 Scientific Realism, Instrumentalism, and Ramsey . . . 68
4.2 Structuralism without metaphysics? . . . 71
4.3 Extending "Theories" . . . 75
4.4 Summary . . . 87

5 Conclusion **89**

Bibliography **94**

Chapter 1

Introduction

Twentieth-century philosophy of science was marked by attempts to understand the relation between scientific theories and our knowledge of the empirical world through considerations of abstract mathematical structure. Such considerations led Bertrand Russell to an account of the relation between our theoretical picture of the world and its real nature as a relation of structural similarity. Subsequently, Max Newman gave what has become a well-known logico-mathematical objection to Russell's account. This critique indicated that the notions of mathematical structure and structural similarity Russell used are too abstract to be informative. William Demopoulos recently showed that Newman's objection applied not only to Russell's realist account, but also to a variety of otherwise disparate accounts of theoretical knowledge. The work of F.P. Ramsey has played an important role in the history of those accounts. This study seeks to reassess Ramsey's work in light of its historical context and its significance to contemporary philosophy of science.

1.1 Context

Russell represents an historical attempt to account for the classic problem of the relation between appearances and reality by applying our understanding of mathematical structure to the problem. Kant thought that we can only know things as they appear to us, according to our forms of intuition and categories of understanding, and not as they are in themselves. Russell sought to provide a framework in which he could articulate a notion of similarity that would respond to the Kantian limitation to understanding the world outside our acquaintance. He argued that the world really has a mathematical structure, and theories succeed to the extent that they provide models that are structurally similar to the structure represented by our sensations. In Kantian terms, Russell sought to provide a way to relate the phenomenal and noumenal worlds, or things as they appear to us and things in themselves. Russell's theory of propositional un-

derstanding considered it fundamental that "every proposition which we can understand must be composed wholly of constituents with which we are acquainted," or analysable into constituents with which we are acquainted. The noumenal world, however, is not given to us in sensible intuition, and hence we are not acquainted with it. Moreover, for the Kantian problem, we cannot assume that there are properties in common between the phenomenal and noumenal worlds. The problem, or challenge, thus posed is of giving an account of what knowledge is possible of the world beyond experience (or acquaintance) and how we are able to understand it.

Russell's response was that Kant saw the problem as intractable and devoted immense effort to demarcating the limits of our knowledge. However, Kant lacked the sophisticated modern logical characterization of similarity. Russell, having played an important role in developing that characterization, thought this purely logico-mathematical—and hence independent of sensible intuition—understanding of similarity was capable of providing a sufficiently robust account of the relation between phenomena and noumena, without attributing any of the sensible properties and relations of the phenomenal world to the noumenal. While we cannot be acquainted with the world beyond experience, Russell believed both that, contra Kant, we could have knowledge of the 'noumenal', and that that knowledge could be expressed by means of a similarity of structure using the modern resources of mathematical logic.

The mathematician M.H. Newman levelled a devastating criticism against Russell's project: using relatively basic mathematical and logical reasoning, he showed that Russell's account could not explain our knowledge of the world as given to us through scientific theory. Briefly, Russell claims that we know nothing of how the world beyond experience really is, other than its logico-mathematical structure, which is isomorphic to the structure of our experience. Newman objects that this claim is trivial because any set can be represented as having an arbitrary structure, provided that the structure is compatible with the cardinality (number of elements) of the set. Russell's structuralism therefore fails as an account of our theoretical knowledge: according to Newman, Russell's theory, insofar as it asserts that only structure is known, has the unfortunate consequence "that nothing can be known that is not logically deducible from the mere fact of existence, except[...]the number of constituting objects" (Newman 1928, 144).

F.P. Ramsey, aware of and partially in response to Russell's work, developed a distinctive analysis of theories that considered them as languages. He developed a logical representation of the relation of a theory's theoretical vocabulary and its observational vocabulary that is now known as the Ramsey-sentence of the theory. Carnap developed Ramsey's basic idea of theories as languages into the most sophisticated version of the logical positivist's view of theories—as formal languages that are connected to the empirical world through rules of interpretation. While both Russell and the positivists viewed theories as logico-mathematical

structures, the positivist view was an alternative to Russell's position, abandoning Russell's realist view of theory. Instead, they emphasized the role of rules, decided by convention, for interpreting those logico-mathematical languages empirically. Although the positivist program was subsequently criticized for a variety of reasons, contemporary work of William Demopoulos has argued that the problem faced by Russell's structuralism is a problem for any view of theories that treats theories as abstract structures satisfied by sets of objects. To temporarily gloss the technical details of the point, *any* set, given that it is big enough, can satisfy the abstract mathematical structure appealed to as a representation of theoretical knowledge. This work has suggested that Carnap's theory of theories is just as susceptible to Newman's objection as Russell's.

Demopoulos and Friedman (1985), while addressing Russell's structuralism and the implications of Newman's argument for Russell's metaphysics and epistemology, articulated the broader applicability of Newman's objection. Subsequently, Demopoulos produced an instructive and wide-ranging account of several disparate approaches to theoretical knowledge that suffer a common problem. He argued that they all share the abstract conception of theories[1] which holds that the non-logical language of a theory can be partitioned into observational and theoretical terms. Moreover, and essentially for the epistemological issue, the partition is a reflection that our "understanding of the theoretical vocabulary is importantly incomplete and problematic in a way that our understanding of the observation vocabulary is not," (Demopoulos 2012d, 140). According to Demopoulos, the abstract conception of theories gives rise to a common principle held by the views of theoretical knowledge he critcizes. This common principle is the structuralist thesis which holds that "the theoretical component of what our theories express is wholly captured by statements which depend only on the logical category of their constituent concepts," (161). The common problem that arises from these considerations is that structuralist accounts of theoretical knowledge are essentially trivialized by reducing them to claims about satisfiability conditions in a structure. In that context, Newman's objection, with limited assumptions, guarantees our theoretical claims to be true in virtue of a matter of logic and ambient set theory. This situation, Demopoulos argues, deprives our claims to theoretical knowledge of the character of significant *a posteriori* discoveries.

The views of theoretical knowledge (or more precisely, those members of the abstract conception of theories) that Demopoulos engages most thoroughly are what he considers the broadly logicist discussions of scientific theory of Russell, Ramsey, and Carnap.[2] Demopoulos' criticism, however, is not restricted to those three figures of the broadly 'syntactic' tradition.

1. These notions are discussed in detail in 2.3.3 and contextualized more broadly in 2.3.2.

2. The extent to which Ramsey and Carnap's analyses of scientific theory are genuinely attributable to a logicist tradition, or rather something more of a hybrid involving aspects of Hilbert's formalist approach, is disputable.

Demopoulos argues in several places for an application of his criticism to semantic views of theories as well. I have already emphasized that the concern is epistemological, but it is worth making the point absolutely clear. Demopoulos considers the abstract conception of theories as it runs through Russell, Ramsey, and Carnap as "not a merely schematic representation of the general notion of an empirical theory, but the backbone of a general account of our knowledge of the physical world," (Demopoulos 2012c, 108). Moreover, it affects a surprisingly wide class of views that do not share the basic metaphysical or epistemological orientation of Russell's *The Analysis of Matter,* including semantic approaches to theories like constructive empiricism, and those forms of structural realism endorsing the Ramsey-sentence.

As it will be made more clear in the following chapters, the Demopoulos–Newman criticism is essentially set or model theoretic. The mathematical aspects of the argument are indeed unobjectionable and the views, as Demopoulos has presented them, fail, for the same reason in each case, to give a satisfactory account of our theoretical knowledge in science. That set theory is a good foundation for mathematics does not imply it is a good foundation for physics. Indeed, the notion that a scientific theory is an abstract formalism is a bad starting point. My analysis aims to show that this abstract conception of theories does not adequately characterize Ramsey's view. The views set out in his seminal paper "Theories" are not an attempt to do the epistemology of science in a fashion like that of Russell or Eddington, or those views that continue to dominate the philosophy of science. For Ramsey, a scientific theory is fundamentally more than its logical structure. Demopoulos' arguments notwithstanding, Ramsey's own view is to be distinguished from the structuralist views of most who have adopted the Ramsey-sentence. Arguing for this thesis requires both exposition of Ramsey's work and an attempt at reconstructing, or perhaps constructing, a broader theory of theories in light of Ramsey's other remarks bearing on the philosophy of science.

1.2 Overview

Chapter 2 describes Newman's objection in the original context of Russell's account of theoretical knowledge. From there some general mathematical background is developed for the subsequent discussion. Demopoulos' application of the Newman objection from his "Three views of theoretical knowlege" is then explained to show the wide applicability of the criticism to seemingly disparate approaches to theoretical knowledge. Eddington's philosophy of science and 'scientific epistemology' is used as a contrasting case of structuralism to Russell's, while simultaneously demonstrating another historical application of Newman's objection. Lastly, Newman's objection is given in a generalized, model-theoretic form to understand its broad application.

Chapter 3 develops a reconstruction of Ramsey's thought contrary to Demopoulos' interpretation. To that end it emphasizes the philosophical context of Ramsey's paper "Theories." The chapter begins by situating Ramsey's work initially as a direct response to Russell's views. From there an exegesis of Ramsey's "Theories" is developed in order to distance Ramsey's work from Demopoulos' criticisms and the form of structuralism attributed to it. The reconstruction of Ramsey's views proceeds from there by placing "Theories" in the broader context of his papers on general propositions and causality. Crucially, I argue that the Ramsey-sentence is not meant to be an explication of our theoretical knowledge, but rather a tool for understanding the inferential and conceptual role of theoretical terms when a theory is considered as a language along the lines dictated by the philosophical context Ramsey inherited from Russell and others.

Chapter 4 analyses the philosophical context Ramsey was investigating, but more significantly, reconsiders the philosophical context best suited to the application of his views. Ramsey's ideas have been variously attributed to forms of scientific realism, instrumentalism, and structural realism. This chapter distances Ramsey's work from questions about the preferred interpretational framework for evaluating the truth of a theory. If the terms of the realism-instrumentalism debate are to be applied to Ramsey, his remarks on various topics, including the appropriate notion of truth, indicate that he was surely an instrumentalist; however, there is good reason to think that his analyses were not concerned to argue for the metaphysical, epistemological, or semantic theses that divide realists and instrumentalists. It is shown that Ramsey anticipates something like Carnap's internal–external distinction. Demopoulos extends Carnap's distinction and instructively applies it to the realism–instrumentalism controversy, using the confirmation of the atomic hypothesis as a case where what seems to be an external question on Carnap's account is settled a posteriori by methods within the theoretical framework. I show that a parallel extension is compatible with Ramsey's reconstructed view. Moreover, I argue that Ramsey's analysis of Newtonian space–time, along with other remarks, uphold the authoritative role of experience in our theoretical knowledge while illuminating the inferential role that theoretical terms play in empirical judgements.

Chapter 2

The origins and applications of Newman's objection

2.1 Newman's objection contra Russell

2.1.1 Russell on the external world

Newman's objection to Russell occurs in the context of Newman's criticism of Russell's causal theory of perception as formulated in *The Analysis of Matter*. While someone might think this perhaps narrowly confines Newman's cricticism, the fact is that the causal theory of perception plays a central role in Russell's book. There, Russell seeks to investigate the philosophical outcome of physics, or rather more accurately, whether physics has a philosophical outcome. Newman connects this question with the philosophical problem of our knowledge of the external world. It is Russell's attempt to solve this problem that Newman initially criticizes, but also finds his objection applicable to Russell's treatment of the problem of interpretation in physics.

Like many of us, Russell has decided that the external world does, in some sense, exist. The problem he faces, however, is that of giving an account of the world beyond our experience. That is, Russell and Newman, the latter at least for the sake of argument, take for granted several principles which frame the problem. Our experience serves as the data for forming physical theories as well as the material by which which we test them. Everything else we might include in the formation and testing of our theories is then at best an inference. This is taken to imply a view of physical theory such that a theory just is the set of all predictions about our sensations. The suitability of this view is not something to trouble ourselves with now. Rather, the important point is to note, as Newman does, that this view of theories does not entail that there is nothing but our experience or sensations. As Newman says:

> When the province of the physical has been marked off there still remains the important question whether in fact predictions about our own sensations exhaust all that can be said about the world, or whether there are other external entities which are the sources of our sensations; and if it is held that these entities exist there is the further question, what can significantly be said about them.(Newman 1928, 138)

Russell, of course after arguing against competing positions, defends the position that the unperceived parts of the world included in physical theory do exist. Hence, my frequent references to Russell's realism. As for what can be significantly said about them, Russell's account is built around a notion of structure. I think it is remarkable that Newman emphasizes (139) that 'structure' is not defined for these purposes, but rather that Russell depends on the concept 'sameness of structure'. Without digressing too far from the main point, it is worth indicating why this is remarkable: first, Newman's objection involves no such refined notions of structure as would be found in later model theoretic (or modal logical or category theoretic) discussions—though of course his characterization is perfectly in keeping with the way these issues are dealt with by model theory; second, its impressive given the importance of the notion of structure in twentieth–century philosophy of science that both then, and often now, it is taken for granted that we either have, or do not need, a clear analysis of the concept of structure. The first point suggests the generality of Newman's objection; the second that the history and development of some of these concepts are rather murky—and it is not a mark against Russell or Newman because in a similar fashion Godel and Skolem left structure undefined though discussed satisfaction in a structure—inviting careful analysis of how, precisely, we are to understand what seem obvious notions in their various applications.

Sameness of structure is defined by Russell as isomorphism. Russell's appeal to this notion is part of his attempt to overcome the apparent difficulty that we can talk about structures as being similar only when we have direct epistemic access to both. Appealing to isomorphism is thus an attempt to justify our epistemic claim to structural knowledge when we lack direct epistemic access to one of the pair of similar structures. So that we do not to take the notion for granted, Russell describes an isomorphism as a special kind of map, namely a (1,1) correlation. Let's call this map ϕ. Suppose we have a set A of objects and a relation R that holds for certain subsets of A, and likewise a set B and the relation S. ϕ sets up a coordination of the objects of A and B and the relations R and S such that when members of A have the relation R, their correlates in B have the relation S (and conversely). Importantly, this definition of having the same structure does not require the objects of A and B, nor the relations R and S to be qualitatively similar. Russell does not take this lack of qualitative similarity to be a deficit, but rather the reason for which structure is important: "when two relations have the same

structure..., all their logical properties are identical" (Russell 1927, 251) and that "whenever we infer from perceptions, it is only structure that we can validly infer; and structure is what can be expressed by mathematical logic, which includes mathematics"(254). For Russell, then, our knowledge of the world beyond perception is concerned exclusively with its logical properties, and not its qualitative character. As he says, "our knowledge of physics is mathematical: it is mathematical because no non-mathematical properties of the physical world can be inferred from perception,"(253).

It would seem then, that Russell has explained in what sense the external world exists: it is structurally similar to the world of our experience, and knowledge of structure amounts to a knowledge of its logical properties. Of the intrinsic qualities of the world beyond experience, nothing can be said. Of course, as an account of the nature of the world as given to us from our knowledge of physics, or perhaps equivalently an analysis of the knowledge gained from physics, Russell's account is disappointing. That, however, is partially unfair to Russell insofar as he is trying to establish a kind of realism for the world beyond our sensations contra solipsism and phenomenalism. From that perspective, establishing that we have knowledge of structure beyond our experience does prove an advance over those other philosophical positions. In that sense, he is showing a philosphical outcome of physics.

One way to object to Russell is clearly to challenge his realist arguments and show that they are not sufficient to refute solipsism or phenomenalism. The reader will have noticed that I have not given Russell's *argument* that the external world is structurally similar to our sensations. This is not an oversight, but instead rather beside the point immediately at issue regarding the Newman objection; later, when developing the general characterization of the structuralist thesis given by Demopoulos, and Gupta's analysis of the rational contribution of knowledge to experience, we will see more clearly that both Russell's causal theory of perception and structuralism embed a propositional conception of the given in experience. However, whatever merits or flaws Russell's causal theory of perception and justification for the structural similarity between the world and our sensations have, they are tangential to seeing the generality and the force of Newman's criticism. Rather, if we take the point for granted and assume that there is a similarity of structure, Newman noticed that there is a lurking epistemological criticism for Russell's account of what can be meaningfully said about the world beyond experience, i.e. the "further question" Newman remarks in the above quotation.

2.1.2 The objection

The key issue which Newman identifies is Russell's commitment that *nothing* but structure is known. As a result, we cannot say anything of importance about the world beyond experi-

ence: lacking any direct, qualitative/intrinsic knowledge, all that can be known about the world beyond experience is the number of objects it is required to have, but nothing at all about the character of those objects. That is because any set of things can be organized to have a given structure as long as the structural requirements are compatible with the number of objects (e.g., there being at least three objects). This might seem counter-intuitive, but from a set theoretic perspective it is correct. This claim seems to be the central point at issue between proponents of structuralism and its opponents—that while set-theoretically correct it either is applicable to our arguments about the epistemological outcome of physics, or not. There is an important sense then, that insofar as Russell has reduced our knowledge through structural similarity to purely logico-mathematical properties, we could as well be talking about a numerical system: any investigation of that structure would be like an investigation in pure mathematics, and if suitably codified, as an investigation of an axiomatic system like geometry.

Whether this *should* deeply trouble Russell, I will leave unexplored except to say that he very clearly endorses the proposition that of the world beyond experience we can only meaningfully say what can be expressed by mathematics: "[t]he only legitimate attitude about the physical world seems to be one of complete agnosticism as regards all but its mathematical properties" (270). However, there is a subtle way in which Russell's account and Newman's objection differ from later discussions of theoretical knowledge that will concern us in later sections. I do not mean to suggest that in those later discussions Newman's objection is misapplied; quite the contrary, it achieves a statement of its full generality in those contexts and we will see that many of the considerations Newman applies to Russell's analysis apply in those contexts as well. I raise the point to highlight and distinguish the objection as it is applied to Russell from the accounts given by Ramsey and Carnap. In any case, the mathematics involved is essentially the same, though conceptually, the accounts differ. To bring this out, I quote a passage of Newman's in full:

> These statements can only mean, I think, that our knowledge of the external world takes this form: The world consists of objects, forming an aggregate whose structure with regard to a certain relation R is known, say W; but of the relation R nothing is known (or nothing need be assumed to be known) but its existence; that is, all we can say is "*There is* a relation R such that the structure of the external world with reference to R is W". Now I have already pointed out that such a statement expresses only a trivial property of the world. Any collection of things can be organized so as to have the structure W, provided there are the right number of them. Hence the doctrine that *only* structure is known involves the doctrine that *nothing* can be known that is not logically deducible from the mere fact of existence, except ("theoretically") the number of constituting objects.

> The generating relation of the structure of the world as conceived by Mr. Russell I take to be what he calls "causal continuity," *i.e.*, if we make a map in space, exhibiting the structure, the parts that are near each other in the map are those that represent events causally continuous with each other. But the introduction of this name does not help us, for if Mr. Russell's principles are to be upheld this statement must be merely the *definition* of causally continuous: if anything were directly known about its nature we should know something not structural about the external world. (Newman 1928, 144-145)

There are, I think, two fairly interesting features of Newman's analysis here. Nowhere in Russell's chapter on the importance of structure does he mention a 'generating relation'. He does say that "the inference from perception to physics, which we have been considering, is one which depends upon certain postulates, the chief of which, apart from induction, is the assumption of a certain similarity of structure between cause and effect where both are complex" (Russell 1927, 249). So, it is not unreasonable for Newman to suppose that causality is supposed to play the role of the relation between our sensations and the external world which establishes the isomorphism. Indeed, given Russell's causal theory of perception this makes sense. What the point brings out quite clearly is that on Russell's account the sensations are in 1-1 correspondence to the external world, of which we know nothing beyond its logical properties. In the case of the Newman criticism as it is applied to Ramsey and Carnap, it is a theory as a whole, *specifically* its theoretical part, which can be trivialised by arbitrarily mapping it to a set of compatible cardinality; i.e. given a cardinality assumption a trivializing structure can be generated for the theoretical partition of the domain of a theory. Those details, and their relevance will be brought out in context later; for now I only mention that Russell is not questioning the validity of the inference "from percepts to events which no one perceives" but rather its scope: "i.e. how much we can know about unperceived events, assuming the causal theory of perception" (226). On this point he never wavers: we know only the mathematical properties of those events.

The second feature of the quotation from Newman is the suggestion that Russell is defining 'causal continuity' as the relation between experience and the unperceived world. Of course, Newman is clearly correct that if it were not a definition then we would know something not purely structural about the relation. What is not clear is that the relation "R" is supposed to be *part* of the external world. Quite clearly, we do not *perceive* causal continuity. But if as Newman interprets Russell "the world consists of objects, forming an aggregate whose structure with regard to a certain relation R is known, say W..." then it seems that conceptually R is not so much part of our knowledge of the external world, but rather that in virtue of which we can have structural knowledge of the external world at all. That is, R *induces* the

structural correspondence between perception and the external world. In that role, it is fitting to describe it as a definition of causal continuity, for then we bypass any question of how we have knowledge of causal continuity between percept and stimulus. Or moreover, why other non-structural properties of the external world may not be directly known if causal continuity were itself non-structural knowledge. Nevertheless it is important to understand that Russell never intended his account to attribute anything more to our knowledge beyond perception than mathematical properties; regardless whether those properties could be assigned to any set of sufficient cardinality can seem rather beside the point when understood as part of his explication of the causal theory of perception.

2.2 A mathematical interlude

2.2.1 Preliminaries

A central theme for the previous and subsequent discussions is the role of Newman's objection, or more properly its general applicability to structural claims. Essentially, Newman's objection to Russell is a kind of permutation argument. While Newman applies his observation to Russell's account of our knowledge of the world beyond sensation, Putnam later applied it in a model theoretic context. Button and Walsh (2018), go on to use the core insight in a variety of contexts to generate epistemological, or rather doxastic (which is to say, questions about how we can possibly have even beliefs let alone knowledge) problems primarily in mathematics and the philosophy thereof. Those details and their arguments are not of immediate concern except in this sense: if their project of problematizing how we can even have beliefs about mathematical structures is successful, it poses a genuine challenge to those epistemologies of science which take the mathematical structures deployed by scientific theorizing as having a genuine explanatory role. The bright side, I think, is that we can set this aside as a prior problem. That is to say, we leave those problems to the philosophy of mathematics. Of course, if we could not form beliefs about mathematical entities and structures, we could not appeal to our knowledge of mathematical structure for explanatory or epistemological purposes in the philosophy of science. So then, we take for granted that we do seem to have knowledge of mathematical structures and leave the epistemology and doxology thereof to the philosophy of mathematics.

I mention this to indicate that permutation arguments like that found in Newman's objection, first, have a more general form which cause a problem for structural accounts in the philosophy of science other than Russell's, and secondly, that this sort of argument has philosophic interest extending well beyond the philosophy of science to the philosophies of mathematics, language, and metaphysics. The first point is that which concerns us for better understanding

the philosophical-exegetical issues at play with structuralisms in the philosophy of science. To that end, what follows in this section is a brief presentation of the mathematical backbone of Newman-style objections, or what we will call, following Button and Walsh, push-through constructions. Indeed, Demopoulos' quick treatment of the model theoretic version of the objection in his papers has led to some doubt and attempts to refute his claims on logico-mathematical grounds both in print, e.g. (Lutz 2020), and in discussion. Conceptually, the push-through construction is a manner of defining a function, specifically a bijection, on one mathematical structure that under the action of that function a new structure is created which is isomorphic to the first. In other words, the function's action on elements, sets of elements, sets of sets etc. induces the required conditions for an isomorphic copy of the original structure.

The signature of a structure $\mathcal{A}$ is a set of three kinds of symbol:[1] the set of constants of $\mathcal{A}$, for each n>0 the set of n-ary relation symbols, and the set of n-ary function symbols. Hereafter $\mathcal{L}$ will be used to signify signatures. If $\mathcal{A}$ has signature $\mathcal{L}$, we call $\mathcal{A}$ an $\mathcal{L}$-structure. $\mathcal{L}$ may also stand for a language, which is convenient as we may think of a signature as a kind of rudimentary language for talking about a structure $\mathcal{A}$.

A structure $\mathcal{A}$ is a mathematical object consisting of:

1. A non-empty set A which is the domain of $\mathcal{A}$

2. An object $c^{\mathcal{A}} \in \mathcal{A}$ for each constant symbol of $\mathcal{A}$

3. For each n>0 a set of n-ary relation symbols on A, i.e., $R^{\mathcal{A}} \subseteq A^n$ for each n-ary relation symbol from $\mathcal{L}$

4. A set of operations on $\mathcal{A}$, i.e. maps such that $f^{\mathcal{A}}\colon A^n \to A$ for each n-ary function symbol of $\mathcal{L}$

2.2.2 Isomorphisms

Let $\mathcal{M}$ and $\mathcal{N}$ be $\mathcal{L}$-structures. A bijection (one-one correspondence) from $\mathcal{M}$ to $\mathcal{N}$, $h\colon \mathcal{M} \to \mathcal{N}$, is an isomorphism if and only if (iff): for any $\mathcal{L}$ constant symbol, n-ary rela-

1. I follow Button and Walsh's notation throughout for ease of reference because for the purpose of my discussion we only need snapshots from their project. It should be noted that their $\hbar$ below is an idiosyncratic usage; readers may be disposed to understand it under the interpretation of Plank's constant. In our context it is merely an abbreviatory device to show its relation to the defined function h as acting over tuples.

tion, and n-ary function symbols, and all $a_1 \dots a_n$ from M:

$$h(c^{\mathcal{M}}) = c^{\mathcal{N}}$$
$$a_1 \dots a_n \in R^{\mathcal{M}} \quad \text{iff} \quad (h(a_1), \dots h(a_n)) \in R^{\mathcal{N}}$$
$$h(f^{\mathcal{M}}(a_1 \dots a_n)) = f^{\mathcal{N}}(h(a_1), \dots h(a_n))$$

We write $\mathcal{M} \cong \mathcal{N}$.

Hereafter the tuples $a_1 \dots a_n$ will be abbreviated $\bar{a}$. To make things snappier, let $h\colon \mathcal{M} \to \mathcal{N}$ be any bijection and let $\bar{a}$ be from M. Then $\hbar(\bar{a}) = (h(a_1) \dots h(a_n))$. Conceptually, what we are doing is pushing the map h through sets of elements of $\mathcal{M}$ and $\mathcal{N}$.

An Aside: This extends to sets of sets of elements, etc., up the iterative hierarchy of sets to define h on higher level objects if we wish. That is, for $X \subseteq M^n$, $\hbar(X) = \{\hbar(\bar{a})\colon \bar{a} \in X\}$ and similarly, for $Y \subseteq \wp(M^n)$, $\hbar(Y) = \{\hbar(X) : X \in Y\}$. Here, Y is a set of sets of tuples. So the map h on a higher level object ϕ is defined as the set which collects the action of h on all of ϕ's members. In the example of Y we could see Y as the range for n-place relation variables in a (second order) Henkin $\mathcal{L}$-structure defined on M. I mention this first to show that these notions generalize, but more importantly, because appeals are sometimes made in the philosophy of science to non-standard (i.e. Henkin) semantics though I have not seen it noted that the permutation argument applies mutatis mutandis (that is, other than by Button and Walsh).

2.2.3 Push–Through

This follows Button and Walsh's (2018) discussion closely.

