Journal for the History of Analytical Philosophy

Volume 3, Number 5

Logic and the Structure of the Web of Belief
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In this paper, I examine Quine's views on the epistemology of logic. According to Quine's influential holistic account, logic is central in the "web of belief" that comprises our overall theory of the world. Because of this, revisions to logic would have devastating systematic consequences, and this explains why we are loath to make such revisions. In section 1, I clarify this idea and thereby show that Quine actually takes the web of belief to have asymmetrical internal structure. This raises two puzzles. First, as I show in section 2, Quine's mature, thoroughly naturalized view seems to offer an alternative explanation: logic is simply obvious, and this explains why we do not typically consider revising it. While Quine presents this naturalized view as a way to make good on his earlier metaphor of centrality in a web of belief, I argue that the resources of Quine's naturalized epistemology do not seem to be able to explain why we are reluctant to revise logic. And, Quine seems to recognize this point himself. In light of this, I explain in section 3 how Quine can resolve this apparent tension in his view and allow that our overall scientific theory has systematic structure in a way that is consistent with his naturalistic strictures. Second, the asymmetrical internal structure of the web of belief seems to be inconsistent with its being a holistic web at all. I defuse this problem in section 4 by showing how Quine distinguishes between structural and confirmational considerations. I close by using this distinction to show how Quine's view can evade Michael Friedman's criticisms, and allow for important methodological distinctions between areas of the web of belief.

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1. The Metaphor

Quine describes the structure of science variously as a web, a fabric, and a field of force. This idea of *confirmational holism* is at work in the famous passage in §V of "Two Dogmas of Empiricism" (Quine 1951) in which Quine claims that theories face the tribunal of experience only as a corporate body. Theories, on this view, can be confirmed or disconfirmed only in their entirety.[1] Given this, it is natural to ask how, according to this view, should we respond to disconfirmation? It would clearly be an over-reaction to reject the *entire* theory and start over. Rather, Quine says, we should revise only as much as we have to restore "equilibrium." The principle at work here is, as Quine puts it, "a maxim of minimum mutilation." (Quine 1970: 7) Quine cites this principle in various places, but it is most common in his discussions of revisions of logic. (Quine 1986a: Ch. 6) Thus, even though logic is in principle revisable, logic is typically accorded immunity to revision when our overall theory is disconfirmed by experience. This is because logic occupies a "central" place in our theorizing, and in consequence revision of it would require drastic revision of the entire system. Quine writes:

> Mathematics and logic, central as they are to the conceptual scheme, tend to be accorded such immunity, in view of our conservative preference for revisions which disturb the system least; and herein, perhaps, lies the "necessity" which the laws of mathematics and logic are felt to enjoy. (Quine 1950: xiii).[2]

The central elements of our theory—such as logic and mathematics—are those that we give up last, if at all, in the face of "recalcitrant" experience. This is explained by the fact that we have a "conservative