Let $\mathcal{L}$ be any signature, $\mathcal{M}$ an $\mathcal{L}$-structure with domain M, and let $h : \mathcal{M} \to \mathcal{N}$ be *any* bijection. We can then use h to define an $\mathcal{L}$ structure $\mathcal{N}$ on the set N by defining $s^N = \hbar(s^M)$ for every $\mathcal{L}$ symbol s. I.e.:

$$c^{\mathcal{N}} = h(c^{\mathcal{M}})$$
$$R^{\mathcal{N}} = \hbar(R^{\mathcal{M}}) = \{h(\bar{a}) : \bar{a} \in R^{\mathcal{M}}\}$$
$$f^{\mathcal{N}} = h \circ f^{\mathcal{M}} \circ \hbar^{-1} \quad \text{such that} \quad f^{\mathcal{N}}(\hbar(\bar{a})) = h(f^{\mathcal{M}}(\bar{a}))$$

(Here $\hbar^{-1}(\bar{b}) = \bar{a}$ iff $h(\bar{a}) = \bar{b}$; we know that $\hbar^{-1}$ exists because we defined $\hbar$ to be a bijection.)

So what is the cash value of the push-through construction? If we think that model theory (or mathematics generally) pins down the ideas of reference and truth, the push-through construction can raise serious sceptical concerns regarding the indeterminacy of reference, and thereby truth conditions. In fact, as we will see later, the issue of truth as it relates to Ramsey and Carnap is a major concern in Demopoulos' analysis.

A more recherché aside: There are examples in the literature that use toy examples to make this more accessible; however, I do not always find them to be entirely illuminating. They certainly illustrate the point, but our intuitions about the ordinary use of language, as well as truth and reference can make the examples seem like a bit of a sleight of hand. Instead I will give a contrast that I think makes the point more clear. In Tarski semantics we have a variable assignment which is a function from the set of variables to the underlying domain of our structure. Two distinct variable assignments will differ insofar as they assign different elements to at least one variable. Here h is a function which permutes the reference of our non-logical vocabulary (i.e. constants, relations, functions). Where two variable assignments can make different sentences true in the same structure (i.e. $\mathcal{M}, \sigma \vDash \psi(x)$, but $\mathcal{M}, \gamma \nvDash \psi(x)$), by construction of h, the structure $\mathcal{N}$ (the h image of $\mathcal{M}$) makes *exactly* the same $\mathcal{L}$ sentences true as $\mathcal{M}$, despite the permutation induced by h. That is, by construction $\mathcal{M} \cong \mathcal{N}$, hence they satisfy all the same sentences, regardless of the permutation of the underlying domain.

2.3 *Three Views of Theoretical Knowledge*: A critical exegesis

In order to appreciate Demopoulos' application of Newman's objection to Russell, and to get a grasp of the situation for other forms of structuralism, it is advantageous to closely examine his last published paper on these issues. There he isolates the role of both the abstract conception of theories and the structuralist thesis.[2] For the purposes of understanding the Newman objection and its impact for structuralism in the philosophy of science generally, and the work of F.P. Ramsey in particular, this paper of Demopoulos' explores the relevant issues, while emphasizing the generality of the underlying arguments and considerations.

2. Arguably, "On the rational reconstruction of our theoretical knowledge" is his most representative paper characterizing together the views of Russell, Ramsey, and Carnap, but it is only in (Demopoulos 2012d) that Demopoulos explicitly diagnoses the underlying problem for theoretical knowledge as arising from the abstract conception of theories and the structuralist thesis.

2.3.1 Context of the paper

"Three views of theoretical knowlege" is the culmination of a series of papers Demopoulos wrote exploring the Newman criticism. In particular it extends the considerations in his "On the rational reconstruction of our theoretical knowledge" where he also lays out Russell's, Ramsey's, and Carnap's views. There, his central thesis is that the reconstructive programs of Russell, Ramsey, and Carnap fail to respect our "pre-analytic" intuition that the truth of a theory, over its intended domain, is a significant a posteriori truth. Like Russell's structuralism, the Ramsey-sentence "approach" makes the truth of a theory depend on an assumption about cardinality. In "Three views of theoretical knowlege," Demopoulos offers a sharper diagnosis of where structural views go wrong, emphasizing that it is the common underlying principle he characterizes as the structuralist thesis stemming from the abstract view of theories[3] which causes the common problem for a wide range of approaches to theoretical knowledge. Moreover, he sketches a positive proposal in contrast to the structural views he criticizes.

Notice that I refer to a Ramsey-sentence "approach". There are two points to be made here. The first point is this: the following sections discuss this approach to follow Demopoulos, but it is not clear in the histories of philosophical logic or philosophy of science that work done involving the Ramsey-sentence can be characterized as engaging with a common approach; certainly it engages with a common logical construct, but the research is not evidently concerned with any unique application of that construct. The second point is that we need a clear statement of what is meant by a Ramsey-sentence. The "Ramsification" of a theory is essentially a technique for formalizing the structure of a scientific theory whereby:

1. the primary and secondary systems divide the language of the theory,

2. their interrelations are exhibited in some fashion, i.e., a dictionary or set of correspondence rules, and axioms,

3. the reference to the secondary terms (or entities) is removed through existential generalization.

To give an idea of this, the following is how Ramsey suggested the ideal representation of a theory should be written: "$(\exists\alpha,\beta,\gamma)$: dictionary $\cdot$ axioms". That statement is Ramsey's infamous Ramsey-sentence. A more contemporary representation would take some theory T with terms $t_1 \ldots t_n$ in the secondary system, i.e. $\mathrm{T}[t_1 \ldots t_n]$, and replacing those terms with variables: $\exists x_1 \ldots \exists x_n \mathrm{T}[x_1 \ldots x_n]$. For immediate purposes, we are not going very far into Ramsey's characterization of theories, or the general idea of Ramsification beyond that outlined above.

3. Cf. 2.3.3 below and my remarks in the Introduction

This serves a methodological purpose. To avoid pre-judging any of the relevant issues it is important to have at hand a sufficiently general idea of Ramsification to understand Demopoulos' arguments in the following sections. In the context of Demopoulos' analysis the primary and secondary systems are assumed to be divided between observational and theoretical languages.[4] When referring to a theory in the context of Ramsification, the convention I will follow generally will be to refer to a given theory by 'ϑ' and the Ramsey-sentence thereof 'R(ϑ)', except in cases where it is more helpful to adhere to some other notation (such as to remain consistent with a primary source), in which case the relevant notation will always be clear in context.

2.3.2 Overview

The target of Demopoulos' analysis is the structuralist thesis which he describes as underlying the views of theoretical knowledge advocated by Rusell, Ramsey and Carnap. The structuralist thesis implies that the Ramsey-sentence of a theory adequately expresses its factual content.[5] This is to say that the theoretical component of our theories is captured by statements which depend only on the constituent concepts having the right arity and logical type. He argues that any empiricist view built on the thesis fails as a representation of our theoretical knowledge because it conflates model theoretic satisfiability with truth. That is, the truth of our theoretical statements becomes a fact of the ambient set theory or metalogic given only an assumption about the cardinality of the underlying domain. This clearly violates our pre-analytic intuition that the truth of our theoretical claims are substantial a posteriori discoveries.

In order to justify that last claim he demonstrates how Newman's objection to Russell's structuralism can be applied to both Ramsey and Carnap's reconstructive programs. Newman's objection essentially relies on a certain kind of argument for constructing isomorphic structures. In the specific cases of Ramsey and Carnap, the construction requires the extra stipulation that the new structure has an observation-language reduct which keeps the interpretation of the observable part of the domain fixed. All this can be proven. Notice that the problem the Newman objection poses to all three views is not only the difficulty in specifying an intended model among a class of isomorphic models, but the deeper point that the truth of our theoretical claims is reduced to satisfiability in any, hence, all of the models. For Russell, the objection deflates his realism regarding positing extensions of the domain for theoretical entities; for Ramsey, we have no apparent reason to oppose Russell's realism; for Carnap, as

4. I label the above in terms of primary and secondary because I believe that framing Ramsey's views in terms of a strictly observational/theoretical partition is a major example of subsequent theorists misattributing a substantive philosophical position to Ramsey which he did not obviously share.

5. Cf. Button and Walsh 2018 Proposition 3.5 and its corollary Proposition 3.2 for a proof that a Ramsey-sentence of a theory is observationally equivalent to the un-Ramsified theory.

the culmination of the structuralist thesis, theoretical truth loses any semblance of its empirical a posteriori character.

Demopoulos ends the paper with a positive view drawing on work by Gupta. The proposal involves a shift away from the structuralist thesis and a reconsideration of the role for experience in interpretation. On the views characterized by the abstract view of theories, experience gives us a priveledged class of statement, i.e. the observation language. While Gupta is not engaging directly with the philosophy of science, his work seeks to provide an account of the logical contribution of experience. Briefly, experience gives us an entitlement not to a proposition or a privileged class thereof, but to a proposition relative to a particular background view. The given in experience is hypothetical, that is, it serves the role of something like a rule of inference giving us hypothetical entitlements relative to the view we have adopted. Gupta, and Demopoulos' extension of his thought to issues of theoretical knowledge, try to account for the authoritative role of experience in our knowledge, which has been undermined by misguided forms of empiricism.

2.3.3 Target of the analysis

The target of Demopoulos' analysis is theoretical knowledge as construed by the views, belonging to the *abstract conception of theories*, and which subscribe to the *structuralist thesis*.[6]

Abstract conception of theories:

> I mean that view of theories which asserts first, the existence of a partition of the non-logical vocabulary of the language of a theory into observation and theoretical terms, and holds, secondly that this partition reflects the fact that our understanding of the theoretical vocabulary is importantly incomplete and problematic in a way that our understanding of the observation vocabulary is not. (Demopoulos 2012d, 140)

Structuralist Thesis:

> The theoretical component of what our theories express is wholly captured by statements which depend only on the logical category of their constituent concepts. (161)

Moreover, it"implies that the Ramsey-sentence of a theory adequately represents the theory's 'factual' content," (140).

6. Notice that the way I have construed it has the views subscribing to the structuralist thesis as a subset of the abstract conception of theories which itself is included in accounts of theoretical knowledge.

Notice that he goes on to say that:

> If this consequence of the structuralist thesis could be sustained, then any difficulty the theoretical vocabulary might be thought to pose could safely be ignored... (Demopoulos 2012d, 140)

So, Demopoulos is bound to argue either that 1) the Ramsey-sentence of a theory does not capture a theory's factual content, or 2) it does not obviate the difficulty the theoretical vocabulary poses.

2.3.4 All that business about toy models and Craig transcriptions

The details here are rather technical, but it is not essential to venture too far into them to see their value. First, Demopoulos constructs a toy theory whose purpose is designed to show that the Ramsey-sentence, in a sense, has a content which goes beyond the observational consequences of the theory. To do this he contrasts the Ramsey-sentence with a Craig transcription. Craig transcriptions are a way of generating a model of the observational consequences of a theory, but where unlike the Ramsey method, the theoretical terms are not existentially generalized away, but rather eliminated altogether while preserving the observational consequences of the theory. I will not venture into the details here; for reference, Psillos 1999 contains a superb discussion of Craig transcriptions in the context of the philosophy of science. I will only mention that Craig transcriptions apply to first-order theories, where Ramsey-sentences are higher order representations—Ramsey does not stipulate that they be only second order either, leaving it open that Ramsey-sentences could characterize theories in n^{th} order languages, though it is generally taken that the Ramsey-sentence of a theory is a second order sentence. I mention as well that Putnam (2012) provides a very similar proof for the same point that Demopoulos' toy model is intended to serve.

What Demopoulos' toy model shows is that there are cases where we can have a model of a Craig transcription of a theory, i.e. one in which all the observational consequences of a theory are true, but where a model of the corresponding Ramsey-sentence for the theory fails. To put it briefly, the toy theory requires for the truth of its Ramsey-sentence a non-standard model of the natural numbers. When the theory is characterized using full second order logic (that is, using the standard semantics where the domain of the relations ranges over the full powerset of the domain of the structure) the Craig transcription of the theory is true, but the Ramsey-sentence fails. The Craig transcription comes out true because the toy theory was designed to only need standard numbers for its observational component. However, the Ramsey-sentence of the toy theory, because it describes the ranges of relations of the theoretical component, requires a non-standard model but, by a theorem of metalogic/mathematics (Dedekind's Categoricity

Theorem), all full models are categorical—which is to say that there *are* no non-standard models.[7] So, we have a case where the Ramsey-sentence of the theory constrains the class of models of the observational consequences of the theory. Before proceeding, we need to rehearse what we mean by extensions and expansions.

Extension (subinterpretation):$_{df}$ enlarging (contracting) the domain while keeping the language fixed.

Expansion (reduct):$_{df}$ enlarging (contracting) the language while keeping the domain fixed.

In slogan form: extensions change ontology; expansions, ideology.

2.3.5 Demopoulos reading Russell

Demopoulos recognizes that Russell neither proposed a theory of theories that required a language partitioned into observational and theoretical terms, nor suggested that the Ramsey-sentence of a theory adequately expresses its factual content. Russell developed his structuralism in *The Analysis of Matter* before Ramsey developed his own ideas. Russell was, however, committed to the structuralist thesis and, in virtue of his epistemological project of analysing propositional understanding on the basis of knowledge by acquaintance, he was similarly committed to the abstract view of theories. The structuralist thesis is, according to Demopoulos, *the* fundamental assumption of any reconstruction along the lines of such a distinction/partition, hence why we collect Ramsey and Carnap along with Russell.

On the account of knowledge derived from Russell's theory of meaning, the causal theory of perception, and his distinction between acquaintance and description, we require an account of those properties and relations with which we can have no acquaintance. That is, we need to have a different account of our knowledge of the unobservable or theoretical relations (and entities) posited by our theory. As Demopoulos puts it: "Russell's project is to recover a facsimile of what passes for our knowledge of the world within the framework of epistemic constraints imposed by his theories of perception and propositional understanding," (Demopoulos 2012d, 149). Russell's account thereof is, however, fundamentally impeded by Newman's objection. Here is Newman's argument in a nutshell: For any model $\mathcal{M}$ of our theory ϑ we can construct

7. Technically this is not quite right: Dedekind's theorem addresses itself to second order Peano arithmetic and not natural numbers per se. Indeed, the version I am familiar with uses "is a natural number" in the metalanguage so we seem not to have stepped outside of the circle if we are trying to pin down "the" natural numbers. But this is all just a bit of pedantry beside Demopoulos' point. It should also be noted that Button and Walsh, in their appendix to the discussion of Newman's objection, raise some concern that the way these considerations are formulated in Demopoulos 2012d can mishandle observables in the context of a modified Newman objection using elementary extensions, but it is not clear that this is detrimental to the point about Ramsey-sentences and Craig transcriptions.

another model $\mathcal{N}$ which satisfies ϑ. We will (only very slightly) sketch an adaption of a proof of Winnie's (1967) to highlight the relevant points.[8]

Let $\mathcal{L} = \mathcal{L}_o \cup \mathcal{L}_v$ and $\mathcal{L}_o \cap \mathcal{L}_v = \emptyset$. Let $\mathcal{M}$ be any $\mathcal{L}$-structure such that $\mathcal{M} \models \vartheta$. Let A be the part of the domain that is the observables. Let U be any set of cardinality κ where κ is the cardinality of the unobservables in domain $\mathcal{M}$, i.e. $\kappa = |\mathrm{M} \setminus \mathrm{A}|$ and $\mathrm{A} \cap \mathrm{U} = \emptyset$. Let φ be a bijection $\varphi\colon \mathrm{M} \setminus \mathrm{A} \to \mathrm{U}$. Let ψ be a bijection $\psi\colon \mathrm{M} \to (\mathrm{A} \cup \mathrm{U})$ such that $\psi(x) = x$ if $x \in \mathrm{A}$ and $\psi(x) = \varphi(x)$ if $x \in \mathrm{M} \setminus \mathrm{A}$. Now define a structure $\mathcal{N}$ such that $c^{\mathcal{N}} = \psi(c^{\mathcal{M}})$ and $R^{\mathcal{N}} = \psi(R^{\mathcal{M}}) = \{\psi(\bar{a}) : \bar{a} \in R^{\mathcal{M}}\}$. We can extend this to account for functions as well: $f^{\mathcal{N}} = \psi \circ f^{\mathcal{M}} \circ \psi^{-1}$ such that $f^{\mathcal{N}}(\psi(\bar{a})) = \psi(f^{\mathcal{M}}(\bar{a}))$. To explain just what happened here, we took the bijection we defined and used it to construct a new structure where the interpretation of the non-logical vocabulary in the new structure is the value under ψ of our original structure. By construction we kept the observable part of the domain the same, but we have "pushed through" the values of the unobservables to their interpretation in the new structure.[9]

This is not quite Newman's objection to Russell as we saw it in 2.1.2 because we are keeping the underlying domain of observables fixed, but it is an adaption that makes perfect sense. His general objection finds itself well illustrated model-theoretically by the push-through construction (2.2.3). For comparison, recall what Newman *did* say contra Russell:

> Any collection of things can be organized so as to have the structure $\mathcal{W}$ provided there are the right number of them. Hence the doctrine that *only* structure is known involves the doctrine that *nothing* can be known that is not logically deducible from the mere fact of existence, except ("theoretically") the number of constituting objects. (Newman 1928, 144)

Note that in the text, Demopoulos frames the Newman objection in terms of extensions instead of (as we just did; at least tacitly) in terms of expansions. Button and Walsh 2018 compellingly argue that the best form of the Newman objection contra the realist is (similar to) that which we just offered: the "Newman Cardinality Objection". They treat Demopoulos' "Newman Extension Objection" and show that there is no way to rule out the possibility that the elements of the enlarged ontology, which are intended to be theoretical, end up being designated such that they belong to 'Ob' in Winnie's terms; where 'Ob' is a predicate to which all and only the observable entities and relations belong—its role is as a technique to fix the observables in the domain. Their discussion makes use of an overspill lemma (in this context it is for non-standard models of Peano Arithmetic rather than analysis). In a slogan: the Newman Extension Objection mishandles 'theoretical' entities. Though Button and Walsh's argument

8. The subscripts indicate the observational and theoretical partitions of the language.
9. For all the details, see Button and Walsh chapters 2 and 3, 2018.

is correct, I think Demopoulos was emphasizing a feature of Russell's approach to logical construction and Russell's realist assumptions.[10] While this runs the risk of mishandling observables, Demopoulos is right to challenge the realist assumptions Russell's view employs, namely that "the realist component of [Russell's] theory consists in the assertion that there is an extension of the domain of events that are known by acquaintance to one that includes theoretical events" (Demopoulos 2012d, 151). His conclusion contra Russell riffs on a now familiar theme from the older papers. Here is the quotation in full:

> But the structuralist component's account of the nature of the knowledge expressed by such assertions[11] is actually in tension with the realist component, since it has the consequence that statements about the theoretical part of the domain are true as a matter of logic and an assumption about cardinality, a consequence that vastly understates the intended epistemic significance of theoretical statements and threatens the robustness of Russell's claim to realism about the theoretical part of the domain. (159, my footnote)

It is worth nothing that while Russell did not seem to countenance the Newman objection here, he understood something like it. He makes very similar points to the cardinality considerations in his *The Problems of Philosophy* and specifically in his *Introduction to Mathematical Philosophy*. The history of Russell's response to Newman is unclear. We know that he accepted the objection, but he also tried to suggest that Newman's characterization of his position, and hence the objection, misses the mark. Nevertheless, there are many points in Russell 1927 encouraging that interpretation, and Russell never clarified what he really intended.

2.3.6 Demopoulos reading Ramsey

Demopoulos' interpretation of Ramsey focuses on a perceived difference between Ramsey and Russell regarding positing an extension to the domain of entities described by observational language in order to satisfy the claims in the theoretical part. He contrasts Russell's realism with what he describes as Ramsey's anti-realism. As a result, much of Demopoulos' discussion focuses on the toy model of the natural numbers he develops to show that a theory can have a true Craig transcription but a false Ramsey-sentence. While this discussion is interesting in its own right, it runs the risk of overlooking one of Demopoulos' central claims by focusing on the toy model. That claim is that Ramsey's approach to theories, characterized by the

10. Crucially, the point Button and Walsh are making about the Newman Cardinality objection is that notions of consequence-conservation, and expansion-conservation align in the second order context of the Ramsey-sentence, but fail to align in in the first-order context considering elementary expansions.

11. i.e., about events outside our acquaintance.

Ramsey-sentence, endorses both the abstract conception of theories and the structuralist thesis. Ramsey's view, like Russell's, is therefore held to be subject to Newman's objection. Briefly, I turn to discuss Demopoulos' characterization of the difference between Russell and Ramsey.

Demopoulos notices that "for Ramsey, the secondary system introduces new parameters that are defined on the domain of any application of the theory..." (Demopoulos 2011, 191). He contrasts Russell with Ramsey insofar as the latter does not require for the interpretation of the parameters (theoretical variables) an extension of the observable part of the domain. According to Demopoulos, "the purpose of the secondary system and the theoretical vocabulary it introduces is to organize our knowledge of the things with which we are acquainted" (191). The fact that the inclusion of the parameters need not enlarge the domain encourages Demopoulos to suggest what he calls *Ramsey's Principle*: "If the Ramsey-sentence of a theory can only be modelled by an extension of the domain of a model of its $\mathcal{L}_o$-consequences, then this is grounds for rejecting the theory" (191).

He characterizes Ramsey's view as a *development* of Russell's earlier phenomenalism, contra Braithwaite's interpretation which claims that Ramsey's goal was a refutation of Russell's project of logical constructions. Briefly, the refutation follows these lines: if we follow Russell's program, we would have to explicitly define terms of the secondary system by terms in the primary.[12] Doing so would prevent the theory from being capable of growth, *but* we want our theories to be dynamic, ergo Russell's project cannot be right. Demopoulos instead argues that the issue separating Russell and Ramsey relates to the legitimacy of extensions of the domain. The issue turns on how we are to understand the truth of a theory which Demopoulos takes to be equivalent to asking "whether or not the truth of the theory requires extensions of the domains of its application" (Demopoulos 2012d, 157).[13] That is, whether we ought to extend our claims to theoretical knowledge, as Russell would, to entities beyond those known by acquaintance, or rather, as Demopoulos suggests of Ramsey, that our theoretical knowledge ought only to be expressed in terms of a primary system even if the larger theoretical system aids in expressing truths beyond what could be inferred with a primary system alone.

Notice this quotation:"Ramsey's view of the role of theories and the interest he attached to ramsification would then come down to the idea that a potentially infinite description in

12. Ramsey defines the primary system in terms of the secondary system in order to approach questions regarding explicit definitions (cf. Sahlin 1990, 135). This method of approaching the definitions would not be allowed by Russell since in his case, we can assume any definition would need to come from the epistemologicaly prior objects of acquaintance. This itself suggests Ramsey was not concerned with the issue of definability for epistemological reasons, or at the very least, not directly.

13. Specifically, Demopoulos is looking at truth in these terms here. His "On the rational reconstruction of our theoretical knowledge" and "On extending "Empiricism, Semantics and Ontology" to the realism–instrumentalism controversy" are instructive accounts discussing different meta-theoretic attitudes to truth. Those issues are discussed in chapter 4.

terms of primary propositions is rendered manageable—finitely axiomatized—by the addition of finitely many new 'theoretical' parameters," (Demopoulos 2011, 190). Craig and Vaught proved the finitely axiomatizability of systems through the addition of additional parameters in 1958. It is important to keep in mind that while the Ramsey-sentence may not be adequate to express our theoretical knowledge, it need not be considered as a failed endeavour. There was much work done in the middle part of the twentieth century to answer questions both about the Ramsey-sentence, and issues it was suggested to solve, particularly regarding notions of definability.

While Demopoulos may be right that "the phenomenalist contention that the secondary vocabulary is eliminable is one that Ramsey's analysis was intended to *support*" (Demopoulos 2012d, 157), he has not shown that for Ramsey it is an elimination for epistemological purposes. Ramsey does explicitly deny the need for such eliminations, and doubts their value. Applying the Newman argument only seems to make sense on the assumption that Ramsey is trying to characterize our theoretical knowledge as knowledge of (or by) structure, and moreover, that in "Theories" Ramsey is engaging with primarily epistemological concerns. The next chapter will explain why we should doubt both these points. Two large questions remain: to what extent did Ramsey mean to support elimination as part of a structuralist approach to theoretical knowledge—so far that is a presupposition by Demopoulos for the purposes of his targeted criticisms of the structuralist account of theoretical knowledge; and how we should understand the notion of elimination itself. There is an entire literature[14] regarding in just what sense we can say that the theoretical terms are 'eliminated': that while they are generalized away, reference to theoretical concepts remain through the higher-order variables and the (sets of) tuples of the domain satisfying them (this should be contrasted with Craig's transcriptions, cf. 2.3.4 or the especially lucid discussion thereof in Psillos 1999).

Demopoulos is quite right regarding the virtues of reading Ramsey this way. It presents an interesting contrast with Russell and a context for Carnap's development of the Ramsey-sentence. I also agree that the point of Ramsey's paper "Theories" is far from transparent. Indeed, Demoupoulos' interpretation has the value of showing how a structuralist approach to theoretical knowledge along these lines can go wrong. I disagree that it is a correct or charitable reading of Ramsey. Demopoulos, like most commentators based his interpretation of Ramsey largely on "Theories," though he also made use of unpublished notes from the Ramsey archives. However, a more complete picture emerges from the texts Demopoulos does not consider, particularly "General Propositions and Causality" and "Causal Qualities." The

14. Of course, the existence of an entire literature does not necessarily imply there is a meaningful issue; however, in this case there has been not only philosophical analyses, but also concrete logico-mathematical results (e.g. van Benthen, 1978).

next chapters consist in my reconstruction of Ramsey making heavy use of those works and other papers to situate "Theories" in its larger philosophical context.

2.3.7 Demopoulos reading Carnap

The treatment of Carnap focuses on the argument that Carnap represents a resolution (synthesis) of Russell's realist and Ramsey's anti-realist accounts. He claims that for Carnap, the role of the observational vocabulary is to contribute to the evidential basis of theoretical claims. Notice, this suggestion is specifically concerned with evidential and epistemological issues. Demopoulos notes that all three figures recognize that "the observational vocabulary is fully understood in a way that the theoretical vocabulary is not" (Demopoulos 2011, 195). But, notice as well that we lack a characterization of this understanding—we are simply told that we do understand the primary system, but not the character or range of that understanding. Demopoulos frames it as a problem regarding the evidential base and the truth of our theoretical claims. We could, however, plausibly suggest that the way our understanding is incomplete is that we do not understand the semantic or conceptual role of our theoretical vocabulary when we *consider* a theory *as* a language for expressing facts in the primary system. Indeed, as Hempel shows with the theoretician's dilemma, there is a sense in which, on the latter construal, our understanding of the primary system is also incomplete, or at least problematic, because we do not yet understand the systematic connections imposed on it by the secondary system; that is, the role of the secondary system in forming inductive, and not only deductive, connections.

Nevertheless, let us follow Demopoulos in considering the defect in our understanding as roundly epistemological concerning truth and the evidential base for theoretical claims. He isolates the problem, as construed by Carnap, as the the issue of finding a way of (non-arbitrarily) marking an analytic-synthetic distinction in the theoretical vocabulary.

For Carnap, the factual component is captured by the Ramsey-sentence, while the analytic component can be isolated through the Carnap sentence, i.e. the meaning postulate of the theory. We will not go into any of those details here.[15] Instead, note that to suggest that a theory's factual content is captured by the Ramsey-sentence is to recognize that the content of the theory exceeds any construction that only preserves the $\mathcal{L}_o$-consequences, like a Craig transcription. Regarding the issue of extensions or expansions, Carnap deflates the issue by suggesting that indeed, there exist logico-mathematical entities to enable us to operate the theory. So, Carnap seems open to extensions, unlike Ramsey, but unlike Russell, those extensions need only be understood mathematically.

15. Cf. Winnie 1970.

> "To run Newman's objection against Carnap it is unnecessary to appeal to an empirical assumption about the cardinality of the domain of theoretical events, since for Carnap the 'abstract' model $\mathcal{N}$ of the lemma[16] that figures in that objection already suffices for the interpretation of the theory." (Demopoulos 2012d, 161, my footnote).

We might wonder here whether there is any point in running Newman's objection against Carnap. I suggest that he seems to be engaging with other concerns.

2.3.8 Demopoulos' conclusion and suggestion

According to Demopoulos, the structuralist thesis underlying all three of these views is the culprit for the violation of our pre-analytic conception of the truth of our theoretical claims. Namely, that the truth of those claims are important a posteriori discoveries, and not truths from metalogic. In each case, the structuralist thesis encourages the thinker in question to draw specific conclusions[17]. However, in each case the Newman objection problematizes the position developed. Russell's account of knowledge of the real world has the consequence that we can only know the number of constituting objects; for Ramsey's account, we have no apparent reason to oppose Russell's realism; and for Carnap's account, the truth of theoretical claims is reduced to satisfiability in a model. It is not so much that the issues with the structuralist thesis derive from the use of Ramsey-sentences or their proxies. Rather the thesis encourages the view that the Ramsey-sentence expresses the factual content of the theory. Here, we are left wanting an explication of the factual content, now that Demopoulos has argued that the Ramsey-sentence does not adequately represent it. The structuralist thesis, because of Newman's objection, undermines any view of empiricism using it, because the thesis equates model theoretic satisfiability of a theoretical claim with truth.

The positive view Demopoulos presents at the end suggests a reconsideration of the role of experience such that its role is "equally provisional" in providing a model for the interpretation of both theoretical and observational vocabularies. Notice that up to now we do not have any suggestion how to interpret the theoretical vocabulary, except those views just undermined by his analysis. He encourages a view that takes theories as dynamic, fluctuating, and responsive to experience at both observational and theoretical levels. Notably, "this process is never resolved by the prescription that a correct interpretation of the theoretical vocabulary is one that fulfils the matrix of the Ramsey-sentence of the theory to which it belongs" (Demopoulos

16. The lemma referred to here is the 'folk' result Demopoulos cites from van Benthem. It is also in Button and Walsh as Thm. 4.18 along with proof.

17. Cf. pp. 161 for Demoupoulos' detailed description of these.

2011, 200). We are no longer considering the so-called observational partition of our theory as having some kind of epistemic privilege such that its interpretation can be explained by some claim to ostension or direct access whereas the theoretical vocabulary's interpretation, by lying beyond observation, must be given by the satisfaction of some collection of conditions. Moreover, it is not a straightforward task to give an adequate observational/non-observational distinction so that the language of a theory can be partitioned. We saw with Russell that this reduced to knowledge by acquaintance. The crucial problem Demopoulos identifies, however, is not the difficulty in drawing an appropriate distinction between observational and theoretical terms, but rather, that even if such a partition could be satisfactorily (in both a philosophical and methodological sense) established, the central problem Newman raises would still arise in virtue of the adherence to the *epistemic difference* attributed to the partition, exemplified in the structuralist thesis.

The criticism Demopoulos raises cuts much deeper than any particular qualms, problematic and genuine as they might be, for marking the boundary between observational and theoretical language. Demopoulos' suggested research program reconsidering the role of experience ties in with Gupta's program in *Empiricism and Experience.*[18] Gupta recognizes that classical empiricism has trouble explaining experience as our main epistemic guide. He diagnoses the flaw endemic to these forms of empiricism as the result of two related conceptions: the Cartesian conception of experience and the propositional given. The Cartesian conceptions of experience are characterized as those varieties of classical empiricism that in one form or another hold that the given in experience is something with which we are immediately acquainted. The sense-data theory is a paradigm example of a Cartesian conception. The key feature of these conceptions, despite whatever specific differences, is that they are committed to the given in experience being propositional; e.g., with the sense-data theory the given is a proposition of experiencing thus-and-so, here-and-now.

Gupta contends that the central role of experience can be maintained only if we abandon certain classical assumptions, in particular the assumption that the given in experience is propositional in form. Instead of construing the given in experience as a special kind of proposition (or class thereof), Gupta formulates an account where the given in experience is a relative notion. Gupta's main thesis in his novel account of empiricism is that experience gives us an entitlement not to a proposition, but to a class of judgements or propositions *relative* to a particular view. His goal is to understand the *logical* relationship between experience and knowledge. More precisely he is concerned with the way in which experience contributes to the reasonableness of a belief, where the given in experience is defined as the total rational contribution of an experience. As an alternative to the Cartesian conception and the propositional

18. A brief overview of Gupta's compelling arguments can be found in his (2009).

given, Gupta argues the given in experience is a function which takes our current view (of the world or some subdomain thereof) and then, with input of an experience, outputs a class of judgements. Our current view has a fundamentally hypothetical character: given the view of the subject matter that we hold, a particular experience can generate a class of judgements. In Gupta's symbolic representation we have $\Gamma_e(v)$ where we read that as Γ, the given in experience is indexed with some particular experience e, and view v, to give the judgements the experience yields relative to the view we have. The given in experience, relative to that particular view is like a rule of inference giving us hypothetical entitlements internal to the view we have adopted.

Demopoulos embraces Gupta's claims against the propositional given, recognizing that the structuralist thesis embraces this sort of conception. In particular, he rejects the idea that experience provides us with a privileged class of propositions that form the observational partition of theories. It is appropriate in this sense to consider Demopoulos' suggestion as a dethroning of the privileged observational vocabulary because he encourages expanding the role of experience beyond the epistemic boundaries represented by the partition of a theory's language, while at the same time upholding the pillar of empiricism which holds that experience is our main epistemic guide. Notably, this is contrary to the dogma Demopoulos sees as motivating the epistemic distinction between the observational and theoretical:

> The notion that the distinction is a distinction of epistemological importance is fostered by the dogma that unless it is accorded such significance, an important pillar of empiricism will collapse. But what the dialectic reveals is not a collapse of empiricism, but the failure of any view which is led by its understanding of empiricism to the structuralist thesis, and from that thesis to the equation of the mere satisfiability of a theoretical claim with its truth. (Demopoulos 2012d, 164)

Demopoulos endorses Gupta's proposal where the logical relationship between experience and knowledge is functional rather than propositional, and identifies the assumption of a propositional given with the defect in the accounts of theories he criticizes. The research program he suggests is one which takes account of this functional, hypothetical character of views, adapted to the context of scientific theories. It abolishes the epistemic privilege of the observational vocabulary while simultaneously extending the role of experience for revising our theoretical beliefs and the interpretation of our theoretical terms. According to Demopoulos the views he has criticized are all committed to the notion of a propositional given insofar as they are committed to the structuralist thesis. He describes the situation as follows:

> In the accounts we have been discussing, the commitment to the propositional given is expressed by the epistemologically privileged role these accounts accord

> observation sentences, and by the special epistemological status they accord the vocabulary with which observation sentences are expressed... But exactly *how* the epistemically privileged status of the observation vocabulary is spelled out is of less importance than the contrast all three of the views we have described draw between observation and theoretical vocabulary. For each of these views, not only are propositions expressed with theoretical vocabulary not part of the given in experience, but because we are not given the meanings of their constituent theoretical terms, theoretical statements are accorded an analysis that conforms to the structuralist thesis. (Demopoulos 2012d, 166)

This suggests that the extent to which Ramsey and Carnap's views are subject to the Newman objection depend on whether they in fact adhere to the structuralist thesis; Russell clearly does. Ramsey's own more nuanced views, which I reconstruct in the following chapters, will be seen to have a kinship and compatibility with the position developed by Gupta and encouraged by Demopoulos. For now, I turn to another characterization of the epistemological significance of structure and invocation of Newman's objection.

2.4 Newman's objection applied to Eddington

2.4.1 Summary of *The Philosophy of Physical Science*

Eddington's book, which was based on his Tarner lectures, provides a clear statement of a position in the philosophy of science which is roughly contemporary with Russell's, and which also had Newman's objection applied to it. The contrast it provides sheds further light on Russell's position, as well as on the scope and applicability of Newman's objection. A further methodological reason for examining this book of Eddington's is that it was written for a more general audience than his technical books on physics, but unlike other less technical (or popular) works he wrote, *The Philosophy of Physical Science* addresses itself to specifically philosophical concerns, while at the same time exhibiting a continuity with the more philosophical remarks throughout his corpus, e.g. *Space, Time, and Gravitation.* Despite this seeming continuity in his views, some caution is required; Eddington seems to show a more sophisticated, or at least a more careful understanding of structure in his *Report on the Relativity Theory of Gravitation*. Hence, the following discussion is confined primarily to *The Philosophy of Physical Science* and critical responses to it.

It is helpful to consider part of the contrast between Russell and Eddington as two ways of responding to Kant. Russell's account is clearly intended to be a posteriori. Even as we move behind the causal theory of perception in order to construct the world beyond experi-

ence, any of those constructions are fundamentally reducible to our primitive experiences of sensation. Russell is concerned to show that we can in fact say something of substance about the world beyond our experience, namely its logico-mathematical properties. Eddington by contrast provides an a priorist account of our scientific knowledge. Instead of rebutting Kant's circumscription of our knowledge to the phenomenal, he goes on to examine something like the conditions for the possibility of our empirical knowledge, from which, he claims that he can *deduce* fundamental propositions of physics which, ordinarily seem to be the result of experimental discovery. He seems to embrace the Kantian idea of a transcendental argument for fundamental physical principles.

Eddington broaches his characterization of our physical knowledge with a consideration explicated by a charming metaphor. He describes an ichthyologist who wishes to know the creatures in the sea. Eddington takes the dialectic to be this: the ichthyologist could sweep and catalogue the sea with his net, categorizing creatures and coming to various conclusions about the lifeforms underwater. However, the ichthyologist is perforce using a net. This net will set limitations on the sorts of creatures he can collect, most notably he will fail to collect all those which are smaller than the structure of the net. Eddington thinks that these same conclusions could be drawn by the epistemologist if they were only to consider the characteristics of the net. This, for Eddington is scientific epistemology: the epistemological investigation of those frames of thought within which our scientific endeavours take place. The following is representative: "[o]ur purpose is to expose, not necessarily to justify, the frame of thought underlying the expression of our physical knowledge…" (Eddington 1939, 121)

Eddington's views are clearly of interest to other issues in the philosophy of science beyond structuralist epistemology. For example, it is tempting to take his considerations and explore the subtle connections between discussions of theory mediated measurement with Eddington's conception of scientific epistemology and his notion of good observation. This temptation is, however interesting and valuable in its own right, beside the point for understanding Eddington's conception of our knowledge of the physical world. The issue for Eddington is prior to any idea of stepping outside of the theory-ladeness of observation, assuming as it does the possibility of a bifurcation between some objective world which we hope the phenomena can somehow reveal. Rather for Eddington the point is to decry the notion of objectivity in science whatsoever: in virtue of features of our epistemological constitution there is an ineradicably subjective character to our physical knowledge. In Eddington's explorations of the proper definition of physical knowledge he is led to reject the idea that objectivity plays the role of a defining property. Indeed his epistemological definition precludes any sort of difference between the physical universe and the universe of physics.[19] The latter is that which is inextricably bound

19. This discussion may be interestingly compared to the difference in the conception of phenomena between

up with our epistemic condition.[20]

The following excerpts give a sense of his main contentions. The numerals indicate steps in his argument summary of the first half of the book.

> (12)...epistemological principles play a part which was formerly taken by physical hypotheses, i.e. generalisations suggested by an *a posteriori* study of the results of observation.
>
> (13)...It appears that when the epistemological scrutiny of definitions is systematically applied, and its consequences are followed up mathematically, we are able to determine all the "fundamental" laws of nature (including the purely numerical constants of nature) without any physical hypothesis.
>
> (14) This means that the fundamental laws and constants of physics are wholly subjective, being the mark of the observer's sensory and intellectual equipment; for we could not have this kind of *a priori* knowledge of laws governing an objective universe.
>
> (16) The subjective laws are a consequence of the conceptual frame of thought into which our observational knowledge is forced by our method of formulating it, and can be discovered *a priori* by scrutinising the frame of thought as well as *a posteriori* by examining the actual knowledge which has been forced into it.
>
> (18) Epistemological laws (if correctly deduced) are compulsory, universal, and exact. Since the fundamental laws of physics are epistemological, they have this character—contrary to the view usually advocated in scientific philosophy, which has assumed that they are merely empirical regularities.
>
> The next four chapters will be devoted to a more intensive study of the conceptual frame referred to in (16). (Eddington 1939, 104-105)

The intensive study indicated in the last excerpt leads to the result that our knowledge is inherently structural. I will be the first to admit that Eddington's book contains subtle and valuable insights for the philosophy of science. An entire book could (and should) be written to detail the explication of his views and the interconnections with other philosophers of science. However, in spite of whatever positive value his suggestions might contain, his overall account

Newton and Kant. For Kant, and it seems Eddington as well, the phenomena include all objects of experience, including causal and dynamical information; whereas for Newton, and his deduction from phenomena involve the relative motions of the (then) observable bodies in the solar system from which causal and dynamical inferences are deduced. Cf. Friedman 2020, §2.

20. The reader is referred especially to the discussion from pp. 157-162 as well as 102-105

is prey to the same kind of structural issues as beset Russell. We will see in 2.4.2 the application of Newman's objection to Eddington. For Eddington, the highly mathematical character of physics today results from, in his words, our putting the mathematics there. Mathematics, he claims, gains its foothold not through mathematical nomenclature but by the recognition of group-theoretic structure.[21] In order for an abstract notation not to disappear along an infinite regress, we require a terminable collection of operations. He identifies groups as an adequate such collection of operations. In a remarkably similar passage to Russell's discussion in his defense of the causal theory of perception, Eddington explains how there is no way for individuals to compare their sensations with one another. Rather, they can only compare the structure of their sensations. In this way, we step outside our private experience and can begin to discuss a world that is independent of our private sensations. However, what is independent and which is communicable between persons is knowledge of structure. As we extend our knowledge from sensation to broader realms, we reach physical science, but:

> Physical science consists of purely structural knowledge,[22] so that we know only the structure of the universe which it describes. This is not a conjecture as to the nature of physical knowledge; it is precisely what physical knowledge as formulated in present-day theory states itself to be. In fundamental investigations the conception of group-structure appears quite explicitly as the starting point; and nowhere in the subsequent development do we admit material not derived from group structure. (142)

In light of our previous discussion of purely structural knowledge, we should already be cautious of Eddington's position. While for Russell we begin with sensa and through causal theory of perception we reach the mathematical properties of the external world, with Eddington's scientific epistemology, while we begin with experience—and I note that he too starts with sensa and observation—through discerning the group-theoretic character of our experience we can gain purely structural knowledge of physics. But recall the purpose of scientific epistemology: it is to investigate the net by which we gather experience like the ichthyologist gathers their sea life. So while for Russell we gain logico-mathematical knowledge of a world beyond our experience, an objective world, on Eddington's account we gain structural knowledge of the world, but of the world fundamentally as we must receive it. His a priorism cuts against empiricism: instead of experience being our main epistemic guide, it is only able

21. For Eddington's argument in full, cf. Eddington 1939, 139ff

22. This seems to be a place where Eddington diverges from his Kantian influence. Kant does not claim that our scientific knowledge is purely structural, nor that we seek to characterize the noumenal in structural terms. A transcendental argument concerning the structure and conditions of our experience is significantly different from an argument that claims physical knowledge is structural knowledge.

to exhibit the structure revealed by epistemological laws that are compulsory, universal, and exact.[23] Demopoulos' objection to the structural thesis impresses itself with full force. On the abstract conception of theories as he has explicated them, we lose the character of our theoretical claims being significant a posteriori discoveries. With Eddington's a priorism, we see a structuralist view that deliberately divests theoretical knowledge of its a posteriori character.[24]

2.4.2 Braithwaite and Solomon's criticism

Braithwaite's criticism of Eddington has a mocking tone to it, and the way he frames it, it is difficult not to be surprised by the view Eddington puts forward given that his a priorism is advanced around the middle of the twentieth century by someone who deeply understood 20th century physics.[25] In the previous section I tried to remain more charitable, but even so suggested grounds to be troubled by Eddington's view. Braithwaite's review criticizes Eddington's a priorism, as well as Eddington's approach itself. He raises several technical objections to Eddington, to which Eddington later responded. Those details are not so useful for the purpose at hand. Whether Eddington was justified in his epistemological considerations for using his chosen mathematical apparati, or whether it is as absurd as Braithwaite attempts to show (e.g., that we get the structure of the physical world out of the "rump" of the propositional calculus), is beside the point to understand the general view being put forward. Other than the admirably clear exposition of the main thread of Eddington's book, and indeed its situation in the context of Eddington's other physical and philosophical writings, Braithwaite applies Newman's objection to Eddington's structuralism. Eddington's subsequent rebuttal, that Newman's objection to Russell applies to a less sophisticated conception of structure than his own is a rebuttal recapitulated by later structuralist philosophers which through some appeal or other claim that they have a more refined notion of structure that is not subject to the Newman argument.

As I mentioned before, 2.1.1, Russell does not define his notion of structure, though he does refer the reader to his *Principia Mathematica* where his notion of structure is defined as a 'relation number'. Eddinton's suggestion that his notion of structure, which he defines to be group structure, is more sophisticated than Russell's, is misguided. While Russell did not appeal to group structure or any other algebraic structure specifically in his claims regarding structural knowledge, on Russell's account, groups, rings, what-have-you, could all be expressed using the apparatus of the 'relation number' since a relation number is essentially an isomorphism class of models (in the modern, model theoretic sense) of a system of relations. Group theory

23. Cf. (16) in the long quotation.

24. In a sense, of course, Eddington's argument escapes Demopoulos' objection, because Eddington apparently does not want to be an empiricist.

25. Unless, of course, one is not surprised by a priorism or Kantianism.

is just one example of the kinds of structure that could be characterized using the resources of *Principia Mathematica.* The following quotation from Solomon clears up some of the terminological issues, and, he notes as well that for physicists at the time Eddington was writing, group structure was taken as the paradigm abstract structure. The content in the quotation is attributed to personal correspondence between Wilfred Hodges and Solomon:

> Russell's concept of structure is to be distinguished from the concept of structure treated in textbooks like *Model Theory* (1973) by C.C. Chang and H.J. Keisler, and Jane Bridge's *Beginning Model Theory* (1977). In these texts, *structure* consists of a domain (a set of elements) and a family of indexed relations and functions on the domain. A *model* is a structure that belongs to a class of structures satisfying a set of (mathematical) laws that are expressed in some formal language. For Russell a *structure* (or, in *Principia Mathematica*, a *relation-number*) is an isomorphism type of systems of relations. A *system of relations* is very much like a model theoretical structure; the principal differences being that the domain of a system of relations need not be a set and that Russell has no concept of indexing the relations in the system. In model theoretic texts the set of indexes for a structure (model) is its *signature*. All structures in a class of structures have the same signature. Indexing is a useful notion, and one Russell would have no reason not to adopt. (Solomon 1989, 500)

The theory of groups is exactly the kind of structure that is treated in contemporary model theoretic texts. Moreover, in Russell's terminology, a particularly defined group is a system of relations, and the isomorphism class of that system is a structure in his sense. In the modern terminology, the defined group is a structure, a model thereof is a structure which satisfies the laws governing the group, and an isomorphism class is a class of models of the group structure, all of the same cardinality. Indeed, this is why it makes little sense to ask how many models exist for a given structure, but rather the meaningful question is how many isomorphism classes of models the structure has. These terminological issues are not just mere pedantry, but a bog through which the researcher needs to travel, without stepping off the paths and getting mired in confusion. Talk in modern, model-theoretic terms is apt,[26] since model theory arises precisely as the study of abstract structures and formal languages through which they are defined, and moreover, it abounds in meta-mathematical results of the kind so crucial to figures like Russel, Ramsey, Braithwaite, and Carnap. Kleene's veritable bible of mathematical logic *Introduction to Metamathematics* is itself instructive as it represents a clear point of transition where the

26. And should also be familiar from 2.2—I have deliberately framed things in modern model-theoretic terms for consistency with some of the best contemporary discussions of structure available.

terminology of systems is being couched in the more familiar terms of contemporary model theory.

The point at issue is not to defend model theory as the best methodological tool for philosophers of science or physicists; perhaps category theory is a better candidate for certain purposes. Or indeed, perhaps graph theory or Ramsey theory (the branch of pure mathematics which he also established bearing a close relationship to graph theory) are better tools for particular explicative purposes. Rather, the point is to highlight that appealing to a more sophisticated abstract structure (or in Eddington's case a token kind of abstract structure which is compatible with Russell's characterization) does not itself sidestep the epistemological considerations raised by Newman's criticism of Russell, nor Demopoulos' application thereof to the structuralist thesis. Braithwaite puts it thus when he criticizes Eddington's structuralism by invoking Newman: "[i]f Newman's conclusive criticism had received proper attention from philosophers, less nonsense would have been written during the last twelve years on the epistemological virtue of pure structure," (R. B. Braithwaite 1940, 463). In the over ninety years since Newman's criticism, and especially after Demopoulos' work, there has been an immense amount written defending the epistemological role of structure. I will not hazard to call it nonsense—at the worst, the attempts, even if they were to fail, and there is no consensus on that, shed more light on the assumptions implicit and consequences latent, in modern structuralism.

Solomon has pointed out, however, that Braithwaite's application of the Newman objection to Eddington is misguided. He argues, rightfully, that Newman's argument targets Russell's claim that our scientific knowledge beyond that which we experience is knowledge of pure structure, and moreover, a posteriori. By contrast, Eddington's epistemological deduction is an attempt to show that our knowledge of the physical universe is purely structural, and a priori. Obviously Eddington's position runs afoul of the pre-analytic intuition that our theoretical knowledge consists in genuine a posteriori discovery. Indeed, for Eddington, even though he says it is possible we could come to our physical laws a posteriori, his entire purpose, like that in the parable of the ichthyologist, is to deduce those same laws a priori. But in that context, the claim that our theoretical knowledge is one of structure does not need Newman's criticism. Newman showed that the a posteriori knowledge we gain on Russell's account is virtually null. With Eddington, we do not even need experience as our main epistemic guide. Of course, specific observations and specific instances of laws, on Eddington's account are found through experience. However, the character of our theoretical knowledge does not require experience; rather, his Kantian programme of scientific epistemology is supposed to give us the structure of the physical world a priori into which any experience is forced to fit.[27] Eddington only

27. Hence any contemporary commentator (e.g. French 2003) seeking to defend Eddington's structuralism

avoids Newman's objection to the extent that he gives up empiricism and the intuition that our theoretical claims constitute a posteriori knowledge; if he upheld the a posteriori character of theoretical knowledge, his choice of group theory as the paradigm of structure would not bypass Newman's claims in virtue of its complexity.

2.5 Newman's objection applied to Ramsey-sentence structures

It should be clear from the generality of the discussion that the push-through construction of 2.2.3 can be applied to a wide variety of structures. What is essential is that the map from one structure to another is a *structure preserving map*. For example, with sets, the map must be injective and surjective. Sets with relations defined on them, such as a group operation, need to be the kind of structure preserving map appropriate for group theory, i.e., (bijective) group homomorphisms. Indeed, the model theoretic standpoint taken in Demopoulos' work and most contemporary discussions show this nicely. In general the mathematical structures are sets with gadgetry and particular rules governing how that gadgetry works.[28] Model theory need not be privileged. Category theory also has impressive resources for considering structure and the transformation of structure (including preservation). But, the philosophical literature deals more with model theory regarding scientific theories than it does with category theory (though this is changing in some respects), and the model theory is more familiar for most audiences coming to grips with the philosophical issues, plus, as we saw in the pedestrian 2.2 it is rather straightforward to get to the substance of the argument. Model theory has the resources for the philosophical reflection on mathematical structure that is relevant, but I make no claim to its superiority to alternative approaches.

It should be clear, on the basis of how I (and any textbook) have defined languages and structures, that contra Eddington's claim, group theory does not present a more refined notion of structure which allows it to bypass the Newman objection. The push-through construction, for example, has been applied by Button and Walsh to set theories themselves. It should not be surprising then, with all the additional rules, axioms, relations and functions, that a Ramsey-sentence might involve, that the Newman objection applies here as well. Unlike Eddington, structural realists who advocate a Ramsey-sentence method generally appeal to a *more* complex structure than Eddington's identification of structure with group theoretic structure. Their notion is more in line with Russell's insofar as it is supposed to be the structure of the world be-

carries a heavy burden. They must either make peace with his a priorism and defend it, or find a way to salvage a meaningful structuralism from the wreck of Eddington's a priorism.

28. Cf. Geroch 1985.

yond our experience.[29] However, appealing to more complex structures, and Ramsey-sentences in particular, does not bypass Newman's claim.

Among the literature and the disputes they contain, Button and Walsh have recently given a general proof of Newman's objection applied to Ramsey-sentence structures. The technical details are important, but not for the main philosophical point. Rather than repeating the material they develop to provide the main theorem, I will describe it so that it is clear that Newman's objection does indeed apply to Ramsey-sentences. Simply stating the theorem without explaining all of their terminology will likely lend itself to confusion. Recall the very quick 'proof' given in 2.3.5. There I gave a quick sketch largely following Winnie's theorem's from his (1967). In his Theorem One, he showed how by keeping the observational part of the structure fixed, you could permute the theoretical portion, so that entities which in the first case satisfied the structural role of say electrons, in the permuted model, play the role of protons. His Theorem Two goes on to show how you can generate an arithmetical model of the Ramsey-sentence by assigning classes of numbers to the theoretical partition. Button and Walsh's theorem shows that for any structure represented by a Ramsey-sentence, you can generate a trivializing structure in the sense that there is always some set with cardinality κ such that κ is the cardinality of the relative complement of the observational partition in the domain.

In other words, you can always generate a model of the entire Ramsey-sentence, by defining the theoretical relations and functions appropriately in some set of sufficient size. While it is true that there is no obvious way to rule out arithmetical or unintended interpretations, and that Demopoulos recognizes this problem, the deeper problem which he, as well as Button and Walsh identify is that all it takes for a theory to be true over and above being empirically adequate (i.e., all statements about observable phenomena being true) is that there are enough unobservables. I should clarify something: Button and Walsh's theorem and discussion do coincide with the claim that theoretical truth collapses to model theoretic satisfiability. They, however, make the somewhat misleading claim (66) that the problem this poses is for the scientific or structural realist to somehow rule out the trivializing structures as unintended interpretations. This might be true, but it obscures the point that Demopoulos emphasizes more than ruling out unintended interpretations: it divests our theoretical knowledge of the character of significant a posteriori truths, insofar as the truth of our theory reduces to a claim that, we know from mathematical logic, is almost always satisfiable.

My main concern is not to defend Newman's objection; I think that the best characterization of it has been given, and that while there are interesting alternative approaches, such as with sorted languages, for example, I am not interested in defending Newman's claim. In other

29. I am aware that some structural realists, e.g. Elie Zahar and John Worrall, try to describe where Russell went wrong, but those subtleties do not clearly bypass the applicability of the Newman objection to their own position.

words, if after going through all the technical details given in *Philosophy and Model Theory* someone still does not accept the Newman objection, I do not believe any argument of the same kind will persuade them. In this case I think it owes something to the intuition, which I also hold, that there has to be a meaningful (i.e., non-trivial) way to understand structure, though I am persuaded by Demopoulos that it cannot serve the epistemological role that it is given in the structuralist thesis. It has been essential so far to be clear on the objection's origins and applications, but one of my main philosophical concerns is engaging Demopoulos' attribution of the structuralist thesis to Ramsey. For that purpose, the theorem itself is something like a ladder that can be thrown away once we begin dealing with other issues.

2.6 Summary

In this chapter we began by situating and exploring Newman's objection to Russell's structuralism in the context of Russell's causal theory of perception and analysis of propositional understanding in *The Analysis of Matter*. We proceeded in 2.3 to a critical exegesis of Demopoulos' "Three views of theoretical knowlege" in order to get a grasp on the general applicability of the Newman objection and to set the stage for later chapters for the exposition and reconstruction of Ramsey's view of scientific theories and Carnap's structuralism.

The target of Demopoulos' analysis is the structuralist thesis which he describes as underlying the views of theoretical knowledge advocated by Russell, Ramsey and Carnap. The commitments involved in the structuralist thesis result in any empiricist view built on the thesis violating our pre-analytic intuition that the truth of our theoretical claims are substantial a posteriori discoveries. They thus fail as a representation of our theoretical knowledge because the truth of our theoretical statements becomes a fact of the ambient set-theory or metalogic given only an assumption about the cardinality of the underlying domain. The positive research program Demopoulos' suggests is a framework based on Gupta's novel account of empiricism where the logical relationship between experience and knowledge is functional and not propositional. That is, one where the rational contribution of experience does not rely on a division of theoretical and observational language in which the observational component has an epistemic privilege. Rather, "[w]ithin this framework the contribution of experience to the semantic properties of observation terms is methodologically on a par with its contribution to theoretical terms" (Demopoulos 2012d, 167).

We proceeded in 2.4 to consider Eddington's characterization of 'scientific epistemology' and his structuralism to contrast with Russell's structuralism, and to show another application of Newman's objection. In 2.5 we saw the general applicability of the Newman objection to Ramsey-sentence structures. This emphasized Demopoulos' criticism of the structuralist

thesis by showing how easy it is to generate a trivializing structure for our claims to theoretical knowledge if we subscribe to that thesis. In the next chapter we turn to reconstructing Ramsey's theory of theories in order to claim that while the Ramsey-sentence has been taken up in the development of structuralism in the philosophy of science, Ramsey's own account of theories is not one which seeks to advance a structuralist position.

Chapter 3

Ramsey and Theories

It is clear that Ramsey's reflections on theories, near the end of his life, begin as a reaction to Russell. As in his "The Foundations of Mathematics," where he responded to Russell's logicism and project of logical construction by providing a type theory which simplified Russell's ramified theory of types, Ramsey's remarks on scientific theories begin by responding again to these aspects in Russell. In the fragment from Ramsey's Nachlass titled "Physics Says," he engages directly with Russell's *The Analysis of Matter.* Despite the various ends to which Ramsey's work has been applied, and the views that have been imputed to him, Braithwaite saw Ramsey as engaging Russell and exploring an alternative conception of theories and theoretical terms. Significantly, Braithwaite does not give any indication that Ramsey was advocating a kind of structuralism. Indeed, we have seen that Braithwaite not only understood Newman's objection to Russell, but advanced it against Eddington's structuralism. Of course, omissions are possible, but charity suggests that Braithwaite understood Ramsey to be developing something different from a structural explanation or characterization of the world beyond experience. The task of this chapter is to represent and "rationally reconstruct" Ramsey's work on the theory of theories.

This chapter begins by articulating the context of the fragment "Physics Says." Then, I provide an exegesis of the infamous paper "Theories." That exegesis is supported and further developed by an examination of "General Propositions and Causality" and "Causal Qualities," particularly in contrast with the view of theorizing in "Universals of Law and of Fact" which Ramsey explicitly abandons and replaces by the view in "General Propositions and Causality." While my main point is to exhibit that Ramsey is not advocating a structuralist program, I seek also to piece together Ramsey's "theory of science".

3.1 *Theories*

3.1.1 Responding to Russell: What Physics Says

Russell, within the span of a couple pages in the introduction to *The Analysis of Matter,* distinguishes two notions of truth, and adopts several assumptions about the nature of theories. In "Physics Says," Ramsey is prompted to respond to several of these aspects. Russell claims that apart from any philosophical issues concerning the meaning of truth, there is an ambiguity in the question whether physics is true. He claims that in "the narrowest sense, we may say that physics is "true" if we have the perceptions it leads us to expect" (Russell 1927, 8). Russell refers here to Leibniz, but we can also see that in this sense, the "truth" of physics is as compatible with idealism or solipcism as Newtonian mechanics is with Berkeley's idealism. Since, as Newman so cleary notes in his article, Russell is concerned to argue for a philosophical upshot of physics contra idealism and solipcism, Russell endorses a different notion of truth:

> This wider sense, which I regard as the more important, is as follows: Given physics as a deductive system, derived from certain hypotheses as to undefined terms do there exist particulars, or logical structures composed of particulars, which satisfy these hypotheses: If the answer is in the affirmative, then physics is completely "true." (8)

Notice that Russell equates the truth of physics in this wider sense with whether there exists particulars or logical structures composed thereof which satisfy the hypotheses of physics. This is the claim which Newman's objection has shown to be trivially satisfiable. Russell does go on to suggest that he thinks some notion of "event" will prove fundamental and it is the task of logic to construct out of events, the objects and relations required by mathematical physics. Altogether separate from any philosophical interest in his notion of event, the issue Russell frames is one of logical construction. We should also notice that Russell assumes that physics is a deductive system. Ramsey, despite exploring the deductive character of theories, in particular physics, considers them to be more than a deductive system.[1] "Physics Says" should be seen as Ramsey's first engagement with issues and questions which Russell set. Bearing this in mind, we can avoid the temptation to see Ramsey's remarks as advocating a kind of structuralism, or endorsing what Demopoulos calls the structuralist thesis. Instead we can see him as exploring Russell's suggestions, but in turn, dispensing with views of Russell's in favour of his own reflections on general propositions.

1. Hence Hempel's Theoretician's Dilemma could never be aptly applied to Ramsey's views since Ramsey rejected the idea that theories were only systematizations of experience for deduction.

Ramsey's understanding of Russell is captured in the following where he refers to the previous quotation:

> Physics says=is true if
>
> $$(\exists \alpha, \beta, \ldots R, S) : F(\alpha, \beta \ldots R, S \ldots) \qquad (1)$$
>
> Russell p. 8. (Ramsey, n.d., 251)

Immediately, we can notice a similarity to the Ramsey sentence as it is formulated in "Theories," because here, if we keep with the notation of *Principia Mathematica,* the Greek letters refer to class variables and the Latin letters refer to relations in extension. Coupled with Ramsey's comment regarding the Ramsey-sentence (Ramsey 1929d, 131) that its variables may be taken extensionally, we have in both instances an extensional characterization of what physics says. But the similarity between Ramsey's representation of Russell's view and the Ramsey-sentence should not be taken as an endorsement of Russell's view. In fact, Ramsey is defending the narrower sense of truth, contrary to Russell. That is, Russell demands for his notion of truth, that we are able to construct out of percepts (the basic logical events in his causal theory of perception) all the resources for a modern physical theory. It is remarkable that Russell was able to realize that a given abstract structure may be satisfied in various ways, and assert that we typically operate with an intended or "important" (Russell 1927, 5) interpretation, and yet he failed to notice Newman's point. Ramsey rejects that notion of interpretation and the wider sense of truth demanded by Russell.

> Of what sort is the argument for (1).
>
> "We must find an interpretation of physics which gives a due place to perceptions; if not, we have no right to appeal to empirical evidence", Russell p. 7.
>
> He does not really think we can find such an interpretation because the only R's with which we are acquainted in his view are compresence and time interval which are not enough."
>
> Say perhaps "partial interpretation" also perhaps some restriction on the interpretation of the other variables. i.e. all we know about β, S is not that they satisfy (1).
>
> Any evidence must give us not an interpretation exactly but a dictionary; it must be Physics $\supset$ I perceive p
>
> I perceive p
>
> $\therefore$ Physics

> In exact contradiction to Russell ps. 90ff.[2] (Ramsey, n.d., 251)

What is in exact contradiction to Russell is the notion of truth that Ramsey is suggesting. The quotation begins with Ramsey asking what Russell's argument is for requiring that the truth of physics depends on the existence of an appropriate (and appropriately constructed) logical structure. As an alternative, Ramsey tentatively proposes a partial interpretation, where instead of requiring an interpretation, let alone the "important" interpretation, we allow evidence to give us a dictionary. Notice, Ramsey understands that Russell thinks we can only bring empirical evidence to bear provided that we can construct our system out of percepts. On the contrary, Ramsey allows that we can have a partial interpretation of our theoretical system—that is, of those undefined terms which Russell is concerned to construct—whereby perception allows us to infer the broader physical theory we are considering. Ramsey's partial interpretation is intended to dispense with Russell's logical constructions. Ramsey obviously does not give any details here regarding the precise role of experience or the nature of the dictionary. But notice the pseudo-syllogism that he gives. Physics, or better yet, our theory under consideration, is taken as a hypothetical which, if true, entails that we have certain kinds of perceptions. Given that we have the perceptions we are led to expect on the assumption of the theory, we justify our assent to the theory. None of this inferential machinery, however, is suggested to give an epistemic account of the world beyond experience, nor make robust claims thereof to account for the "narrower" notion of truth which Ramsey adopts. As Ramsey must have known, this hypothetico-deductive argument is fallacious if taken in Russell's stronger sense. Hence Ramsey's use of the term "dictionary". He is telling you what "physics says" means instead of explaining its truth in Russell's sense.

I grant that this reading of Ramsey's brief remarks adds content to the skeletal statement he provides, but this reconstruction fits exactly with his later analysis of general propositions. Moreover, in "Theories" Ramsey characterizes a theoretical system and the role of general propositions therein. Under the interpretation, or rather extrapolation, I have just given, we see a continuous development to Ramsey's reflections on theories, as well as an integration of his theory of general propositions. In other words, while it is clear that this Nachlass fragment does not give us a precise characterization of Ramsey's thought, the reconstruction I have provided is continuous with Ramsey's subsequent development of these issues. Before turning to explicating those later contributions, several problems should be emphasized. Ramsey certainly is guilty of suggesting a partial interpretation. What is yet to be seen, however, is whether his notion of partial interpretation is as susceptible to Newman's objection as Demopoulos suggests. Is Ramsey, by advocating a partial interpretation, subscribing to the structuralist thesis? Or is

2. Cleary this is an error where Ramsey is referring to the discussion on page 8 and following.

he presenting a view which, because of having a partial interpretation, collapses our theoretical knowledge to a question of cardinality? The partial interpretation is effected by the dictionary: does Ramsey's use of the dictionary bring Newman-type worries against Ramsey, even if he rejects Russell's stronger sense of truth and logical construction? I think these questions can all be answered in the negative, but to see that we need to wade through Ramsey's investigations and the form of empiricism he develops.

3.1.2 Exegesis of *Theories*

Ramsey, unlike Russell, did not develop his account of theories to construct the world of physics from percepts, nor unlike Carnap, Ramsey did not develop the device of Ramsification in order to demarcate the analytic from the factual content of a theory. His goal, rather, appears to have been to shed light on how a theory functions and the role that theoretical terms play in it. There is textual evidence that in "Theories," Ramsey was concerned with the relation of a theory as a formalized language and particular properties thereof such as equivalence, containment, and definability. Indeed, he opens "Theories" with the thought that a theory is a language for expressing the facts the theory purportedly explains.

To ask whether a theory is a language raises further questions about the relations between realism and instrumentalism (and anti-realism) in the philosophy of science. In becoming clear on just what sort of language a theory would be if it is one at all, we might bring ourselves one step closer to answering whether we ought to understand our scientific theories instrumentally or realistically. Ramsey was not discussing these issues directly or in these terms in "Theories," but throughout the three papers "Theories", "General Propositions and Causality", and "Causal Qualities" there is evidence to conclusively show that Ramsey was not advocating anything like what we would now call scientific realism. This issue is taken up in 4.1. For the current exegesis of "Theories" the concern is to clarify how this paper is in part a continuation of Ramsey's response to Russell in "Physics Says." That is, it is an elaboration of the proposal he makes to considering a theory as a partial interpretation by means of a dictionary, for expressing the facts a theory leads us to expect. This reading of Ramsey is contrary to that which considers the Ramsey-sentence as a means of reconstructing our theoretical knowledge and eliminating theoretical vocabulary. We will see shortly that Ramsey addresses the question of elimination because it is an agenda set by others, but not something he claims as a desideratum for an analysis of theories. In most respects, Ramsey's investigation in this paper is logico-mathematical. That is, it is not driven by an eliminitavist, reductionist, or foundationalist motive. Notice in the passages to follow, just how carefully Ramsey adumbrates the issues he takes himself to be addressing, and notice especially that he is not suggesting Ramsification

is a complete *philosophical* analysis of a theory. It is worth emphasizing this now in order to frame, from the outset, that while Ramsey does recommend the Ramsey-sentence as the best way for writing a theory, that in no way needs to imply that he was proposing Ramsification as an epistemological or metaphysical analysis of our theoretical knowledge.

Theories and Languages

The paper "Theories" begins by suggesting that a theory be considered as a language.[3] After elaborating the parts of the theory-as-language, Ramsey goes on to develop a toy theory as an example of the construction. Once developed, he poses six questions, some of which are directed specifically to his toy theory, others directed to theories in general. Ramsey does not go so far as to suggest any of the now standard descriptions of a language structure as, say, an ordered triple of domain, relations, and distinguished elements. He does, however, take care to suggest desiderata that a formalization of a theory-as-language ought to meet. The paper is dense, and gives little by way of preamble. Moreover, littered throughout are remarks that suggest a concern for the application of his method. Nonetheless, a concern that the structure presented in the paper could be applied is no argument against a logico-mathematical reading, anymore than physicists using developments in pure mathematics in their work is an argument that the pure mathematicians were really concerned to give an explication of physics. The paper opens, with this suggestion:

> Let us try to describe a theory simply as a language for discussing the facts the theory is said to explain. This need not commit us on the philosophical question of whether a theory is only a language, but rather if we knew what sort of language it would be if it were one at all, we might be further towards discovering if it is one. We must try to make our account as general as possible, but we cannot be sure that we have in fact reached the most general type of theory, since the possible complication is infinite. (Ramsey 1929d, 112)

Three points can be readily taken away from this passage. First, Ramsey is making a proposal to *consider* a theory as a language—he is not claiming here that a theory *is* a language. Second, he is well aware that considering a theory as a language may not exhaust a correct philosophical account of the nature of theories. Third, at least part of the purpose in describing a theory as a language is to investigate what properties it would have, *qua* language, if it were one at all.

Leaving many of the technical details involving the toy theory aside, his discussion proceeds through considerations for formalizing a theory which is in some sense already given

3. This need not be taken as a mysterious turn of phrase. The simple idea is that a theory is a language (possibly a set of sentences) for expressing a particular empirical content. However, the devil is in the details.

to us. The general remarks begin by distinguishing a primary system, with its universe of discourse, from the secondary. The terms of the primary system are represented by numbers and the propositions by one-valued numerical functions. The secondary system introduces first new propositional functions, then axioms which are propositions about the values of the truth-functions of the secondary propositional functions. In addition there must be a dictionary giving definitions of the functions of the primary system in terms of those in the secondary. By considering the definitions as equivalences, Ramsey suggests that we can then derive propositions (presuming we have values as inputs for the propositions) in the primary system. These primary propositions are laws or consequences as whether they are respectively *general* or *singular*. Speaking about theories generally, Ramsey says:

> If we take it in its mathematical form we can explain the idea of a theory as follows: Instead of saying simply what we know about the values of the functions with which we are concerned, we say that they can be constructed in a definite way given by the dictionary out of functions satisfying certain conditions given by the axioms. (119)

The formalization of the theory reaches a point where it becomes self-contained as a deductive system. Here it is useful to contrast Frege and Hilbert. Frege held that the purpose of a deductive system was to determine the truths of a specific content matter. Hilbert on the contrary allows the content to be shed—at some point the actual content drops out and you are left with a system, where the reference of the system becomes irrelevant. Clearly, in its application to the world, a formalized theory is being used to deduce specific consequences about the world. On the other hand, this application need not preclude the possibility of other domains satisfying the structure in question. Ramsey is not suggesting that the content of an empirical theory be shed, but by examining a theory from the perspective of a language, we are viewing it schematically, and not with regard to any notion of an 'important' interpretation. Indeed, in the Nachalass fragment "Notes on Theories" Ramsey suggests that the idea the Ramsey-sentence appeals to is formal in Hilbert's sense, where, if the scheme is consistent it "can of course be constructed with numbers or anything else" (Ramsey 1929c, 229).[4]It is worth noting that the term 'system' was widely used by logicians until it was replaced by 'structure'. In many places, what Ramsey says about systems is parallel to what is discussed in terms of structure. Nonetheless, the mere fact that Ramsey is using the term 'system' is not sufficient to suggest he is advocating any kind of structuralism.

4. This fragment in the Nachlass is problematic. Galavotti notes that it was included in the archive with a note not in Ramsey's hand which says it was notes for the paper "Theories," whereas some internal evidence suggests that these are further thoughts on theories after the eponymous paper's composition. Having successfully convinced myself on different occasions that it is logically prior and posterior to "Theories," I refrain from drawing on it much at all. It also does not help that many statements in that collection are obscure or sentence fragments.

Question and Answer

Given this formulation of theories, Ramsey poses and gives answers to the following six questions about the nature of theories. Working through the connections between the answers helps to explicate his conception of the Ramsey-sentence.

1. Can we say anything in the language of this theory that we could not say without it? (Ramsey 1929d, 119)

2. Can we reproduce the structure of our theory by means of explicit definitions in the primary system? (120)

3. ...Is this necessary for the legitimate use of the theory? (129)

4. Taking it then that explicit definitions are not necessary, how are we to explain the functioning of our theory without them? (130)

5. What do we mean by speaking of equivalent or contradictory theories? Or by saying that one theory is contained in another, etc.? (132)

6. ...in what sort of theories [sic] does every 'proposition' of the secondary system have meaning in this [indirect] sense? (134)

Notice that it is not clear Ramsey intends these answers to generalize for all theories or only his toy theory. He explicitly says prior to the first question "before we go on to discuss systematically the different features of the example and whether they occur in any theory, let us take some questions that might be asked about theories and see how they would be answered in the present case," (119). There is no discussion of questions 1 and 2 to suggest or reject their generalization to all theories. Questions 5 and 6 are clearly the most general. Questions 3 and 4 seem somewhat in between. Ramsey answers the first question negatively, "for we can easily eliminate the functions of the second system and so say in the primary system all that the theory gives us" (119). If we grant that this is all the theory gives us and the elimination of the secondary system reduces the theory to its observational consequences, it becomes clear that Ramsey's investigation, while compatible with the later positivistic reductions of theories, is not motivated in order to produce such a reduction, nor is it clearly motivated as a reconstruction of our theoretical knowledge. That is, as I argue, his interest in theories lies elsewhere: in exhibiting the functional-role the theoretical terms play, when a theory is considered as a language.

With respect to the second question, Ramsey answers positively: we can always reproduce the structure of the theory by means of explicit definition. Sahlin gives a more detailed account

of how Ramsey uses the dictionary to answer the issue. For our concern we note that Ramsey asks the question of explicit definitions in the first place "because Russell, Whitehead, Nicod and Carnap all seem to suppose that we can and must do this" (120). That is, Ramsey is exploring an issue posed by the agenda of others, but doing so here in the logico-mathematical context of a theory-as-language. That we can always make these explicit definitions, however, does not show that it is necessary for us to do so, contra Russell et al., in order to legitimately use the theory. His exploration of how to explicitly define the secondary system in terms of the primary includes a passage where he countenances the arbitrariness of proceeding with explicit definition:

> Supposing the laws and consequences to be true, the facts of the primary system must be such as to allow functions to be defined with all the properties of those of the secondary system, and these give the solution to our problem. But the trouble is that the laws and consequences can be made true by a number of different sets of facts, corresponding to each of which we might have different definitions. So that our problem of finding a single set of definitions which will make the dictionary and axioms true is still unsolved. We can, however, at once solve it formally, by disjoining the sets of definitions previously obtained... (120)

From this remark, it is clear that Ramsey recognizes that the secondary system can be reconstructed in more than one way. As a result, the theory with the secondary system eliminated through explicit definition is not able to furnish a representation of our theoretical knowledge because the choice of giving just those explicit definitions is arbitrary, or if not strictly arbitrary,[5] compatible with alternative definitions. The formal solution to the problem is to take the logical sum of the sets of different definitions which correspond to the different sets of facts which make the laws and consequences true.[6] Considering the explicit definition as a logical sum is to say that among the disjoint sets of facts and corresponding definitions, one is true. Although Ramsey does not say it explicitly here, this is clearly what he has in mind based on his earlier work on propositional functions in extension:

> A logical sum is not like an algebraic sum; only a finite number of terms can have an algebraic sum, for an 'infinite sum' is really a limit. But the logical sum of a set of propositions is the proposition that these are not all false, and exists whether the set be finite or infinite. (Ramsey 1925, 219)

However, Ramsey is critical of this method of disjoining the possible definitions. First, the complexity of the disjunctive list is impractical for the actual use of the theory. More important,

5. Because of the mentioned conditions imposed by the primary system.
6. Note that more than one set of definitions may correspond to a given set of facts.

however, is that this way of explicitly defining the secondary system is arbitrary. The selection of which among the disjunctive set of definitions is the correct one is arbitrary insofar as the sets of definitions can be chosen in many ways. This charge of arbitrariness can be further formulated into the Newman-style triviality of the Ramsey-sentence after some preliminary groundwork is laid for the discussion of his fifth question.

After exploring other ways to explicitly define the terms of the secondary system Ramsey concludes that the position we are left in is very close, in terms of arbitrariness and complexity, to the general disjunctive definitions he first suggests. That is, we are unable to avoid a high degree of complexity generally. More significantly, it is not the case that the axioms and the dictionary are true whenever the theory is applicable by defining the propositions in the secondary system by their criteria in the primary, which is to say in accordance with the positivist verification principle. This latter point is significant because of the contrast that it draws with some later remarks in his discussion of the fifth question, where he seems to be endorsing a verification criterion for empirical significance. His rejection of the positivist attitude to empirical meaning in his discussion of explicit definition gives us reason to suspect that those later remarks are not to be read as a plea for verificationism.

Postponing for the moment the issue of verification and meaning, we can see that the answer to his third question is that it cannot be necessary to explicitly define the secondary system in order to genuinely *use* the theory. According to Ramsey, explicitly defining the secondary system would make the theory no use at all because any modification or addition to the definitions would alter the stock of definitions and their relations and hence we would not be able to account for a theory as something in a process of growth: "that is to say, if we proceed by explicit definition we cannot add to our theory without changing the definitions and so the meaning of the whole" (Ramsey 1929d, 230). This is a way of making the rather obvious point that when we take a given formal language $\mathcal{L}$ and make additions or modifications to it we end up, with a new language $\mathcal{L}'$. But it also clearly shows Ramsey's concern with a theory being something that we *use*. In line with what physics purportedly says, a theory must lead us to the experiences we expect, but also given that we actually use theories, that they must also be capable of growth and the accommodation of new facts.

We may now proceed to his fourth question where the several themes of the discussion connect. Here Ramsey gives the famous passage regarding how we are to best write our theories: "$(\exists\alpha,\beta,\gamma)$:dictionary $\cdot$ axioms" (131).[7] This notation means nothing more than what has already been described; the terms of the secondary system are replaced by higher order variables of the appropriate type and by way of the dictionary and axioms we may correlate the variables

7. Keeping with Ramsey's notation I use '$\cdot$' as a mark of conjunction when referring to formulae from his work.

with the terms of the primary system. This can all be taken extensionally and does not appeal to an intended or important interpretation. Historically, Ramsey developed his propositional functions in extension as a tool to resolve issues in the 1910 *Principia's* theory of types. In doing so he had to confront again the axiom of infinity. In contrast to his earlier work on the axiom, which is to be found in the archive of his notes, Ramsey employs his propositional functions in extension to analyse the axiom.[8] Setting the interesting questions about the axiom of infinity aside, we can understand the extensional propositional functions as mirroring the contrast between the logical understanding of a class and the mathematical understanding of a set. Following Demopoulos:

> If φ is extensional but not predicative, the class determined by φ is the class of all individuals a which φ maps to truths. Under an extensional understanding of propositional functions, there is not in general a correspondence between propositional functions and predicates of the language, so that the association with propositions is in this sense "arbitrary." It is also arbitrary in the stronger sense of allowing all possible pairings of individuals with truth values. (Demopoulos 2012a, 248)

My suggestion here is that at the time of writing "Theories" Ramsey could not have failed to recall the propositional functions in extension which he employed four years earlier. Taking $(\exists\alpha,\beta,\gamma)$*:dictionary* $\cdot$ *axioms* to be the best way to write our theory, it is clear that the dictionary is a set of equivalences between the primary and secondary systems. What Ramsey says here substantiates the connection to his earlier work on propositional extensional functions:

> Here it is evident that α,β,γ are to be taken purely extensionally. Their extensions may be filled with intensions or not, but this is irrelevant to what can be deduced in the primary system. (Ramsey 1929d, 131)

The remarks on the arbitrariness of the mapping of individuals to truth, that is, the arbitrary correspondence of individuals to propositions in line with the broader mathematical notion of set, would mean that no particular set of facts or definitions has priority over the others; the theory is, regarding the judgements we are to give through the laws and consequences, "simply a language in which they are clothed" (231). In this context it makes no sense to attribute to Ramsey any attempt to characterize our knowledge of unobservables, nor to attribute any realist notion of characterizing natural relations of the secondary system. Ramsey is explicitly highlighting the arbitrariness of any attempt to define the unobservables or theoretical entities

8. Michael Potter (Potter 2005) has determined this to have been written prior to Ramsey's essay "The Foundations of Mathematics."

by those of the primary system. If he could be considered at all as characterizing "theoretical knowledge" it is apparent that he is suggesting that what we know is a collection of singular and general propositions in the primary system relative to the overall formulation of the theory. That is, the most we can say is parallel to "Physics Says": given the assumption of a physical theory, we can expect to make given observations, and the realisation of those observations justifies our adherence to that theory.

When we examine the Ramsey sentence extensionally, the Newman style objection cannot fail to arise because, modulo an assumption about the cardinality of the domain, the functions in the Ramsey-sentence can map to any of the combinatorial possibilities of individuals to propositions in the secondary system.[9] In Ramsey's vocabulary, it is a matter of indifference which among the sets of definitions (the members of the logical sum) and facts satisfying them, we choose to be the interpretation of the theory because formally, they are all equivalent granting the cardinality of the domain. That is, they each represent the structure of the Ramsey-sentence.

By looking to the last questions Ramsey asks about theories, we find more evidence he would have reasonably been aware of the fault with the Ramsey-sentence as an account of theoretical knowledge. Through the entirety of the paper we see Ramsey grappling with logico-mathematical questions. These are questions which, in their way, foreshadow important discoveries in logic. For instance, Beth's definability theorem is a well-known basic result, which states (roughly) that if a term is implicitly definable, then it is explicitly definable.[10] Ramsey asks whether we can "reproduce the structure of our theory by means of explicit definitions within the primary system," (Ramsey 1929d, 220) and concludes, at least for the case of the toy theory that this is always possible. Similarly, when Ramsey asks whether we can say anything in the language of the theory that we could not say without it (219) is, as Suppe notes, an early statement of the non-creativity of explicit definitions (Newton-Smith 2000, 390). More interestingly, the fact that Ramsey was concerned with this kind of question indicates that he was thinking of the formalized theory as though it were an abstract structure, and the question of definability was one about preserving the structure itself.

The logico-mathematical aspect of Ramsey's thought in this paper appears most clearly at the end. There he is concerned with the relations between theories, in particular when they are equivalent or contradictory, or when one is contained in another. Ramsey distinguishes here between two aspects of a theory: its symbolic form, and its meaning or content. Leaving aside the question of symbolic form, Ramsey claims that "[t]wo theories are called *equivalent*

9. Recall that the permutation argument for the observable part of the domain is the identity map.

10. For relevant, precise statements of theorems, see texts such as *Model Theory* or *A Course in Mathematical Logic.*

if they have the same content, *contradictory* if they have contradictory contents, *compatible* if their contents are compatible, and theory A is said to be *contained* in theory B if A's content is contained in B's content," (Ramsey 1929d, 233). These same questions appear in all virtually all model theory texts. Consider, for instance, Robinson's Consistency Theorem to the effect that two theories, Σ and Π are consistent with one another provided that there is no sentence ϑ such that $\Sigma \models \vartheta$ and $\Pi \models \neg\vartheta$. Of course, discussions of substructures and embeddings parallel the idea that a theory A's content is contained in a theory B's content.[11] Moreover, English 1973 and Demopoulos 2012 have both shown that under Ramsification, two theories cannot have equivalent primary systems and incompatible secondary systems.[12] In other words, if there are two secondary systems Γ, Δ both of which share a primary system Υ, then Γ may be eliminated and stated in terms of Υ. Then via the appropriate dictionary transformed into Δ. And conversely for the translation of Δ into Γ. Likewise Ramsey himself seems to have understood something like this point because when considering equivalent theories, he acknowledges that the functions of A could be definable in terms of B (or conversely) because "each set of functions *can* be defined in terms of the primary system and therefore of those of the other secondary system *via* the dictionary" (233).

So far I have claimed that Ramsey's consideration of theories consists in the technical or formal investigation of the response to Russell outlined at the end of his "Physics Says," and that response necessarily includes addressing issues like explicit definition as part of the agenda set by Russell and contemporaries. This stands in contrast to the view that sees Ramsey as engaged in a project where the elimination of theoretical vocabulary by means of Ramsification is both a philosophical account of the nature of scientific theories, and a way of reconstructing our knowledge as given to us by a theory. On the contrary, there are considerations that show that the project in "Theories" is a restricted project analyzing a particular conception of theories, but does not purport to be an exhaustive articulation of Ramsey's view on theories. Indeed, the theory of science Ramsey was developing can hardly be called a completed view. When considered as an epistemological tool, namely as a rational reconstruction of our knowledge in science of the world beyond experience, Newman's objection contra Russell comes into force. The benefit of understanding Ramsey as exploring the logico-mathematical properties of his response to Russell, is that much of the bite is taken out of Newman's objection—Ramsey's rejection of Russell's stronger notion truth and of logical construction should warn us at the outset that he is not trying to give a structuralist reconstruction of physics. Indeed, Newman's objec-

11. Detailed discussion of Ramsey-sentences and elementary substructures can be found in van Benthem 1978.

12. Demopoulos thinks that English misattributes to Robinson's theorem what should be attributed to Craig's. English's reasoning, however, is correct. Robinson's theorem can be proved independently of Craig's lemma, whence the latter comes as a corollary. Likewise, Craig's lemma can proven independently of Robinson's theorem and then used to derive it.

tion is rendered an observation if Ramsey is not trying to give an epistemological-structuralist explication of theory. Ramsey can give an account of the functional role of theoretical terms in empirical judgements without committing himself to a particular epistemological thesis regarding the world beyond experience.

The contrast between these ways of considering Ramsification, or more minimally, Ramsey's discussion of theories as languages, can be illustrated by what Kleene calls the "full picture" (Kleene 1952, 65) of the formalization of a theory. Kleene is, of course, obviously discussing mathematical theories, but the distinctions apply nicely here. In the full picture there are three distinct "theories" involved in any formalization. There is the informal or pre-formalized theory with which we begin. Moreover, there is the formalized theory, which is the result of formalizing the informal theory. There is also the metatheory, which is the theory in which the formal system and its properties are investigated. Considering Ramsey's remarks involves identifying Ramsification as part of the formalization of our pre-formal theory. Once the theory is formalized, we can ask specific questions about the relations internal to that system, such as for example deriving laws and consequences in the primary system. In that sense, the formal system has become self-contained as a deductive system. Understanding that formal system, in turn, as a structure, and investigating the properties that it has such as theoretical equivalence, translation, definability, consistency, and containment, are all aspects of the metatheory, or rather, logico-mathematic considerations that bear on the various properties of the given formal system as a system. This tripartite distinction then, gives a richer picture of Ramsey's investigation of theories than an account which places his view and the Ramsification of a theory in the tradition of rational reconstruction or the abstract view of theories characterized by Demopoulos.

There is no direct evidence that Ramsey was considering a Newman–style objection to his work. However, we have good reason to think that Ramsey was aware of similar (if not actually the same) issues because his remarks show that he was concerned by the arbitrary correspondence of the sets of definitions in the Ramsey sentence of a theory. Moreover, even if he was not directly considering the defects of a structural explanation of theoretical knowledge, there is sufficient evidence to show that most of Ramsey's concerns in "Theories" were logico-mathematical, and stimulated in response to the agenda set by Russell. These considerations raise the prior question that given the arbitrariness of the Ramsey method, and thereby its inability to significantly serve as an epistemological explication of our empirical knowledge, what, exactly was Ramsey's motivation in urging the method of the Ramsey-sentence if it was not to represent our empirical knowledge through theory? Was it only to address questions of formalization and meta-theory?

I suggest that Ramsey was motivated to claim that $(\exists\alpha,\beta,\gamma)$*:dictionary* $\cdot$ *axioms* is the best

way to write our theories because it serves to demystify[13] the relationship between the secondary and primary systems, and thereby the secondary system itself through the clarification of that relationship. His discussion of the meaning of the theoretical terms has many connections with his attitude toward the meaning of general propositions, causal laws, and tautologies. Those interesting issues have to be temporarily set to one side, however, in order to expose the role that the Ramsey sentence plays in Ramsey's elaboration of *his* notion of partial interpretation. The method of Ramsification, in effect, amounts to an explication of the relation of the primary and the secondary systems because it yields a representation of the theory in which the functional role, or better yet the inferential role of the theoretical system is apparent.

The following discussion addresses how Ramsey's understanding of additions to our theories helps us better explain this role of demystification. I have already discussed, in the context of explicit definitions, how no modification or addition could be made to the definitions without changing the meaning of the whole. This consideration is apparent when Ramsey discusses the theoretical and practical differences of adding an axiom to the theory:

> Any additions to the theory, whether in the form of new axioms or particular assertions like $\alpha(0,3)$,[14] are to be made within the scope of the original α, β, γ. They are not, therefore strictly propositions by themselves just as the different sentences in a story beginning 'Once upon a time' have not complete meanings and so are not propositions by themselves. (Ramsey 1929d, 131)

The "theoretical difference" is that when we ask for the meaning of the addition, that meaning can only be given if we know the stock of 'propositions' of both the primary and secondary systems to which the addition is to be made. The meaning is the resulting difference in the primary system (its effect on the observational consequences) between $(\exists\alpha, \beta, \gamma)$*:stock* and $(\exists\alpha, \beta, \gamma)$*:stock* $\cdot$*addition*.[15]

The "practical difference" is to adopt an attitude toward the addition which is different than the attitude which we take to a genuine proposition.[16] Ramsey's attitude is to withhold from making the addition whenever we may do so in our theory, that is, whenever the truth of the addition is compatible with the truth of the $(\exists\alpha, \beta, \gamma)$*:stock*. It might be the case that the negation of the addition is likewise compatible with $(\exists\alpha, \beta, \gamma)$*:stock*. Hence, we must also consider what other future additions we might wish to make to our theory and whether our

13. In contrast to Carnap's project of eliminating the secondary vocabulary.

14. This is a reference to his toy theory he was using as an example.

15. A way to understand this is by analogy with Carnap's meaning postulate approach: by adding a meaning postulate φ to a language system $\mathcal{L}$ we possibly obtain a different set of derivable (analytic) consequences in $\mathcal{L} \cup \varphi$ from those which were derivable in $\mathcal{L}$ alone, (cf. Winnie 1970).

16. We will see more about genuine propositions in the next section.

addition is liable to be more suitable than its negation. We adopt an attitude where we refrain from making the addition (or its negation) because we hope that experience will lead us to formulating a new law as opposed to deciding arbitrarily what additions to make to our system.

Given that the propositions of the secondary system are not complete in themselves but depend on the meaning of the whole, Ramsey makes a remark which anticipates Carnap's internal-external distinction. Working from his metaphor about characters in a story, Ramsey claims that there is no problem with these propositions being incomplete as long as any of the modifications are seen as taking part within the original story, i.e., within the scope of the existential quantifiers of the Ramsey sentence: $(\exists\alpha, \beta, \gamma)$. He says, famously, "that the incompleteness of the 'propositions' of the secondary system affects our disputes but not our reasoning" (Ramsey 1929d, 132). The disputes are those questions which can be asked meaningfully internal to a given theory—where within the scope of the prefix all the logical combinations take place. Our reasoning on the other hand includes the principals and framework in which we make the inferential connections. Disputes need not be resolvable within the theory merely by reasoning from established principles of the theory. There are examples in "General Propositions and Causality" where Ramsey considers ways in which people might disagree but which do not take the form of one asserting p and the other $\neg p$. The important contrast is between questions which are posed within a theoretical framework and questions about the framework or its principles themselves. By way of contrast one could consider the axioms and rules of inference of a logical system on analogy with reasoning, and whether a particular proposition is deducible therefrom on analogy with disputes. As Ramsey notes, our reasoning is unaffected by the incompleteness of the secondary propositions, "for we can reason about the characters in a story just as well as if they were really identified, provided we don't take part of what we say as about one story, part about another" (132), but our disputes crucially depend on the collection of propositions that can be inferred from the theory. While this raises the problem whether there is a way to affirm that a story is the right one, or better than another, we can ignore this otherwise important question as tangential to Ramsey's explication of a theory as a language.[17]

The role of the Ramsey-sentence as a demystification of the theoretical system is thereby made apparent. Ramsification allows us to determine the meaning, or more precisely the interrelationships, of the primary and secondary systems of a given theory and the functional role of theoretical terms and propositions. This is aptly represented by the theoretical difference that adding an axiom or particular assertion makes. The addition must be understood as taking

17. That is, as tangential specifically to the explication of a theory as a language per the discussion in "Theories"; we will see in Ch 4, that Ramsey faces this philosophical challenge rather well in relation to his broader theory of science.

place within the scope of the quantification for the theory as a whole. Moreover, the practical difference is that we must understand the additions or modifications to our theory in light of other future additions we might want to make. More significantly, when considering an addition or modification, we should do so with an eye to generating laws on the basis of empirical experience as opposed to an arbitrary choice when two alternatives are equally compatible with a theory.[18] Furthermore, we do not see a need in Ramsey's account for an "absolute" notion of the primary system, as we would regarding Russell's criterion of knowledge by acquaintance. 'Primary' and 'Secondary' can be reasonably construed as a relative distinction,[19] where we have a some primary system, e.g. the relative motions of the observable bodies in the solar system, and a target theoretical system, e.g. the causal and dynamical information to be deduced from the aforementioned 'primary' phenomena. Ramsey's own toy theory, it should be remarked, does not mark a strict line between acquaintance or sensation and the theoretical—both systems relate to unproblematically observable conditions.

3.2 General Propositions, Causal Considerations

3.2.1 "General Propositions and Causality"

Ramsey's "General Propositions and Causality" poses several interpretive problems which I suggest can be resolved by framing it in the context of a development of a broader view of Ramsey's philosophy of science, and thereby situating it in the context of "Physics Says," "Theories," "Causal Qualities," and "Universals of Law and of Fact." First, it is among the collection of 'Last Papers' in the Braithwaite edition of *The Foundations of Mathematics and Other Logical Essays* where it is suggested Ramsey was writing for himself, rather than preparing a manuscript for publication: there is some question regarding the exact motivation and argument structure. Second, for adapting it to present purposes it is not clear that this is meant to be part of an argument or characterization of his views in the philosophy of science. Sahlin (1990), for instance, treats this paper separately from Ramsey's account in "Theories," but he recognizes that Ramsey is using concepts there which he critically elaborates in "General Propositions and Causality." I claim that it is correct to emphasize the connections between these papers as elaborating Ramsey's views on theories, especially given the contrast between Ramsey's earlier view of general propositions *and* of theories in "Universals of Law and of Fact" which he explicitly rejects and reevaluates here. Nonetheless, while Ramsey certainly is engaging with concepts, specifically that of causal necessity and causal laws, that are part of

18. That is, when our theory is compatible with the addition of either φ or $\neg\varphi$.

19. We could perhaps usefully compare it to the relative notions of the a priori or analytic in Carnap's thought where those notions are relative to a given framework.

the philosophy of science, he is approaching them here not primarily as a philosophical treatment of scientific theories, but from a theory of belief and propositional attitudes. It *might* be appropriate to say, that insofar as he is analysing causal laws and necessity from a theory of belief, he is giving an account of scientific *theorizing*, but it is clear in the paper that his account is meant to have a broader scope than scientific theories. On the other hand, he does refer specifically to his 'theory of science' and the examples of causal laws do make the connection to scientific theory explicit (though, they indicate as much applicability to psychology as to physics).[20] Hence, while the view Ramsey develops applies to general propositions *in general*, it is crucial to understanding his approach to theories to understand the role of general propositions therein. I claim that the considerations Ramsey develops concerning general propositions here serve as an elucidation of the role that general propositions play in our reasoning regarding the phenomena our theory seeks to explain.

It is not clear that Ramsey had a mature, or definitive view on these issues; they could equally be taken to be probative and exploratory attempts to elucidate the problems he addresses, but there is evidence that he clearly was developing what he calls a "theory of science." Indeed, it is more plausible that Ramsey's views were under ongoing development. Nevertheless, that development does not give sufficient reason to think that Ramsey was proposing a structuralist view of theories. It is worth mentioning that Ramsey's thoughts on chance and probability have a prominent place in "General Propositions and Causality," but because Demopoulos' application of the Newman objection to his reconstruction of Ramsey and the extension to contemporary forms of structuralism bypass these views entirely, we can sidestep them as well. This is not, however, to say that an adequate theory of theories may not require an account of belief and probability in some fundamental way, but rather that the account of the world beyond experience, as given by a theory and theoretical terms, does not obviously need to wade into any of the problems in the philosophy of probability. Sahlin (Sahlin 1990, 112ff) contextualizes how "General Propositions and Causality" can be added to Ramsey's philosophy of probability. In note (2) of this paper, Ramsey himself suggests that "[c]hance and law are used in the same way in a theoretical system as in a primary system," and also, in note (1) that "[a]ll theories, chances and laws are constructed with a view to supplementation by discovery of further facts…" (Ramsey 1929b, 162). This suggests that chance, at least with respect to a theory of science, can be considered in the same way as laws with respect to their role in theories. Minimally, since the issues with probability arise in the same way in Ramsey's primary and secondary systems, i.e., insofar as general propositions occur in both, any special philosophical problems in probability are applicable to both domains and need not

20. Sahlin gives examples in his discussion of framing Ramsey's economic theory in the context of Ramsification. This suggests how Ramsey's insights are certainly much more broadly applicable than only to physics.

be an obstacle to understanding the relation between and philosophical explication of the two systems.

Ramsey's argument touches on a variety of conditional statements, what it means to reject them or disagree, general propositions, realism in science, necessity, and causality. His analysis of causal laws proceeds from a analysis of a kind of general proposition which he labels a 'variable hypothetical'. He concludes that causal necessity is not a fact, and the assertion of a law is the assertion of a variable hypothetical. Strictly speaking, he concludes that a variable hypothetical is not a proposition, but rather like a *schema* for deriving propositions.

> On the view that we have been explaining, causal necessity is not a fact; when we assert a causal law we are asserting not a fact, not an infinite conjunction, nor a connection of universals, but a variable hypothetical which is not strictly a proposition at all, but a formula from which we derive propositions. (159)

Notice that causal laws in Newtonian physics seem to exemplify this: we are given an abstract/schematic account of how to determine the forces in an interaction. We are not told that there are such forces, nor the causal mechanism; rather, we are told that if there are any forces at all as described within the theoretical framework of the laws of motion, we can go about determining them on the basis of the observed relative motions. Notice as well, that describing causal laws as variable hypotheticals, and hence as judgements on Ramsey's account, we see a point of similarity with Gupta's approach to the given in experience as a judgement relative to a background view.

Ramsey claims that general propositions come in two kinds: conjunctions, and variable hypotheticals. Those that are conjunctions, on his analysis, are general statements which we would now say have bounded universal quantifiers. His example is 'Everyone in Cambridge voted' and he suggests that the variable is not people in Cambridge, but rather a restricted region that is relative to the intended definiteness of 'Cambridge'. Variable hypotheticals, by contrast appear to be what we would now describe as having unbounded universal quantifiers—e.g. $\forall x(\phi x \longrightarrow \psi x)$—and Ramsey denies that these could be conjunctions.[21] It is important to note two points regarding the analysis so far. First, Ramsey is engaging a topic that had contemporary interest, as there was debate regarding the meaning of quantifiers among the logicians of his day; he is not broaching the topic without any precedent. Second, Ramsey's

21. This denial of universal quantification as an infinite conjunction could be taken as a consideration against infinitary languages. I do not know of any place where Ramsey considers such a language, but clearly Ramsey could, as a philosopher of science and as an epistemologist, deny such constructions for particular areas of inquiry, but entertain the idea as a mathematician. This is to say that I think his remarks on quantification here should be used only very cautiously in regard to understanding the late developments in Ramsey's philosophy of mathematics.

analysis of general propositions need not be correct, rather all we need is to *understand* his claims regarding them so that we can understand the role they play in his thinking about the philosophy of science. This latter is simply to recognize that philosophical issues surrounding counterfactuals, as well as laws, persist and have a dedicated literature whose concerns well exceed Ramsey's remarks.

Granting that a variable hypothetical is not a proposition, Ramsey poses how one can be right or wrong. He notes that many sentences can express cognitive attitudes without being propositions. Ramsey analyzes variable hypotheticals as a kind of habit or disposition. The following passage is the clearest statement of Ramsey's position:

> Variable hypotheticals are not judgments [sic] but rules for judging 'If I meet a ϕ, I shall regard it as ψ. This cannot be *negated* but it can be *disagreed* with by one who does not adopt it. (Ramsey 1929b, 149)

There is not a lot by way of argument leading up to Ramsey's view. Much of the rest of the paper involves his responses to anticipated objections, and giving examples of the way in which speakers can disagree. The second part of the paper does take up the issue whether "causation is a reality or a fiction; and, if a fiction, is it useful or misleading, arbitary [sic] or indispensable?" (153). He rejects a realistic view of causality, however, denying a 'real connection of universals' as nonsense, and, he also rejects the analysis of a causal law as an infinite conjunction. Ramsey explains away causality this way:

> The world, or rather that part of it which we are acquainted, exhibits as we must all agree a good deal of regularity of succession. I contend over and above that it exhibits no feature called causal necessity, but that we make sentences called causal laws from which (i.e. having made which) we proceed to actions and propositions connected with them in a certain way, and say that a fact asserted in a proposition which is an instance of causal law is a case of causal necessity. This is a regular feature of our conduct, a part of the general regularity of things; as always there is nothing beyond the regularity to be called causality, but we can again make a variable hypothetical about this conduct of ours and speak of it as an instance of causality. (160)

If "General Propositions and Causality" is obscured by the various considerations and assessments of a variety of conditional statements, the two points that need to be taken away regarding the philosophy of science are the rejection of a realist view of causality, and the emphasis on laws being not judgements, but schemata for judging. Ramsey's "Causal Qualities," despite its brevity, more clearly emphasizes connections in the philosophy of science. Indeed, it sheds light on those two key points made in Ramsey's analysis of variable hypotheticals.

3.2.2 "Causal Qualities"

"Causal Qualities" is peculiar insofar as Braithwaite and Mellor, in their respective edition of Ramsey's papers, locate its relevance differently. Braithwaite places it among Ramsey's last papers, following "General Propositions and Causality" and other papers, presumably because of its emphasis on causal laws and the notion of a variable hypothetical, which are introduced and systematically discussed in "General Propositions and Causality." Mellor, by contrast, claims that "Causal Qualities" is a postscript to "Theories," since it deals explicitly with scientific concepts. I suggest that its most fruitful to read "Causal Qualities" juxtaposed with both papers for mutual clarification. In these notes Ramsey considers issues of definition with respect to particular terms. He again utilizes the distinction between a primary and secondary system. Here, however, he notes that primary system is dealt with as part of a *fictitious* secondary system, which allows both fictitious qualities and fictitious entities. There is no difference between singular propositions of the primary system and singular propositions of the secondary system: they are both believed with various degrees of probability. He claims that in singular propositions, the fictitiousness is ignored when we reason with them. The difference between singular propositions of the primary and secondary systems is that "we are not ultimately interested in fictitious propositions, but use them merely as intermediaries: we do not care about them for their own sake" (Ramsey 1929a, 260). General propositions in the secondary system, on the contrary, are just like variable hypotheticals (and as he discusses in "General Propositions and Causality," so too just like chances).

Ramsey makes one of his most explicit statements regarding what we would call his theory of theories: "A theory is a way of saying the primary propositions and the variable hypotheticals that follow from it" (260). This remark might seem peculiar; recall in "Theories" that Ramsey does not think that a theory needs to explicitly define away its theoretical terms in order to be properly used. Here, he seems to suggest that the theoretical aspect of the theory is only of use for expressing propositions of the primary system. This reading would be too quick: because Ramsey claims we treat general propositions of the secondary system just like variable hypotheticals—indeed, following from his analysis of general propositions, they *are* variable hypotheticals—a theory then is a way of saying both singular primary propositions, and variable hypotheticals of *either* system (the singular propositions of the secondary system are inferential intermediaries). This implies that the variable hypotheticals of the secondary system are crucial for imposing the connections in the primary by way of which we can arrive at singular propositions of the primary system. Ramsey is moreover explicit in his analysis of general propositions that they are not superfluous, but rather essential to our thinking (Ramsey 1929b, 153). In order to remain consistent, then, Ramsey cannot suggest that the general propositions of the secondary system ought to be eliminated, or subscribe to reductionism, that

infamous second dogma of empiricism. In this regard, his account of scientific theories stands apart from forms of logical positivism which sought to reduce a theory to its observational system.

Here, as in the case of causal laws, Ramsey dismisses the realism with respect to theoretical terms. He considers this kind of realism "foolish" and that asserting the existence of a theoretical term, like the quality 'mass', "is nonsense unless it means merely to affirm the consequences of a mechanical theory" (Ramsey 1929a, 138). His attitude can be at least partially explained in this remark:

> No proposition of the secondary system can be understood apart from the whole theory to which it belongs. If a man says, 'Zeus hurls thunderbolts', that is not nonsense because Zeus does not appear in my theory. I have to consider it as part of a theory and attend its consequences, e.g. that sacrifices will bring the thunderbolts to an end. (137)

Ramsey is suggesting that Zeus and his thunderbolts are meaningful relative to the theory in which they appear, and more specifically to the consequences of that theory. In the same way he suggests that asserting the existence of mass means affirming the consequences of a mechanical theory. The claim that understanding a proposition from the secondary system requires the theory as a whole, coupled with Ramsey's rejection of realism about theoretical terms, suggests an almost Hilbertian attitude. That is, rather than trying to refer to entities which lie beyond our experience, the meaning of the theoretical terms come from the theory itself. Of course, this clearly is an extension of Ramsey's claims, but it suggests a plausible analysis: the terms and propositions of the secondary system are meaningful in virtue of the axioms of the theory and the systems of laws and consequences connecting them to the primary system. In this sense, theoretical terms are defined by the theory, and not by any images or associations we have.

3.2.3 Drawing Together

We can draw these various threads together by contrasting Ramsey's view of theories and general propositions in "Universals of Law and of Fact." There, he is concerned with determining a difference between between universals of law, and those of fact. In "General Propositions and Causality" he dispenses with demarcating that distinction, and as we saw, focuses on developing his notion that general propositions are not propositions at all, but rather variable hypotheticals, which upon analysis, are like schemata for making judgements. Running through these three papers is a concern for understanding causal laws, and as Ramsey puts it,

"whether causation is a reality or a fiction..." (Ramsey 1929b, 153). In that regard, while Mellor considers "Causal Qualities" to be an addendum to "Theories," we can see that its content is shared between the main concern expressed through the papers focused on variable hypotheticals and causation, as well as the issues in "Theories" for understanding a theory as a language, where, just before the close, Ramsey claims that causal axioms belong to the secondary system and must be put into the theory. Clearly, then, it makes sense to consider the papers together. But doing so allows us to see explicitly a view of theories and an interpretation of "Theories" which he now clearly rejects. In "Universals of Law and of Fact" Ramsey criticized Braithwaite's view that universals of law are general statements believed on non-demonstrative grounds. In "General Propositions and Causality," he repeats his criticism of Braithwaite, but he also rejects his own earlier position:

> I, therefore, put up a different theory by which causal laws were consequences of those propositions which we should take as axioms if we knew everything and organized it as simply as possible in a deductive system.
>
> What is said above[22] means, of course, a complete rejection of this view (for it is impossible to know everything and organize it in a deductive system) and a return to something nearer Braithwaite's. (150)

After this, Ramsey turns to giving an account of what we mean when we talk of an unknown law of nature. He draws a comparison to the finitist theory of mathematics regarding unknown true mathematical propositions. For someone to say that a new theorem has been proven, means that someone has constructed a proof of a certain limited size. Similarly, "an unknown truth in the theory of numbers cannot be interpreted as an (unknown) proposition true of all numbers, but as one proved or provable," (151). Here, provability is being taken as a kind of limitation imposed on the assertion of the existence of a true mathematical proposition. In the case of an unknown causal law, Ramsey asks what corresponds to the process of proof which holds in the mathematical case. His solution is the following:

> Clearly only the process of collecting evidence for the causal law, and to say that there is such a law, though we don't know it, must mean that there are such singular facts in some limited sphere (a disjunction) as would lead us, did we know them, to assert a variable hypothetical. But this is not enough, for there must not merely be facts leading to the generalization, but this when made must not mislead us. (Or we could not call it a true causal law.) It must therefore also be asserted to hold within a certain limited region taken to be the scope of our possible experience.

22. That is, in his reflections in the paper up to this point.

> There was nothing corresponding to this in the mathematical case, for a mathematical generalization must if proved hold in any particular case, but an empirical generalization cannot be proved; and for there to be evidence leading to it and for it to hold in other cases also are separate facts. (Ramsey 1929b, 152)

Recall in "Theories" where Ramsey discusses the addition of a new axiom or assertion to the theory. There, both a theoretical and a practical difference were made by adding an assertion. The theoretical difference is between the consequences of the theory before and after the addition. But the practical difference is to "adopt an attitude rather different from that which we should adopt to a genuine proposition" (Ramsey 1929d, 131). In this case, the addition is not a genuine proposition because it does not have a complete meaning independent of the theory and the stock of propositions the theory already contains. That is, there is a kind of meaning holism involved with the interrelated definitions and propositions of the theory, much as in the sense of a Hilbertian scheme. Moreover, the crucial point is that Ramsey encourages us not simply to make an addition when it is compatible with a theory, but rather, in keeping with his description of collecting evidence for a causal law, we wait and "hope from observed instances to find a law and then to fill in the unobserved ones [i.e. instances][23]according to that law, not at random beforehand" (132).

It is clear then that Ramsey considers a theory to be something more than a deductive system for organizing known facts as simply as possible. In both "Theories" and his notes at the end of "General Propositions and Causality" he asserts the importance of a theory being capable of growth. Describing his view he says the following:

> (5) As opposed to a purely *descriptive* theory of science, mine may be called a *forecasting* theory. To regard a law as a summary of certain facts seems to me inadequate; it is also an attitude of expectation for the future. The difference is clearest in regard to chances; the facts summarized do not preclude an equal chance for a coincidence which would be summarized by and, indeed, lead to a quite different theory. (Ramsey 1929b, 163).

Not only must a theory be capable of growth—something which would be lost if it were necessary to explicitly define the secondary system—but that growth is methodologically connected to our ability to not simply collect facts and form new generalizations, or new hypotheses, but more precisely to our ability to assert a variable hypothetical on the basis of singular facts in some limited sphere *and* that this generalization must not mislead us within the scope of our future experience. Theoretical terms, like variable hypotheticals generally, are crucial to our

23. The parenthetical remark is mine.

thinking, and moreover, crucial to our ability to form the judgements pertaining to the consequences of the primary system. While the analysis Ramsey gives in "General Propositions and Causality" is meant to apply to how we reason with variable hypotheticals in general, and not exclusively in scientific theorizing, the case of disagreement in the context of theorizing might seem problematic. In fact, I think that its exploration elucidates the role variable hypotheticals play in our scientific theorizing.

Recall that variable hypotheticals are found in both the primary and secondary systems. I suggested in §3.2 that we see a nascent form of the internal–external distinction when Ramsey remarks that the incompleteness of the meaning of secondary 'propositions' affects our disputes but not our reasoning. On that analysis, disputes are issues posed within a theoretical (or conceptual) framework, and our reasoning involves the principles of the framework itself. But, variable hypotheticals are described as inferential schemata: as formulae from which we derive propositions or as rules for judging. It would appear then, that variable hypotheticals belong to the framework of our reasoning. As part of our reasoning, we might then wonder how someone could disagree with a variable hypothetical, or how speakers could disagree.[24] There are, I think, two straightforward ways.

Suppose the variable hypothetical is part of the secondary system. We know that there is a kind of meaning holism at work in "Theories." Recall what Ramsey says about adding an axiom or secondary 'proposition': the meaning of that proposition amounts to the difference in the primary system between the stock of propositions of the theory before and after the addition (cf. Ramsey 1929d, 131). Here, it is easy to see that even though the variable hypothetical has the status of something like an inference rule, if it fails to agree with a course of experience or with predictions in the primary system, then we have grounds to reject it. That is, in agreement with the long quotation above, our generalizations must not mislead us; the variable hypotheticals "must therefore also be asserted to hold within a certain limited region taken to be the scope of our possible experience," (Ramsey 1929b, 152).

Now consider another case of disputing a variable hypothetical. In the previous case, the general proposition was cast into doubt because it was misleading or failed to hold as the generalization that it is. In this second case, the dispute is at the level of forming the generalization That is, some collection of facts suggests a law-like generalization. But our disputants disagree about its formulation. Can Ramsey allow for this case? Of course. To see this, compare:

> Two theories may be compatible without being equivalent, i.e. a set of facts might be found which agreed with one but not with the other. The adherents of two such theories could quite well dispute, although neither affirmed anything the other

24. Clearly there is a distinction between *people* disagreeing, and the notion of a disagreement within the propositions of a system.

> denied. For a dispute it is not necessary that one disputant should assert p, the other $\overline{p}$. It is enough that one should assert something the other refrains from asserting. (Ramsey 1929d, 133)

and

> Variable hypotheticals or causal laws form the system with which the speaker meets the future; they are not, therefore, subjective in the sense that if you and I enunciate different ones we are each saying something about ourselves which pass by one another like 'I went to Grantchester', 'I didn't.' For if we meet the future with different systems we disagree even if the actual future agrees with both so long as it *might* (logically) agree with one but not with the other, i.e. so long as we don't believe the same things. (Ramsey 1929b, 149)

This is consistent with Ramsey's claim that variable hypotheticals, as rules for judging cannot be negated, but can be disagreed with by one who does not adopt them. It is also consistent with the endnote (5) quoted earlier where the "facts summarized do not preclude an equal chance for a coincidence which would be summarized by, and indeed, lead to quite a different theory" (163). Moreover, the claim in this context that a variable hypothetical cannot be negated need not threaten the analysis in the first case. In that context is not a matter of a proposition being affirmed or negated, but rather of a rule being accepted or rejected insofar as it accords with the facts to be generalized, and does not mislead us in applying our judgements in future cases.

There is one last sense in which the notion of a variable hypothetical can be seen in the context of theorizing. So far the analysis has considered specific general propositions which inhabit the the primary and secondary systems. But there is also a sense in which the entire theory (or its Ramsey-sentence) could be take as a kind of meta-level variable hypothetical. Ramsey remarks in endnote (4) to "General Propositions and Causality" "of course the theoretical system is all like a variable hypothetical in being there just to be deduced from; and a law in the secondary system is at two removes of deduction," (162). In this context, the theory as a whole is conceived not as a statement which is either true or false, but rather as a scheme of rules for forming the judgements with which we meet the future. That is, in Ramsey's sense, a forecasting theory.

Ramsey's theory of science is one which does not reconstruct our knowledge of the world beyond experience through logical constructions or appeals to the logico-mathematical properties Russell advocated in his structuralism. Instead, Ramsey's theory of science explores the inferential role played by variable hypotheticals and the secondary system in which our experience is embedded in a given theory. His investigations move through the logico-mathematical

issues pertaining to definability and other inter-theoretic relations when considering a theory as a language, but he is also led by his reflections on universals of law to a new theory of variable hypotheticals and causal laws. Across these papers there is a remarkable degree mutual elucidation and a clear emphasis on interrelated problems.

3.3 Summary

In this chapter we began in 3.1.1 by showing a fragment of Ramsey's Nachlass to be a response to and rejection of Russell's remarks on theories in *The Analysis of Matter*. There Ramsey suggests his notion of a dictionary, as well as some notion of a partial interpretation. In 3.1.2 I proceeded to show how Ramsey's paper "Theories" can be shown to be a deeper articulation and exploration of the proposal he gives in the Nachlass fragment. More than that though, I argue that Ramsey was responding to issues and questions set by others instead of advocating the elimination of theoretical terms. Nor, I argued, was Ramsey trying to give an epistemological account of the world beyond our experience in that paper, but rather exploring the inferential or functional role of theoretical propositions and terms in their relation to a primary system. While Ramsey systematically describes the structure[25] of a theory as a language he does not articulate, nor advocate a structuralist thesis pertaining to the nature of our knowledge of the world beyond experience. In 3.2 I argued that Ramsey's views on the philosophy of science should be seen in light of other papers. These explore issues to be found within "Theories," but also investigate Ramsey's notion of a variable hypothetical as a special kind of conditional statement crucial to our ordinary reasoning, and our reasoning with the laws found in theories. In this broader context, where general propositions are explored as schema for forming judgements, we do not see an endorsement of the structuralist thesis attributed to Ramsey in chapter 2, but rather see Ramsey grappling with methodological questions involved in both the formation of laws that transcend any given number of finite experiences, and how we are to understand our reasoning with those variable hypotheticals.

I have not claimed that Ramsey had a fully developed theory of science. It is, however, clear that he was seriously engaged with developing one. The nascent theory he had developed was nonetheless not a species of structuralist explication of our empirical knowledge. Indeed it was a rejection of Russell's notion of the truth of a theory being a question of whether, assuming a theory as a deductive system, there exist particulars or logical structures composed of particulars which satisfy the hypotheses of the theory. Ramsey rejects this notion of truth at the outset in "Physics Says" and makes no indication of adopting it later. Moreover, he rejects the view of a theory as a deductive system. Of course, deduction of the singular primary proposi-

25. Possible structure: he does not claim that his formulation here is the only way to give the idea.

tions in a theory or of the singular propositions from a variable hypothetical is a crucial aspect of theorizing, but Ramsey shows a sensitivity to understand a theory as something more than a deductive system. Overemphasis on the logico-mathematical issues in "Theories" unduly assimilates Ramsey to a project like Russel's, when it is clear by now, that Ramsey was attempting a much broader investigation into formulating a theory of science: namely one which focuses on methodological aspects of theory change, growth, interrelations, as well as how we reason with theories. Considering a theory as a language, like Ramsey says clearly, is focusing on theories from one perspective. That perspective, and more specifically the abstract view of theories and the Ramsey-sentence's invocation by others, fails to do justice to the theory of science Ramsey was developing.

Chapter 4

Structure, more broadly

The primary task of the previous chapter was to provide a reading or rational reconstruction of Ramsey's view of theories, particularly in light of his views of general propositions and causality. The task of this chapter is to continue to reframe the philosophical context Ramsey was investigating, but more significantly, to reconsider the philosophical context best suited to the application of his views. The latter culminates in an extension of Ramsey's views by considering an implicit internal–external distinction therein which seeks to account for the intuition that a theory ought to be able to account for advances in theoretical knowledge as a matter of a posteriori discovery. I have argued that Ramsey is not using the Ramsey-sentence as a reconstruction of theoretical knowledge, but rather investigating the functional role of theoretical terms in a theory construed as a language, that is, as demystifying the conceptual and inferential role theoretical terms have in a language structure in which we cannot presume acquaintance with theoretical elements. His account can be extended, however, in such a way that a theory is both a framework for and object of empirical enquiry. The former issue involves contextualizing how Ramsey's thought has been imported into other philosophical debates—scientific realism/instrumentalism, and, in particular, recent debates over structural realism—and whether it is necessary to frame it in these terms. Both goals of the chapter are, however, to varying degrees intertwined.

The chapter begins by briefly looking at Ramsey within the realism-instrumentalism debate. He has been variously interpreted as some sort of scientific realist or some kind of instrumentalist. More precisely, I respond to Psillos' characterization of Ramsey as a kind of scientific realist.[1] While I think that *if* the terms of that debate are to be applied, then Demopoulos has the correct reading, but otherwise there is a way to see Ramsey's view as indifferent to that debate.

It is difficult to adequately discuss Ramsey's views and their relation to both structuralism,

1. Demopoulos, as we saw, understood Ramsey to hold a form of instrumentalism contrary to Russell's realism.

per the structuralist thesis, and their relation to the realism/instrumentalism debate without considering the ways Carnap adopted and incorporated Ramsey's idea. In this case, Michael Friedman[2] argues that we can understand Carnap as developing a structuralism without metaphysics, which is not hindered by Newman's objection. While I am not concerned to defend Carnap (Friedman accomplishes this better than I could), the notion of structuralism without metaphysics provides a context in which Carnap's internal–external distinction can be seen to be implicit in remarks by Ramsey. I think that a reasonable way to put the issue is that we best understand Ramsey's relevance in the debate by understanding that he anticipated the internal–external distinction and therefore anticipated important ways in which Carnap's views can be extended. Moreover, it is plausible that the conflicting views of Ramsey's realism or instrumentalism arise from failing to appreciate that he was developing an account which anticipates the distinctions of what is sayable *in* a framework, what is sayable *of* a framework, and what a framework implies. I argue that the implicit internal–external distinction is then subject to an extension wherein a theory can be both a framework for empirical inquiry as well as an object thereof, without reducing to something like a pragmatic choice of linguistic framework. I claim that this extension is likewise compatible with a theory giving us insight into the structure of the world in a sense that does not deprive it of its character of a posteriori discovery.

4.1 Scientific Realism, Instrumentalism, and Ramsey

From the previous chapter it should be rather clear that Ramsey was not articulating his views as either a form of, or an endorsement of scientific realism. If a label is to be applied to his views, it seems most appropriate to consider Ramsey an instrumentalist. We can briefly review some of those considerations: a Ramsified theory can be taken purely extensionally; that the terms and functions of the secondary system were described as fictional; that causality is a fiction; that the nature of general propositions is such that they govern behaviour and expectations; and that the existential claim that there is such a quality as mass is nonsense unless it means *only* to affirm the consequences of a theory in which it has a role.[3]

Stathis Psillos, in his "Ramsey's Ramsey-Sentences" argues instead that Ramsey's own view is a kind of scientific realism. Debating and trying to establish conclusively what Ram-

2. Recall that Friedman was a co-author with Demopoulos in "Bertrand Russell's *The Analysis of Matter*: its historical context and contemporary interest" which brought Newman's objection back to contemporary attention.

3. The relevant passage for this last remark, should be sufficient to dispel any attribution of scientfic realism:

> It is possible to have a 'realism' about terms in the theory similar to that about causal laws, and this is equally foolish. 'There is such a quality as mass' is nonsense unless it means merely to affirm the consequences of a mechanical theory. (Ramsey 1929a, 138)

sey's own preferred conception was, however, yields diminishing returns when situated in its proper context. Russell was a kind of realist and posited his appeals to structure to grant us knowledge of the world beyond experience. Granting that Ramsey was an instrumentalist might serve to distance Ramsey's work from the adoption of the Ramsey-sentence by contemporary structural realists. Yet creating that distance lacks a proper philosophical motivation.

The fact that an idea of Ramsey's, the Ramsey-sentence, has been deployed in Carnap's neutralism, incorporated into modern structural realisms, and even advocated as a form of scientific realism, shows at the very least that the method of Ramsifying a scientific theory does not lead to exclusively one '-ism'. Even if it could be shown to imply a particular metatheoretic attitude, the debates and issues in those areas would be largely unaffected since the Newman objection has already been applied to these positions and addressed, successfully or not, by their proponents.[4] Moreover, nothing is to be gained in regards to settling the issue of the so-called syntactic and semantic views of theories. Newman's original target was axiomatic structures as considered by Russell, but Demopoulos showed that the same criticism applies to theoretical structures considered from the semantic point of view.[5] There is a sense in which Newman's point is made even more obvious in the semantic view: if you want to talk about models of a theory you implicitly acknowledge that the relations of that theory can be variously instantiated in abstract models—knowledge of structure, in this case will be knowledge of common structure across models.

Appealing to an empirical hypothesis that the world is a model of the theory is no more or less philosophically insightful than asserting that we have developed our theory in order to represent the world.[6] Recent work of Halvorson has questioned the received view of the differences between syntactic and semantic approaches,[7] but has also sought to show how in the formalism of category theory we can appropriately represent the structure of scientific theories and explore important notions of equivalence and reducibility. Indeed, I think that the metamathematical spirit of Ramsey's efforts find themselves a twenty-first century kinship in that kind of approach, though I am not concerned to argue that claim here. The metamathematical issues involved in developing the best, or at least an adequate set of axioms, or the question of the appropriate formalism for representing the structure of a theory are by no means idle. In logic and mathematics, syntactic methods have yielded deep results, and semantic methods

4. Structural realism in particular.

5. Recall that Winnie's 1967 and Button and Walsh's generalization of Newman's objection are from a model theoretic context.

6. This is one way in which it could be suggested that the semantic view of theories turns on an implicit realist assumption: if there is to be a difference between 'believing' a theory and 'accepting' one, we might ask on what that distinction turns.

7. William Craig, by contrast emphasized the important interplay and mutual enrichment of considering both methods, cf. (Craig 1957)

have taken our understanding to a level of abstraction and unification likely undreamed of in the crisis in the foundations of mathematics of the early twentieth century. The importance due to formal issues, and issues of formalization, however can provide genuine philosophical elucidation, such as Minkowski's formulation of special relativity and characterization of the 'world-postulate', and it is not necessarily an idle question to ask whether a given formulation is 'best' or at least more informative.[8] Even if the 'best' way to write out theories is not the Ramsey-sentence as Ramsey suggested, or if an excessive fascination with formalization in the style of the logical positivists is inappropriate, it does not follow that metamathematical investigations of theories are idle. Questions about formalization have led to interesting results, but the difference between axiomatic and model theoretic representations does not obviously affect the evaluation of Ramsey's account of theories.

While in the semantic approach to theories the positivist preoccupation with rigorous axiomatization was set aside, nevertheless talking about models of a theory, and especially the 'empirical hypothesis' that the world is one of its models, takes for granted precisely that which is supposed to hold true in any theory: the axioms and laws thereof. Investigating the role of Ramsification and the Ramsey-sentence in these various debates certainly does not lack historical interest, nor perhaps the possibility of shedding light on nuances in the conceptualization of those various philosophical positions. Nonetheless, these investigations can, indeed have, bypassed the reconstruction of Ramsey's thought I have given in the previous chapter. The contemporary relevance of a deeper understanding of Ramsey's views lies not so much in their subsequent philosophical appropriation, but how they might be extended and applied to understanding the physical interpretation of formal structures. Of course, this is not to say that some of the mentioned positions are not attempting to answer the question of the physical interpretation of formal structure. The positivists certainly were engaged in that task. However, post-positivist accounts of theories have not helped to address the problem raised against positivist views, as characterized by Demopoulos, namely, how to translate structural claims as genuine empirical knowledge instead of trivial claims. The issue becomes whether we can develop Ramseyan insights to achieve a kind of philosophical understanding of physical interpretation of formal structures, and indeed characterize our theoretical knowledge, without automatically falling into the debates of the late twentieth century.

8. N.B. the difference between Minkowski's and other formalizations of special relativity is independant of the difference between axiomatic and model theoretic representations of them.

4.2 Structuralism without metaphysics?

Psillos' (1999), other than being a defense of scientific realism, clearly lays out the historical progression of the two language approach to theories, albeit primarily through the development of Carnap's contributions. While I am not concerned to defend, nor lay siege to, any particular form of realism or instrumentalism, it is in the context of that debate that structural realism arises. Structural realism, at least in its modern incarnation in Worral's "Structural Realism: The Best of Both Worlds?*" was supposed to take account of the best intuitions of both realists and anti-realists, while also ideally dispensing with the limitations of the respective positions, in particular that over the course of theory change the referents of theoretical terms can radically change or altogether disappear.[9] Moreover, modern structural realism advocates the Ramsey-sentence of a theory as representing the structure of which they are either ontic or epistemic realists about.[10]

Psillos explicates Carnap's mature position as attempting to avoid metaphysical and metatheoretical debates regarding realism and instrumentalism, and to embrace a genuine kind of neutral position through the logico-mathematical apparatus of the Ramsey-sentence. He argued that Carnap's development of the position collapses at different times towards realism or instrumentalism. It is claimed that the best that can be said is that it characterizes a kind of structural realism. However, structural realism faces problems of mulitiple realizability and of the generation of trivialising structure through permutation arguments like that presented by Newman contra Russell's *The Analysis of Matter.* Lastly the structural realist is supposedly placed in a dilemma where their position collapses either toward scientific realism, or trivialization where the truth of an empirically adequate theory is guaranteed by ambient set theory.

Psillos is clearly aware of Newman style considerations and deploys them effectively. However, Psillos suggests that they might be addressed by restricting the domain of quantification and relations from full models. Nevertheless, he does not acknowledge that permutation arguments and adaptations of Newman's argument can be applied to Henkin structures as well. There is a deeper objection as well: even if we had reason to restrict the domains of quantification for the theoretical terms, there is the prior question in virtue of what do we know how to restrict those domains. That is, we lack a principled way to restrict domains. We can pose the issue in the form of a dilemma. If all we know is structure, we do not have a well motivated reason to restrict the domain. If we know something more than structure, we require an exact

9. Cf. (Friedman 2020) for a characterization of Howard Stein's project in juxtaposition with Worrall's and in the context of aspects of Newtonian and Kantian methodology.

10. This use of the Ramsey-sentence transforms Russell's inherently unverifiable claim about things in themselves into a trivial claim. This exemplifies the dilemma outlined by Newman and Demopoulos—either we cannot spell out the truth conditions for structural realism, or it is trivially true.

account of that epistemic access to the theoretical domain that does not prejudge the issue in favour of any particular thesis of the scientific realist.[11]

It is in this context that we can best see the motivation for Friedman's defense of Carnap. In his (2008) and (2011) Friedman argues in defense of Carnap's anti-metaphysical and anti-epistemological stance in his *Wissenschaftslogik*. To explicate Carnap's position and attempt to dissolve rather than resolve traditional problems in the philosophy of science, Friedman contrasts Carnap's understanding and subsequent development of the Ramsey-sentence approach to theories with Hempel's understanding thereof. While Carnap does not see an appeal in using Ramsification for the formulation of a scientific theory, and prefers instead to deal with theoretical terms as constants in deductions from axioms in keeping with scientific practice, he sees residual value in Ramsification for explicating the analytic and synthetic component of scientific theories. A Ramsey-sentence, coupled with the Carnap sentence,[12] allow for the demarcation of the analytic and synthetic content of a theory, as well as the empirical content, since on his formulation, the synthetic does not exceed the empirical content. Carnap's preference for keeping theoretical terms as constants fits the Hilbertian implicit definition of terms and Carnap recognizes the successes in physics that modern axiomatics have led to, shedding the reliance on any kind of intuitive understanding for successful manipulation and investigation involving the highly abstract concepts introduced in modern physics. Moreover, Friedman argues that Carnap is not susceptible to the Newman objection, and that Demopoulos' argument to that effect relies on a realist intuition insofar as our theoretical claims are required to be discoveries. He also shows how van Fraassen's constructive empiricism, despite being a defense of instrumentalism, belies a realist attitude when it marks a difference between accepting a theory and believing one (i.e., if you were truly an instrumentalist you would not need to base a distinction between acceptance and belief on the notion that what is believed is that the theory is, beyond saving the phenomena, in some sense moreover true).

Friedman's defense of Carnap involves a detailed examination Carnap's semantic analysis of theoretical terms from 1939 onwards. The crucial aspect for satisfactorily extending Ramsey's view, regardless of the success of Friedman's argument, is to highlight the contrast with Psillos' characterization that Carnap's neutralism, and indeed his form of structuralism collapses to realism or instrumentalism. The contrast Friedman draws is clear in the following:

> The circumstance that Carnap has this much in common with both van Fraassen's

11. To be fair to Psillos, the exact arguments regarding Henkin structures and permutation arguments, though straightforward to produce in model theory, are not explicitly stated in the philosophical literature for more than two decades after his book's publication.

12. Given a Ramsey-sentence $R\vartheta$, its Carnap sentence $C\vartheta$ is the statement: $R\vartheta \rightarrow \vartheta$. So, given a Ramsey-sentence and adopting the Carnap sentence as a meaning postulate, we have an implication of the original theory itself, encouraging Carnap to prefer adopting the Carnap sentence as a meaning postulate and treating theoretical terms as constants, rather than in their Ramsified form. Cf. (Winnie 1970) for technical details.

> instrumentalism and contemporary structural realism suggests, at least to me, that Carnap's attempt at neutrality may have succeeded after all. He may in fact have articulated a version of structuralism that recognizes the strengths of both instrumentalism and realism while simultaneously avoiding the philosophical "pseudo-question" on which they appear substantively to differ. But this can only be fully appreciated, I shall argue, when we place Carnap's views on theoretical terms within his wider conception of the task of philosophy of science—which he calls *Wissenschaftslogik*, the"logic of science"—more generally. (Friedman 2011, 252)

and

> Whereas formal logic, throughout much of the modern philosophical tradition (beginning with Leibniz and culminating in the twentieth century mathematical philosophy articulated by Frege and Russell) has had a fundamental importance for epistemology and metaphysics, mathematical logic, in Carnap's hands, has a fundamental importance for *anti*-epistemology and *anti*-metaphysics instead: its role is precisely to safeguard our ongoing practice of developing empirical scientific theories within formal mathematical frameworks from epistemological and metaphysical contamination. (Friedman 2008, 295)

The issue that Friedman's analysis fundamentally brings into the foreground is the manner in which Newman's objection is purportedly avoided by Carnap. There is no attempt by Carnap to suggest any kind of metaphysical, epistemic, or semantic thesis which nullifies Newman's claim. Indeed, Carnap's characterization of *Wissenschaftslogik* is fully compatible with Newman's observation; after all, Carnap acknowledges that theoretical claims require for their satisfaction only that there exist classes, classes of classes, etc., which, whether cognisant of the fact or not, anticipates Winnie's proof of arithmetical models of theoretical structure. By contrast, Carnap's emphasis on the logic of science and his preoccupation with the analytic and synthetic distinction make no attempt to justify which theory it is whose logic we are investigating. Rather, he sought to show how the addition of meaning postulates, in particular the Carnap sentence, could help to isolate those claims in a theory which were true analytically, and those which were empirical questions. That is, the issue was not one of analytic or a priori statements in any kind of absolute sense, but rather in a relative sense: given a specific theoretic structure characterized with a theoretical and observational partition, can we demarcate statements which require for their truth observations from those which are true simply on the basis of the system? Moreover, if so, can we subsequently add meaning postulates to the theory and determine their effect on analytic and synthetic content? These questions need not be tied to

the question of how well, and to what degree, our theory choice was well motivated. So, Newman considerations do not matter for Carnap's structuralism because permuted or arithmetical models have no bearing on the success or failure of answering the specific questions Carnap was posing in this context.

We know that Carnap's approach eventually failed—he imposed conditions which were not adequate to the task—but Winnie (1970) did carry on to show in a rigorous and exact way how we can have a relative notion of theoretical analyticity, which repaired the defects in Carnap's own approach.[13] In this context, the inadequacy of Carnap's approach is eclipsed by the significance of his internal–external distinction for articulating the difference between the kind of question an answer to which can be framed inside a theory, and meta-theoretical questions including metamathematical properties of the theoretical structure, as well as theory choice and change. The greater failure was that despite emphasizing a relative notion of a priori knowledge, that is, a notion of necessity correlated with the postulates of a given theory, Carnap relegates the issue of external questions to a pragmatic issue of language choice and the adoption of conventions for stipulating frameworks. This exemplified the logical positivists emphasis on abstract formalism and conventional coordinative principles for interpretation, which itself represented a resistance to considering mutually empirically adequate theoretical frameworks as the objects of rational and philosophical investigation beyond their formal properties in order to support an anti-metaphysical and anti-epistemological neutrality. By the same token they sought to deflate the realist-instrumentalist debate as a conventional choice of language form. The question becomes, if there is evidence of something like an internal–external distinction in Ramsey's view of theories, does his view likewise strike a tenuous position between realism and instrumentalism? Or does it rather have the resources to allow the distinction, while at the same time accommodating the advance of science through genuine empirical discoveries? That is, in cases where we clearly seem to advance our theoretical knowledge through a posteriori discovery. Is Ramsey's view compatible with a view of epistemic progress in science which goes beyond demonstrating the functional role of theoretical language exemplified in a Ramsey-sentence, and is his reconstructed view capable of an extension which preserves a notion theoretical knowledge, including structural knowledge, that is not trivialized by Newman's observation?

13. This brilliant paper deserves careful study by anyone interested in these Carnapian issues—I have personally found the study of Winnie's proofs in his appendix to the paper more edifying than the discussion he provides on its own.

4.3 Extending "Theories"

Recall that the target of Demopoulos' criticism were those views of theoretical knowledge that subscribed to the abstract view of theories because their claims to structural knowledge are trivialized by Newman's observation. According to Demopoulos, there are two ways in which Carnap's approach casts doubt on the empirical character of scientific knowledge. One is the epistemological emptiness of the Ramsey-sentence method as an expression of our theoretical knowledge, given considerations of cardinality. Whether this is a fair assessment of Carnap's views we can leave to his detractors and defenders because it does not seem to impute anything to Ramsey's work as we have been considering it. The other problem is the difficulty of making sense of empirical discovery in light of the internal–external distinction. In this latter case, it seems that advances in scientific knowledge, such as the establishment of the atomic hypothesis, indicate that there is something more fundamental at stake with our theoretical questions than the mere pragmatic choice of linguistic framework. That is, the success of cases like the confirmation of the atomic hypothesis gives us good reason to reject Carnap's proposal that what is at issue for external questions is a preference of language forms or frameworks.

We can consider the atomic hypothesis as a specific case of the more general issue between realists and instrumentalists regarding the existence of unobservable entities—or, for the discussion at hand, the existence of the individuals and functions described by secondary system. As Demopoulos argues, "realists and instrumentalists evaluate the truth of the Ramsey-sentence relative to different interpretational frameworks" (Demopoulos 2012b, 66). That is, it is a meta-theoretical question about the nature of theories in general that divides realists and instrumentalists: whether theories express truths that transcend observation in a fundamental way, or are only instruments to help us navigate the phenomena. If the dispute between realists and instrumentalists amounts to a debate on an external question—or more specifically, the controversy is one that concerns different views on the nature of theories—then success in cases like the confirmation of the atomic hypothesis seems to amount to a refutation of Carnap's suggestion that the question of the existence of unobservables is a question of language choice. His treatment of the internal–external distinction seems to suggest that ontological commitments follow from commitment to a language form, thus ignoring the idea that a framework might come with methods for posing and answering by empirical procedures, questions about the existence of particular theoretical entities. Carnap's view requires us to think that we settled the external question by choosing a new language form, but this view dismisses the aspect of empirical discovery that is involved in cases like that of the reality of atoms.[14] Similarly, if

14. I note that I am largely not concerned with Carnap exegesis in this chapter. I understand that the issues surrounding Carnap's internal–external distinction are subtle, and disputed. In the chapter I deliberately keep my interpretation of Carnap as close to that of Demopoulos and Friedman as possible. If their understandings deviate,

there is an internal–external distinction at work in Ramsey's conception of theories, his view is subject to the same objection.

Ramsey's position therefore seems to be threatened on two fronts. If the internal–external distinction is shown to be contrary to our sense that empirical discovery can motivate theoretical change, then so too is Ramsey's view insofar as it embraces that kind of distinction. On the other hand, if there is no genuine internal–external distinction in his work, there seems to be little reason to see the Ramsey-sentence as part of a positive account of theories given the Newman objection. The lack of such a distinction could then seem to collapse the distinction between Ramsey's metamathematical investigations and his views on general propositions into a proposal for the nature of theories whose epistemological significance is hamstrung by Newman's observation. However, Demopoulos has shown how to extend Carnap's work to mitigate the issue faced by his internal–external distinction. I suggest that an analogous extension can be made for Ramsey. The development and application of an extension to Ramsey's work has the benefit that although it is reasonable to doubt that the extension represents Carnap's view,[15] there is textual evidence that it in fact serves as an accurate reconstruction of Ramsey's view. While Demopoulos' extension of the internal–external distinction is illuminating for the realism–anti-realism debate, it goes beyond Carnap's own view. An analogous extension of Ramsey's view has the same merits, and arguably, represents his own view. Moreover, it makes sense of his endorsement of the Ramsey-sentence despite recognizing the arbitrariness of the Ramsification of a theory. Here, even if it is a mistake to claim that this is Ramsey's view, this says nothing against the potential philosophical interest such a reconstruction has.

Demopoulos suggests that the internal–external distinction might be extended in a way that is consistent[16] with "Empiricism, Semantics, and Ontology." The extension shows that what appears as a single question might split into two or more different questions. He suggests that questions such as that of the existence of atoms can be interpreted either as external questions about the nature of theories, or as internal questions. Conceived as an external question, the issue between the realist and instrumentalist is about which interpretational framework should applied to theories: in particular, what notion of truth is appropriate and whether theories express truths that transcend observation or are simply tools to help us navigate and predict phenomena. As an internal question, while the example of the atomic hypothesis is a special case of more general existential claims about unobservables, the issue is whether our ordinary methods including our notions of rules of proof and evidence, are adequate to determining,

I follow Demopoulos' interpretation for the obvious reason of developing my interpretation of Ramsey contra his own.

15. Cf. (Demopoulos 2012a, 65-67).

16. Although this extension is consistent with *ESO*, Demopoulos gives good reason to doubt that Carnap would accept it.

within the framework, whether an existential claim can be confirmed. There are two cases which must be distinguished with respect to possible external questions. In the first case, it is an issue for which our ordinary methods fail to stabilize on a particular hypothesis, i.e., they fail to yield a determinate answer. In the second case, the issue is one which falls entirely outside the scope of our ordinary methods.

In the first case there is a speculation about the future results of scientific discovery which, like in the case of the atomic hypothesis, might be overturned and thereby show that our methods *can* stabilize on a determinate answer, the success of which shows the speculation to be mistaken. In this first case, what we might have had good reason to consider an intractable problem for our ordinary scientific methods, like the existence of atoms in the early twentieth century, is shown to be an issue which can be resolved within a given theoretical framework. We can point out that in this case the realism/instrumentalism question about the nature of theories in general, that is, the meta-theoretical question about the appropriate way to understand theories, is left untouched. In cases like confirmation of the atomic hypothesis what seemed like a possibly external question was indeed eventually amenable to the theoretical resources and methods of physics. In the second case of possible external questions, our ordinary methods are such as to never compel us one way or another in the adoption of our meta-theoretical views regarding the nature of a theory. That is, philosophers are in a position to adopt the metaphysical, semantic, or epistemological theses of realism or instrumentalism, but are not compelled either to do so or not on the basis of scientific discoveries, or the lack thereof.

For Carnap, what is at issue between realists and instrumentalists is whether they ought to use theoretical vocabulary. As we have seen, Carnap's neutralism was open to using theoretical terms in accordance with the practice of scientists, and in accordance with his anti-metaphysical and anti-epistemological *Wissenshcaftslogik* he relegated the debate to an issue of language preference. It is clear that Ramsey endorses the use of theoretical vocabulary since he does not think it necessary to eliminate the secondary system through explicit definitions. This, in itself, does not settle the question of whether Ramsey was a realist or an instrumentalist (or either), but Ramsey does seem to have anticipated Demopoulos' framing as an internal question whether our ordinary methods will stabilize on a determinate solution to a particular problem. Consider the practical consequences of the claim that the propositions of the secondary system are not genuine propositions: we are not to add an axiom whenever its truth is consistent with our theory, but rather we should both consider what other additions we might make to the theory and ideally wait until we can generate a law from our experience rather than selecting the new axiom arbitrarily. We could consider Newton's method as an example here, insofar e.g. as we do not add as an axiom or law that there is an inverse-square force holding the solar system together, but rather investigate whether the laws of motion permit us to deter-

mine the existence and nature of a force from the observed motions. We can see in Ramsey's remark about additional axioms that, considered practically, we ought to wait until our ordinary methods stabilize on a determinate solution before opting to add an axiom to our system. We might worry, however, that this is merely an inaccurate interpretation of a brief passage. Although Ramsey makes similar remarks at other points both regarding the moon, and further considerations regarding the meaning of propositions in the secondary system, those remarks are likewise individually too brief to convincingly argue that Ramsey has this issue of stabilization in mind. However, those mentioned considerations collectively, and in conjunction with his remarks at the end of "Theories" regarding the teapot, provide reasonable grounds to apply Demopoulos' extension to Ramsey's view of theories:

> Take, for instance, the problem "Is there a planet the size and shape of a tea-pot?" This question has meaning so long as we do not know that an experiment could not decide the matter. Once we know this it loses meaning, unless we restore it by new axioms, e.g., as to the orbits possible to planets.[17]
>
> But someone will say "Is it not a clear question with the *onus probandi* by definition on one side?" Clearly it means "Will experience reveal to us such a tea-pot?" I think not; for there are three cases:
>
> 1. Experience will show there is such a tea-pot.
> 2. Experience will show there is not such a tea-pot.
> 3. Experience will not show anything.
>
> And we can quite well distinguish (2) from (3) though the objector confounds them.
>
> This tea-pot is not in principle different from a tea-pot in the kitchen cupboard. (Ramsey 1929d, 235)

The distinction between Ramsey's (2) and (3) clearly shows that Ramsey distinguishes two questions involved with our ordinary methods. (2) and (1) concern whether we shall obtain a determinate answer, positive or negative, to our questions. (3) is whether the question fails to

17. Though I do not place any argumentative weight on this point in what follows, I do think this remark on orbits is curious in the context of "Theories." Up to this point he has only considered his toy theory, but now we see a transition to an actual scientific consideration, for an albeit silly example. We might wonder whether Ramsey is considering something like Newton's theory-mediated measure of Jupiter's mass on the basis of its satellites, or the subsequent success of the Newtonian gravitational law in the discovery of Neptune on the basis of perturbations of the orbit of Uranus. Of course, in the Newtonian case we could not settle if the planet had the shape of a teapot, because the gravitational calculations treat the planets as points of mass regardless of their distribution; though, the oblateness of the earth was determined through experimentation with pendulums, so it is not absurd to suggest that an experiment (or observation through an incredibly powerful telescope) might allow us to determine at least approximate shape.

be addressed either positively or negatively by our methods. We read (3) this way as opposed to saying that experience might be inconclusive, which might be no more than a temporary setback, because were it only a temporary setback, (3) would then collapse back into one of (1) or (2)—there would be no reason for Ramsey to disagree with the imagined interlocutor in the quotation unless he thought that (1) and (2) were not exhaustive, and hence, why it is a mistake for the objector to "confound" (2) and (3). The cases Ramsey distinguishes here align nicely with Demopoulos' analysis. When considering a question of the existence of a theoretical object, experience, rather than language choice or definition, has a crucial role. Initially in the case of the confirmation of the atomic hypothesis, experience was inconclusive. However, by our theoretical resources it became a tractable issue in which experience stabilized on an answer. If it were a truly external question, experience would not show anything: the use of a framework that postulated atoms would be a choice for theoretical expedience, but not motivated by empirical evidence. Notice, however, that Ramsey is not making a suggestion about the nature of theories; instead he is distinguishing cases within a theoretical framework where experience has an authoritative role for our assertions of the existence of a theoretical object. These remarks address one horn of the dilemma described earlier: that if Ramsey does subscribe to an internal–external distinction he is vulnerable to the same kinds of objection to which Carnap's proposal is subject. Recall that the suggestion earlier was that if we have reason to reject Carnap's proposal, then we likewise have reason to reject Ramsey's view to the extent that he embraces an internal–external distinction. On Demopoulos' extension, however, the success of a science in answering what Carnap would classify as an external question (the confirmation of the atomic hypothesis) need not undermine the internal–external distinction itself. Therefore it need not be an objection, let alone a decisive one, to Ramsey's view either.

As for the other horn of the dilemma, we still need to understand how Ramsey's view of theories can accommodate a representation of our theoretical knowledge in light of the considerations of arbitrariness. A particular fragment from the Ramsey archive is instructive, because it suggests that a satisfactory theory must have a complete dictionary and no superfluous elements, and also because it emphasizes the role of experience in evaluating theoretical parameters.

> In a completely satisfactory theory I think we should
>
> (a) have a complete dictionary
>
> (b) have no superfluous elements.
>
> (b) cannot be exactly defined; it means that we cannot get a simpler equivalent theory. But we may be able to do so by a little transformation when we cannot by simply leaving out a part as it stands.

> Weyl's requirements (p. 87) are Einstimmigkeit and no überflüssigen Bestandteile.
>
> Which seem to mean that every theoretical quantity can in principle be evaluated and that all ways of evaluating it lead to the same result.
>
> In principle must here mean merely that certain possible courses of experience would determine its value.
>
> If not, of course, there is something superfluous e.g. our velocity in absolute space could not be determined, and so some truth-possibilities of theoretical functions give equivalent theory.
>
> ∴ some economy ought to be possible, but it is not clear how without a good deal of thought.
>
> That makes indeed a good exercise.
>
> What is the proper form of Newtonian mechanics, which gives absolute acceleration a meaning and absolute velocity none.
>
> It must be a sort of geometry containing straight lines and a fixed direction.
>
> One must give an axiomatic description of such a geometry.
>
> Even here there is a sort of superfluous element through all places in this space–time being equivalent, but that will appear in the theory simply as a permutation of names, or can be arbitrarily fixed.[18]
>
> A permutation of parameters is always possible and cannot be regarded as an objectionable superfluity. (Ramsey 1991, 233)

His example of a superfluous element is the formulation of Newtonian mechanics[19] that includes the conception of absolute velocity. Ramsey suggests that the proper form of Newtonian mechanics gives absolute acceleration a meaning, but absolute velocity none. More precisely, since Newtonian mechanics does not involve absolute velocities, the proper space–time formulation of it should reflect this fact, whereas the original formulation maintained it as a superfluous element. Under a formulation of the space–time theory that does not contain this notion, questions about absolute velocity are not genuine questions internal to the framework, but rather can only be posed as external questions such as whether we have reason to adopt a theory in which velocity is an absolute quantity.

This passage of Ramsey's is remarkable because he so succinctly separates Newton's formulation of his theory of absolute space from the physical geometry implied by the theoretical framework of the laws of motion and their corollaries. Not only is this an affine structure

18. It seems that here Ramsey is considering permutations of position and velocity in a Galilean transformation.

19. My remarks on Newton, and issues concerning space–time are indebted to various works by DiSalle, e.g. (2006). It goes without saying that any misunderstandings are my responsibility.

with sameness of direction as a dynamically intelligible notion, but Ramsey sees that Newtonian mechanics allows for a group of transformations that define an equivalence class of allowable reference-frames (i.e. inertial frames). While Newton had the genius to recognize a distinguished class of dynamically equivalent relative-spaces, i.e. those of different states of uniform motion in which force, mass, and acceleration would have the same measurable values, he retained a privileged absolute space. Ramsey, on the contrary, could pose the question what space–time structure is implied by the mathematical structure in Newtonian mechanics. Moreover, Ramsey could distinguish two kinds of superfluity. In the first case there is the unobjectionable class of transformations of spatial coordinates, which is no defect of the implied space–time structure but only illustrates the lack of physical motivation for postulating an absolute space. It is this absolute space which is the objectionable kind of superfluity: we ask what kind of geometry is required by a theory which gives absolute acceleration a meaning, and absolute velocity none, and this is one that does not have absolute space. Notice the way Ramsey poses the issue. It is one of the functional role of a theoretical term: absolute velocity is meaningless because it is a theoretical quantity which cannot *in principle* be evaluated within the theoretical framework of Newton's laws.

With this insight, we can make more sense of Ramsey's seemingly silly example of the moon.

> It is highly relevant to this question of whether propositions have meaning, not merely what general axioms we include in our theory, but also what particular propositions. Has it meaning to say that the back of the moon has a surface of green cheese? If our theory allows as a possibility that we might go there or find out in any other way, then it has meaning. If not, not; i.e. our theory of the *moon* is very relevant, not merely our theory of things in general. (Ramsey 1929d, 134)

The crucial aspect of posing the theoretical question regarding the moon involves the possibility, in principle, of our methods to determine an answer. For a less silly example consider the theoretical quantity of mass. Is it meaningful to ask the mass of Jupiter in the context of Newtonian mechanics? It is, because as Newton showed we can calculate planetary mass on the basis of the behaviour of a planet's satellites and their orbits, but only as a theory–mediated measurement; as an internal question of the theory. So while we might resist Ramsey's characterization of the question of the constitution of the moon as possibly meaningless, we can see that as an internal question the issue is fundamentally whether the question is meaningful given the resources of the theory. As an external question, we might consider a theory of the moon that fails to make a question of its constitution meaningful as an inadequate theory,[20] but

20. N.B. that this kind of external question about adequacy is independent from the issue separating realists and instrumentalists.

whether it is made of cheese or not is irrelevant to a gravitational theory of orbital motion.[21]

Last, but not least, we see Ramsey recognize the possibility of permutations not only of the underlying domain, but of entire theoretical components: in this case the equivalence of inertial frames in the geometry required by Newtonian mechanics. Of course, he is not suggesting a kind of argument like those of Newman or Winnie, because in those philosophical contexts the issue is our justification for epistemological claims about the nature of the world, on the basis of claims to knowledge of structure. Here, Ramsey is not suggesting that the Ramsey-sentence expresses or characterizes our physical knowledge. At best it shows the mathematical structure of the Ramsified theory. In the example from the Nachlass, Ramsey is not giving an epistemological argument regarding the nature of physical knowledge on the basis of the Ramsey-sentence. Instead he is asking, *given* a particular theory, here Newtonian mechanics, what space–time structure is implied such that absolute acceleration is meaningful but absolute velocity is not. In other words, the question posed is what sort of structure do we attribute to the world by saying that it conforms to Newton's laws? Notice that a realist and an instrumentalist can give the same answer to this question while maintaining, as Demopoulos suggests, different attitudes toward the theory. Ramsey's analysis in the fragment does not imply a metatheoretical attitude or constrain the range of attitudes we might chose to take.

Perhaps the Ramsey-sentence of a theory is the best way to represent the theory's mathematical structure for determining theoretical relations and those which might be superfluous. Perhaps not: Minkowski's formulation of special relativity, for instance, was surely more deeply illuminating for the development of general relativity than whatever special relativity's Ramsey-sentence would have been (in particular the Ramsey-sentence of Minkowski spacetime). This is not an objection to Ramsey's larger approach to theories however, but a methodological question about formalization—an inadequacy of higher-order logic for representing the mathematical structure of a physical theory is not likewise an argument against a reconstruction of Ramsey's broader view. Ramsey's deeper insight is that in this context, a permutation of parameters is not objectionable. The case at hand allows the Galilean transformations which are structure preserving in the sense appropriate to Newton's theory (affine transformations which preserve metrical relations for time and space). This is a sense in which we have knowledge of structure that is not threatened by Newman's objection. Unlike structural realists, Ramsey does not claim that either what is real is structure, or what we can know is purely structural, but rather that, given a theory we can ask what structure it ascribes to the physical

21. Unless it were relevant to our gravitational theory whether our gravitational measure of mass is compatible with the possibility that, e.g., it has the density of the densest cheese. But this would only tell us this compatibility; not affirm that it was in fact cheese. Regardless, Ramsey is not talking about the moon's constitution per se, but only, through a silly example, about some part of its surface. A more serious example could be the presence of ice on the moon's surface.

world. Moreover, Ramsey's reflections allow the rational reformulation and simplification of a given theory through the elimination of superfluous elements.[22] The theory itself is an object of empirical inquiry, and not just a framework.

The Ramsification of a theory assumes that the theoretical formulation of the secondary system is correct. Here, however, we see Ramsey suggesting the elimination of elements in the secondary system of a theory. This indicates that he does not see the Ramsey-sentence as a characterization of our theoretical knowledge. Rather, Ramsification makes clear the relations, especially in terms of meaning, of the secondary and primary systems of a theory, but it does not give a representation of the knowledge that we take the theory to give us. The theory as a whole is still subject to considerations of conceptual analysis which may show that the formulation of the secondary system is inadequate to the task of representing our theoretical knowledge. In this sense then, the Ramsey-sentence is only a tool for understanding a theory as a language and for understanding the relations internal to its structure. It is not a representation of our empirical knowledge.

In the case of the atomic hypothesis, experience (that is, theory-mediated measurement) ended the speculation regarding the future results of science: our methods did in fact stabilize on a determinate answer to the question.[23] In this case, a partially interpreted element in the propositional functions of the secondary system was able to be confirmed. While the Ramsey-sentence shows how the secondary system is related to the primary so that the consequences of the theory are empirically meaningful, the confirmation of the existence of atoms enables a modification to the theory where an element of the secondary system could plausibly be imported into the primary. Of course, I do not suggest that the confirmation of the atomic hypothesis made atoms 'observable',[24] but Ramsey does not impose on the primary and secondary distinction Russell's knowledge by acquaintance nor the positivist sensation language; it is enough to recognize that in "Causal Qualities" Ramsey considers the primary/secondary distinction to be relative. There it is relative between observers, but it is also plausible to see it as a relative distinction between e.g. the data in astronomical charts about relative positions in the celestial sphere and claims about the orbits and motions of planets.[25]

In contrast, Ramsey's discussion of the elimination of superfluous elements does not address itself to how the relations of the primary and secondary systems are modified upon empirical discovery. Rather, in the elimination of superfluous elements, Ramsey is arguing that

22. I.e. the elimination of absolute space from the characterization of the space–time structure *because* absolute velocity is not capable in principle of evaluation.

23. As Poincaré recognized, whether we discovered some deeper structure to the atom, we have learned something definite about the composition of matter: that chemical composition operates with an integer ratio.

24. Though Poincaré does talk about 'seeing' atoms as a result of Perrin's and others experiments.

25. Another explicit reference to the relativity of the primary/secondary distinction is (Ramsey 1929d, 114).

the propositions of the secondary system—which acquire meaning only through the whole—must be analysed so that those secondary 'propositions' which are not empirically meaningful in the primary system are eliminated. There is a marked contrast between the space–time case where it is in principle impossible to get an empirical decision about absolute velocity, and therefore position in absolute space—it is a superfluous element in the theory—and cases like the atomic hypothesis where we were uncertain for a while whether experiment will ever be able to provide a determinate answer. This contrast parallels the methodological difference between assuming the correctness of the system and its Ramsification, and in taking the framework itself as an object of analysis as in the Newtonian example. Moreover, it is not simply an issue of analysing for superfluous elements, but more significantly in this case for asking what space–time structure is implicit in Newtonian mechanics: that is, what does the mathematical structure of the theory imply regarding the correct space–time formulation of the theory if we simplify and eliminate superfluous elements.

So, on the one hand we have Ramsey's injunction that any addition or modification to our system be a result of our ordinary methods determining a course of experience which justifies that change. On the other hand, Ramsey cannot fail to include conceptual analysis among our methods, since he so fruitfully makes use of it himself in such cases as, among others, his analysis of general propositions and causation, and his analysis Newtonian space–time. The question of stabilization is more nuanced than the adoption of a positivist criterion for meaningfulness. While the propositions of the secondary system only achieve meaning through the whole, the Ramsey-sentence coupled with Ramsey's recognition of the difference between a negative result and a lack of result emphasize the possibility of theory–mediated measurements which could settle a seemingly external question. The theory must still be subjected to and tested by our ordinary methods, including conceptual analysis of fundamental terms and principles, like absolute space (or, e.g. absolute simultaneity). The Ramsey-sentence is merely a formal tool to aid in that process.[26]

In that sense, although the Ramsey-sentence is subject to the Newman objection, the objection is only detrimental when the role of the tool is misunderstood. Properly understood, the Newman objection is instead a relatively harmless, though insightful, logico-mathematical observation. It is only relatively harmless because it is still a powerful objection to other conceptions which seek to represent the epistemological content of a theory through purely

26. This point echoes Poincaré's analogy of comparing science to a library where experimental physics is entrusted with the purchases:

> As for mathematical physics, its task will be to make out the catalogue. If the catalogue is well made, the library will not be any richer, but the reader will be helped to use its riches.(Poincaré 1913, 130)

structural relations, e.g., Russell's structuralism, constructive empiricism, and perhaps Carnap's application of the Ramsey-sentence. In effect, the Newman objection serves as a check on what we can be taking ourselves to show with the Ramsey-sentence. It is an observation something like a limitative result in logic: rather than showing us, e.g., limits to provability in a given system, it is epistemologically limitative insofar as it dramatically limits appeals to theoretical knowledge in virtue of structure. It is not an objection to Ramsey's approach to theories. Rather, aware of the arbitrariness of the Ramsey-sentence, he nevertheless urges it as the best way of writing our theories. There is no tension in that, as the Ramsey-sentence serves its purpose of demystifying theories as linguistic frameworks. We can now see that while the Ramsey-sentence is subject to the charge of arbitrariness, that charge is a threat only when the Ramsey-sentence is considered as a proposal for the reconstruction of our empirical knowledge. Instead, we ought to understand the Ramsey-sentence as motivated by Ramsey's claim that he is investigating what kind of language a theory would be if it were indeed a language. The Ramsey-sentence achieves this task of elucidating the nature of the secondary system.

Given the reconstruction and extension of Ramsey's views I have presented, it is helpful to consider a case of theory change. In "Theories" Ramsey reflected on theoretical equivalence and containment. There he remarked in a clear connection with his remarks on general propositions[27] that "[t]wo theories may be compatible without being equivalent, i.e. a set of facts might be found which agreed with both, and another set too which agreed with one but not with the other," (Ramsey 1929d, 133). In "General Propositions and Causality" he adds as a postcript note:

> As opposed to a purely *descriptive* theory of science, mine may be called a *forecasting* theory. To regard a law as a summary of certain facts seems to me inadequate; it is also an attitude of expectation for the future. The difference is clearest with regard to chances; the facts summarized do not preclude and equal chance for a coincidence which would be summarized by and, indeed, lead to a quite different theory.(Ramsey 1929b, 163).

Other than explicitly connecting his views in "General Propositions and Causality" to his *theory of science*[28] this passage continues the point that a collection of facts might be compatible with two separate theories, though a further collection may not be. To these reflections we should recall his attitude to adding axioms: that we should not add them so long as they are

27. And counterfactuals more generally.

28. This, and the fact that "General Propositions and Causality" is written as an explicit response to his previous paper on "Universals of Law and of Fact" where he is considering natural laws and scientific theorizing makes it seem incredible that his thought on the philosophy of science is often reduced not just to the content of "Theories" but to the Ramsey-sentence representation of a theory.

consistent with the theory, but in view of formulating a law on the basis of experience. Given his analysis of Newtonian mechanics we can pose this question: to account for the null result of the Michelson-Morley experiment, should we add the Lorentz contraction as a law or not?

Assuming, per 19th century electrodynamics, that light is an electromagnetic wave in the ether means that the rest-frame of the ether should have a distinguished role; however, no attempt to measure its velocity was successful and all electromagnetic phenomena were seemingly independent of the velocity of the ether, in particular the velocity of light. Like in the case of Ramsey's analysis of Newtonian space–time, we have a velocity we cannot measure.[29] However, unlike Ramsey's analysis there where absolute space is a superfluous element, in the case of the velocity of the ether, there should be a phenomenal effect. So it is not simply a case of eliminating a superfluous element, but providing an account of why we fail to measure a theoretical parameter which we seemingly should. Lorentz's hypothesis of contraction is one alternative. In the context of Ramsey's attitude to adding new laws or axioms to the theory, this seems to be a case where we have what should be a theory-mediated measurable parameter, and phenomena which contradict it. Adding the Lorentz contraction would be consistent with the theory, and serve as an explanation of the null-results of electrodynamic phenomena. We could save the phenomena and save the theory.

In contrast, Einstein's conceptual analysis of the relativity of simultaneity ("frames in relative motion can agree on the velocity of light only if they disagree on simultaneity" (DiSalle 2020b, 39)) which led to the special theory of relativity, has a closer kinship to Ramsey's analysis of Newtonian mechanics. Ramsey considered that theoretical parameters be evaluable and dispensed with absolute space because absolute velocity was in principle unevaluable. This is in keeping with the second component of what he thinks is required in a satisfactory theory. But recall that the first component required a complete dictionary. Newtonian mechanics and the implied space–time have planes of absolute simultaneity. Yet, Einstein's analysis of the concept of a frame of reference revealed that we did not have a definition of simultaneity apart from light signalling, and that determining simultaneous events depends on an arbitrary choice of reference-frame. Of course, this is not the place to go into the detail of Einstein's empirical construction of both spatio–temporal measurement and dynamically distinct reference frames[30], but rather to see that Ramsey's concern that theoretical parameters be not just evaluable but appropriately defined, has a kinship with Einstein's injunction that we require a method of yielding an empirical decision for simultaneous events. Like Newton's theory

29. Though in this case it was not a matter of principle that the velocity of the ether could not be determined. The effects of motion through the ether could be calculated as a function of the ratio of the velocity of a thing relative to the velocity of light. This began as a question that seemed beyond the reach of experiment, then it proved to be within reach. This experimental question, however, failed to yield a positive result.

30. Cf. (DiSalle 2006, Ch.4)

of gravity with respect to the laws of motion, Einstein developed his theory by coordinating simultaneity, and more generally time, not just with a concrete empirical procedure (as a logical positivistic coordinative definition might), but with the system of natural laws of classical electrodynamics.

Ramsey's own analysis of Newtonian mechanics suggests that he would have seen the philosophical and physical motivation for Einstein's theory over that of Lorentz. More generally, Ramsey's broader view of theories is well placed to make sense of Einstein's revolutionary analysis. And of course, in the same way that Ramsey asked of Newtonian mechanics, what kind of space–time structure was implied by the theory, he could well have done the same for special or general relativity. That approach would not only be consistent with the reconstruction and extension of Ramsey's view, but consistent with maintaining an internal–external distinction following Demopoulos which remains open to subsequent theoretical discoveries, be they the confirmation of the atomic hypothesis, or the null results of measuring velocity relative to the ether. Fundamentally, this rejects the reduction of Ramsey's view of theory's to be a characterization of our theoretical knowledge by the Ramsey-sentence.

4.4 Summary

In this chapter we began by further distancing Ramsey's view of theories from the way in which his writings, and the Ramsey-sentence in particular, have been imported and adapted in later issues in twentieth-century philosophy of science. In 4.1 I argued that while Ramsey has been variously interpreted as advocating a form of instrumentalism or scientific realism, *if* he was to be categorized it seems that he is an instrumentalist. However, I challenged the idea that the terms of the realism/instrumentalism debate are appropriately applied to Ramsey's thought. Indeed, as we saw in 4.3, the reconstruction of Ramsey's view I have developed does not obviously constrain someone's meta-theoretical attitude to how we should interpret theories. In 4.1 I also argued that the issues between the syntactic and semantic approach to theories are tangential at best to the considerations Ramsey was developing. Moreover, I suggested that while contemporary forms of structural realism embrace the Ramsey-sentence reconstruction of a theory, their uses of Ramsey's thought do not imply that he held or was advancing any of their own metaphysical or epistemological theses.

In 4.2 I further developed the considerations from 4.1 by considering Carnap's adoption of the Ramsey-sentence and his attempt to elaborate, according to Michael Friedman, a form of structuralism without metaphysics. This structuralism of Carnap's, because of it's purported neutrality, is to be distinguished from modern structural realism. Carnap sought to deflate the realism/instrumentalism debate by analyzing it as a conventional choice of language form.

This section, while articulating the notion of structuralism without metaphysics, provided a context in which we could ask whether the reconstruction of Ramsey's thought that I have developed is subject to similar problems that faced Carnap. In particular, Carnap's internal–external distinction seems to face serious problems for accounting for a posteriori empirical discoveries in science, like the confirmation of the atomic hypothesis, which fundamentally do not amount to a matter of linguistic stipulation. The crucial issue 4.3 addresses is a dilemma Ramsey's view faces insofar as he seem to anticipate an internal–external distinction. If he embraces an internal–external distinction, does his view suffer from similar defects as Carnap's view? If he does not embrace such a distinction, how are we to understand Ramsey given the susceptibility of his view to Newman's objection?

I argued that Ramsey's anticipation of the internal–external distinction is capable of an extension similar to the extension Demopoulos offered to salvage Carnap's view. Moreover, I argued that the extension I developed is not only consistent with the reconstruction of Ramsey's view that I have articulated, but seems to be endorsed by several analyses given by Ramsey. Here, we see that Ramsey, even if he was an instrumentalist, did not develop a view of theories which crucially relied on meta-theoretical attitudes for the interpretation of theories. Rather, his view is compatible with a theoretical framework providing methods to resolve questions concerning the existence of theoretical entities internal to that framework which do not reduce to a notion of linguistic convention, but instead emphasize whether our methods of proof and evidence allow us to stabilize on an answer to our question. Moreover, Ramsey's analysis of Newtonian space–time provides a compelling case where he investigates the physical implications of a given theoretical framework and clearly does not articulate the issue as a matter of convention. Ramsey's view seems threatened when we consider the Ramsey-sentence as an analysis of our theoretical knowledge. However, when we analyze the larger context of the reconstruction and extension of Ramsey's view, we see a view that is capable of accounting for advances in theoretical knowledge as significant a posteriori discoveries, and a view which stands outside the later issues in the philosophy of science into which Ramsey's thought was imported.

Chapter 5

Conclusion

In twentieth-century philosophy of science there has been, among other issues, a preoccupation with providing an adequate analysis of theoretical knowledge in terms of structure. Advances in nineteenth century mathematics both expanded our understanding of mathematical structure and produced a multiplicity of abstract structures. While these developments were revolutionary and prompted deep reflections in the philosophy of mathematics about how to interpret these structures, including how to understand geometric developments using imaginary numbers, lines, etc., and points moving to infinity, the great advance was the notion that mathematical structures could be rigorous and uninterpreted: not only the content of the axioms, but the methods of proof were liberated from the appeal to intuition. The crucial problem in the philosophy of science became giving an *empirical* interpretation to the abstract structures whose development were so useful to physics and other sciences. This was a problem that could not arise for Kant. He could not acknowledge the possibility of uninterpreted mathematics because he believed all mathematics to be essentially interpreted through the form of spatial and temporal intuition. The synthetic a priori character of mathematics arose from the extralogical intuitive content of those forms. This is one problem of interpretation: the empirical interpretation of abstract structure.

Another closely related, though distinct, problem of interpretation involves the interpretation of theoretical claims. Kant seemed to think that because of the inherently intuitive content of mathematics, and empirical theories more generally, they could not be about anything other than the world of possible experience. That is, theoretical knowledge was limited to the phenomenal world. Empirical knowledge, and science more generally, had nothing to say about things in themselves, and the notion of explicating the world beyond experience by appealing to the structure of our experience would make no sense to Kant. Rather his project involved showing the a priori necessity of the underlying structure of all empirical experience. That Kant was deeply mistaken about the necessity of Euclidean space, and the role of physical principles

in informing our spatial intuition (i.e., the group of rigid displacements which Helmholtz used to construct a non-Euclidean geometry expressible in intuitive terms), is crucial to understanding the development of space–time theories; however, it is important to note that the Kantian approach to structure and interpretation was not intended to shed any light on the world beyond experience, nor did it countenance the possibility of abstract mathematical structures standing in need of interpretation. Fundamentally, scientific theory characterized the world of possible experience, and the principles which governed it.

Russell, as I have argued, took up the Kantian problem. He sought to show that Kant was wrong in restricting our knowledge to only the phenomenal. The adequacy of Russell's understanding of Kant and Kant's approach to scientific knowledge can largely be set to one side: Kant's conception of 'experience' and the phenomena have a much larger scope than Russell's analysis in terms of knowledge by acquaintance in conjunction with his theories of sensa, propositional understanding, and causal theory of perception. For Russell, the problem was to account for the relation of experience and the world beyond experience, and moreover to explicate the classical problem of empiricism of demarcating what is real from what might only be illusion. Russell was convinced that the modern advances in mathematical logic could provide the means to give an account of the world beyond our experience. Russell recognized that a more abstract notion of structure transcends empirical or intuitive content, which in turn provides a more general conception of mathematics as abstract structure, thereby freeing the truths of mathematics from what seems to be an inherently subjective element. He thought that this notion of abstract structure could then allow us to ask questions about the relation between the world of experience and things in themselves, which would transcend the subjective limits on our knowledge of how the objective world can be structured. While Russell agreed with Kant that we cannot know any intrinsic properties of the world beyond experience, he believed that mathematical logic gave an adequate notion of similarity to explicate how the world of acquaintance resembles the world as it is. Precisely, they resemble one another in their logic-mathematical, that is structural, properties.

Newman's objection to Russell demonstrated the inadequacy of Russell's account, by showing that Russell's abstract structural idea of the connection between our theory and the world essentially trivializes the connection. It would be a mistake to think that the problem that Newman identified with Russell's view depended on his metaphysics, i.e. on his aim to transcend the limitations, alleged by Kant, on our knowledge of the real structure of the world, independent of the forms of our intuition and categories of our understanding. Rather, the flaw Newman identifies is the dependence on a conception of theories as abstract structures that are satisfied by sets of objects. The objection thereby applies to a variety of philosophical accounts of theories, whether they attribute such structures to "the world", or real things,

or only to "the phenomena." Those approaches, whether they were semantic, syntactic, or something else, shared an underlying principle that resulted in a common problem. This common principle—the structuralist principle—made these approaches vulnerable to Newman's objection and thereby threatened to divest our claims to theoretical knowledge of its significant a posteriori character. While Russell's account of theoretical knowledge is strongly tied to his philosophical context, Demopoulos shows that the problem Newman raises is much more generally applicable: the difficulty depends on this general conception of the interpretation of theories, not with whether theories are regarded as describing reality or as "saving the phenomena."

Demopoulos' arguments and his account of the historical progression from Russell, through Ramsey, to Carnap are instructive. They show the development of this abstract view of theories, and the different forms it has taken in connection with differing philosophical conceptions of the import of theories. Moreover, he gives a clear account of how Ramsey's work on theories in "Theories" has been used in this tradition, especially by Carnap. Reading Ramsey in the context of Demopoulos' account, and the way Ramsey's work on theories has been adopted by other philosophers, suggests that Ramsey too subscribed to the abstract view of theories and was therefore susceptible to Newman's objection. My major contention has been that this view is inadequate to Ramsey's approach to scientific theories. In a sense, it is a matter of anachronism: looking back to Ramsey's paper "Theories" from the late twentieth-century perspective that has seen Carnap's use of Ramsification as well as other attempts to explicate theoretical knowledge by means of structure, or in the case of structural realism, by means of the structure expressed by a theory's Ramsey-sentence, it becomes very easy to read Ramsey as articulating a nascent form of those other views. This, however, is an inadequate account of Ramsey's broader perspective on the role of theories in science, and fails to do justice to the complexity of his perspective.

My reconstruction begins from the premise that to adequately understand Ramsey's approach to theories, his paper must be situated in its philosophical context. This involves two contextualizations. First, "Theories" is developed out of Ramsey's response to Russell's approach, as well as issues concerning theories posed by other thinkers. So, Ramsey's principal concern was to address and clarify the relevant problems that were already on the table, rather than posing his own agenda. Second, to adequately appreciate "Theories," it must be understood in light of Ramsey's other writings on general propositions and in light of his remarks on how theoretical principles such as scientific laws actually function. What emerges is a reconstruction of Ramsey which does not consider "Theories" to be Ramsey's philosophical explication of a theory. Rather, as Ramsey himself says, it is an investigation into what kind of language a theory would be, if it were one at all; moreover, the analysis as language need not

exhaust a philosophical account of the nature of theories. Ramsey's concerns in this linguistic analysis have a greater affinity with logico-mathematical investigations into the properties of a theory-as-language, than they do as epistemologically or metaphysically motivated explications. It is true that Ramsey frames "Theories" by partitioning the language into a primary and secondary system. This alone is not sufficient to classify Ramsey as an adherent to the abstract view of theories, nor the structuralist thesis. This partition makes sense when considered as a response to Russell's view. Moreover, Ramsey's use of a 'dictionary' and his reference to 'partial interpretation' are not endorsements of any epistemological tenet, but rather devices to clarify the role of the theoretical terms in the language, and more precisely their role in the formation of judgements. Notably, Ramsey addresses the partition as 'primary' and 'secondary', but not explicitly along Russell's lines of acquaintance and the world beyond experience. With this in view, we can see Ramsey's analysis of a theory as a language (if it is a language at all), not as an endorsement or assertion of the partition, but rather his picking up the issue in the terms furnished by its philosophical context.

Russell distinguished two notions of truth and advocated the stronger; Ramsey by contrast advocated the weaker notion, whereby truth was equated with our having the perceptions a theory would lead us to expect. Ramsey made this point in the earliest Nachlass fragment dealing with theories, which predates his "Theories." This weaker notion of truth and its invocation of perception was a direct response to Russell. In later writings, Ramsey replaces the notion of perception with experience. Granting that he does not provide a philosophical analysis of experience, we may note that Ramsey does not require the primary system to be one of sensa or acquaintance, but also considers expansions of the primary system. We may refer to Kant again: there is nothing in Ramsey's remarks on theories or general propositions to rule out that for him, the world which science sought to represent was the world of phenomena in the Kantian sense. Kantian phenomena, or objects of experience, include the causal and dynamical information which Newton deduced from his notion of phenomena and the laws of motion. Similarly, we can understand Ramsey's notion of phenomena to exclude those causal and dynamical principles, and like Newton, arrive at those principles as a deduction from the phenomena through experience.[1] In other words, the notion of a primary system can include what Newton called phenomena, i.e. the planetary positions relative to the fixed stars as constructed by observation and measurement, or it is compatible with a broader notion of phenomena that include the sort of causal and dynamical information which Newton deduced. The distinction of primary and secondary systems need not imply that phenomena are objects of immediate acquaintance. While the partition into a primary and secondary system could risk developing along the lines of the abstract view of theories, instead, in Ramsey's use, it

1. Friedman (2020) instructively presents the differences in Kant and Newton's methodologies of abstraction.

allows for a relative distinction between primary and secondary systems correlated not with 'acquaintance' but rather with the richness of what we take to be represented by experience and on the independence of the relevant theory from experience in this sense.[2] In this way Ramsey's position is entirely compatible with deducing an inverse-square force from celestial motions, or with deducing a quantitative value for the theoretical property of (planetary) mass on the basis planetary orbits.

Ramsey's analysis of Newtonian space–time justifies an interpretation of experience as authoritative, yet which does not adhere to the abstract view of theories, insofar as Ramsey appeals to a course of experience deciding theoretical parameters. Notably, when he does deal with structural knowledge explicitly, the direction of inference is not the same as adherents of the structuralist thesis. They would have it that our theoretical knowledge arises from or consists in knowledge of structure. Typically, this knowledge of structure would arise from (the misappropriation of) the Ramsey-sentence of a theory. Yet when Ramsey considers structural knowledge it is not by appeal to the Ramsey-sentence, nor an appeal to knowing the structure of the world beyond experience through some relevant notion of similarity. Instead, Ramsey asks what structure is implicit in a properly formulated theory of space–time that obeyed Newton's laws, respected absolute acceleration as a dynamically meaningful notion, and yet dispensed with absolute velocity. That implicit structure, is the space–time structure of the world according to the theory thus formulated.

Clearly there is a gap between Ramsey's thought and the debate among scientific realists, instrumentalists, and structural realists. The adoption of ideas found in Ramsey's work by each of those parties suggests that Ramsey's analyses were not concerned with addressing a meta-theoretical question about the interpretational framework of theories in general. Ramsey's adoption of Russell's weaker notion of truth is the most explicit evidence that he adhered to such a meta-theoretical position. While this would put him in line with modern instrumentalism, it seems a hasty categorization. Kant's restriction of theoretical knowledge to the phenomenal world does not justify categorizing him as an instrumentalist; indeed, it seems like a category mistake.[3] We are reminded of Eddington's injunction that the world of physics is the physical world—we need not, like Russell, try to peak behind the curtain.

Newton was clearly a realist, but he also acknowledged that his principles could have an instrumental value even if they turned out to be untrue. Without hypothesizing regarding the cause of gravity, it proved an instrument for discovering new dynamical properties (or phenomena in Kant's sense). Newton also recognized the difference between establishing a systematic

2. e.g. the Newtonian phenomena are not theory–independent in a general sense, but they are independent of the dynamical principles that Newton applies to them, and which therefore can be called secondary with respect to those phenomena.

3. In the sense made famous by Gilbert Ryle.

feature of nature according to a mathematical law it can only approximate, and establishing the truth of a mathematical law. We see a parallel when Ramsey recognizes that an empirical generalization cannot be 'proven', and the evidence leading to it and its holding in other cases are separate facts. Ramsey's characterization of his theory of science shows a twofold neutrality. First, concerning the scope of the phenomenal world, and hence the related question of the basis of a primary system. Second, his analyses of theories may be read indifferently to a particular theoretican's meta-theoretical attitude. Ramsey's analyses explicate the functional and inferential role of a theory's theoretical terms and the Ramsey-sentence is a tool to that purpose. Nevertheless, his theory of science was more than a deductive systematization, but rather a 'forecasting theory'. His theory of general propositions embeds that inductive character insofar as they serve as schema for judging and for acting—but the general propositions do not only suggest a course of experience that we should expect, but serve as schema for interpreting phenomena as instances of theoretical concepts. One's meta-theoretical attitude to the interpretation of theories in the sense of realism and instrumentalism seem orthogononal to the illuminating features of Ramsey's analyses: trying to press his thought into that mould only serves to further obscure his method and purpose.

We do not see in Ramsey's work a commitment to theories as uninterpreted structures. Nor do we see a preoccupation with many of the debates that detained his peers and successors. Instead we are given an analysis of theories in terms of how they are used, and the logical structure of the inferences and judgements they enable. Ramsey did not leave us with a complete philosophy of science. He did, however, leave us with an analysis compatible with paradigmatic cases of scientific success. Demopoulos is right to criticize the abstract view of theories and the division between structure and interpretation in the ways it has been upheld by many philosophers of science. My reconstruction of Ramsey has sought to show that Ramsey's analysis does not rest easily with those assumptions, and moreover that he presents a subtle view that is sensitive to, and compatible with, the idea that our advances in theoretical knowledge are often the result of significant a posteriori discoveries. Crucially, Ramsey's views are compatible with the authoritative role of experience in our theoretical judgements without being trivialized by being overly abstract. The emphasis on meta-theoretical issues concerning the interpretation of theories obscures the notion that physical, and more generally theoretical, principles can themselves be principles of interpretation. I hope that my reconsideration of Ramsey has shed some light either on his, or toward some truer, understanding of theory.

Bibliography

Andreas, Holger, and Georg Schiemer. 2016. "A Choice-Semantical Approach to Theoretical Truth." *Studies in History and Philosophy of Science Part A* 58:1–8.

Bell, J. L., and Moshé Machover. 1977. *A Course in Mathematical Logic.* New York; Amsterdam: North-Holland Pub. Co.

Benthem, J. F. A. K. van. 1978. "Ramsey Eliminability." *Studia Logica: An International Journal for Symbolic Logic* 37 (4): 321–336.

Braithwaite, R. B. 1940. "Critical Notice: *The Philosophy of Physical Science*." *Mind* 49 (196): 455–466.

———. 1953. *Scientific Explanation.* Cambridge [England]: Cambridge University Press.

Button, Tim, and Sean Walsh. 2018. *Philosophy and Model Theory.* New York: Oxford University Press.

Carnap, Rudolf. 1958a. "Empiricism, Semantics, and Ontology." In *Meaning and Necessity.* University of Chicago Press.

———. 1958b. "Meaning Postulates." In *Meaning and Necessity.* University of Chicago Press.

———. 1967. "On the use of Hilbert's ϵ-operator in scientific theories." In *Essays on the Foundations of Mathematics,* edited by Y. Bar-Hillel, E.I.J. Poznanski, M.O. Rabin, and A. Robinson, 156–164. Jerusalem: The Magnes Press, The Hebrew University.

———. 1974. *An Introduction to the Philosophy of Science.* Dover Publications.

Chang, C., and H. J. Keisler. 1973. *Model Theory.* Vol. 73. New York, Amsterdam: North-Holland Pub. Co.

Craig, William. 1957. "Three Uses of the Herbrand-Gentzen Theorem in Relating Model Theory and Proof Theory." *Journal of Symbolic Logic* 22 (3): 269–285.

Demopoulos, William. 2011. “Three Views of Theoretical Knowledge.” *The British Journal for the Philosophy of Science* 62 (1): 177–205.

———. 2012a. *Logicism and its Philosophical Legacy.* Cambridge University Press.

———. 2012b. “On extending “Empiricism, Semantics and Ontology” to the realism–instrumentalism controversy.” In *Logicism and its Philosophical Legacy.* Cambridge University Press.

———. 2012c. “On the rational reconstruction of our theoretical knowledge.” In *Logicism and its Philosophical Legacy.* Cambridge University Press.

———. 2012d. “Three views of theoretical knowlege.” In *Logicism and its Philosophical Legacy.* Cambridge University Press.

Demopoulos, William, and Michael Friedman. 2012. “Bertrand Russell’s *The Analysis of Matter*: its historical context and contemporary interest.” In *Logicism and its Philosophical Legacy.* Cambridge University Press.

DiSalle, Robert. 2006. *Understanding Space-Time: The Philosophical Development of Physics From Newton to Einstein.* Cambridge University Press.

———. 2020a. “Absolute space and Newton’s theory of relativity.” *Studies in History and Philosophy of Modern Physics* 71 (72): 232–244.

———. 2020b. “Space and Time: Inertial Frames.” In *The Stanford Encyclopedia of Philosophy,* Winter 2020, edited by Edward N. Zalta. Metaphysics Research Lab, Stanford University.

Eddington, Sir, Arthur S. 1939. *The Philosophy of Physical Science.* Cambridge [England]: At the University Press.

———. 1959. *Space, Time, and Gravitation.* New York: Harper & Row.

English, Jane. 1973. “Underdetermination: Craig and Ramsey.” *Journal of Philosophy* 70 (14): 453–462.

French, Steven. 2003. “Scribbling on the blank sheet: Eddington’s structuralist conception of objects.” *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics* 34 (2): 227–259.

Friedman, Michael. 1992. *Kant and the Exact Sciences.* Harvard University Press.

———. 1999. *Reconsidering Logical Positivism.* Cambridge University Press.

———. 2008. “Wissenschaftslogik: The Role of Logic in the Philosophy of Science.” *Synthese* 164 (3): 385–400.

———. 2011. “Carnap on Theoretical Terms: Structuralism Without Metaphysics.” *Synthese* 180 (2): 249–263.

———. 2020. “Newtonian methodological abstraction.” *Studies in History and Philosophy of Modern Physics* 72 (72): 162–178.

Geroch, Robert. 1985. *Mathematical Physics.* University of Chicago Press.

Gupta, Anil. 2006. *Empiricism and Experience.* Oxford University Press.

———. 2009. “Précis of *Empiricism and Experience*.” *Philosophy and Phenomenological Research* 79 (2): 461–467.

Kleene, Stephen Cole. 1952. *Introduction to Metamathematics.* North Holland.

Lutz, Sebastian. 2020. “Armchair Philosophy Naturalized.” *Synthese* 197 (3): 1099–1125.

Newman, M. H. A. 1928. “Mr. Russell’s Causal Theory of Perception.” *Mind* 5 (146): 26–43.

Newton-Smith, W. 2000. *A Companion to the Philosophy of Science.* Vol. 18. Malden, Mass: Blackwell Publishers.

Poincaré, Henri. 1913. *The Foundations of Science: Science and Hypothesis; The Value of Science; Science and Method.* The Science Press.

Potter, Michael. 2005. “Ramsey’s Transcendental Argument.” In *Ramsey’s Legacy,* edited by Hallvard Lillehammer and D. H. Mellor, 71–82. Oxford University Press.

Psillos, Stathis. 1999. *Scientific Realism: How Science Tracks the Truth.* New York: Routledge.

———. 2006. “Ramsey’s Ramsey-Sentences.” In *Cambridge and Vienna: Frank P. Ramsey and the Vienna Circle,* edited by M.C. Galavotti, 67–90. Springer.

Putnam, Hilary. 2012. *Philosophy in an Age of Science.* Edited by Mario De Caro and David Macarthur. Harvard University Press.

Ramsey, Frank Plumpton. 1925. “The Foundations of Mathematics.” In *Philosophical Papers.*

———. 1928. “Universals of Law and of Fact.” In *Philosophical Papers.*

———. 1929a. “Causal Qualities.” In *Philosophical Papers.*

———. 1929b. “General Propositions and Causality.” In *Philosophical Papers.*

Ramsey, Frank Plumpton. 1929c. “Notes on Theories.” In *Notes on Philosophy, Probability and Mathematics.*

———. 1929d. “Theories.” In *Philosophical Papers.*

———. 1931. *The Foundations of Mathematics and Other Logical Essays.* Edited by R.B. Braithwaite. Routledge & Kegan Paul LTD.

———. 1990. *Philosophical Papers.* Edited by D. H. Mellor. Cambridge [England]: Cambridge University Press.

———. 1991. *Notes on Philosophy, Probability and Mathematics.* Edited by Maria Carla Galavotti. Napoli: Bibliopolis.

———. n.d. “Physics Says.” In *Notes on Philosophy, Probability and Mathematics.*

Russell, Bertrand. 1919. *Introduction to Mathematical Philosophy.* London: George Allen & Unwin Ltd.

———. 1927. *The Analysis of Matter.* London: Kegan Paul.

———. 1959. *The Problems of Philosophy.* Oxford University Press.

Russell, Bertrand, and A.N. Whitehead. 1926. *Principia Mathematica.* 2d ed. Cambridge University Press.

Sahlin, Nils-Eric. 1990. *The Philosophy of F.P. Ramsey.* Cambridge University Press.

Schiemer, Georg, and Norbert Gratzl. 2016. “The Epsilon-Reconstruction of Theories and Scientific Structuralism.” *Erkenntnis* 81 (2): 407–432.

Solomon, Graham. 1989. “Discussion: an addendum to Demopoulos and Friedman.” *Philosophy of Science* 56 (3): 497–501.

Winnie, John A. 1967. “The Implicit Definition of Theoretical Terms.” *The British Journal for the Philosophy of Science* 18 (3): 223–229.

———. 1970. “Theoretical Analyticity.” *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 1970:289–305.

Worrall, John. 1989. “Structural Realism: The Best of Both Worlds?*.” *Dialectica* 43:99–124.

———. 2007. “Miracles and Models: Why reports of the death of Structural Realism may be exaggerated.” *Royal Institute of Philosophy Supplement* 61:125–154.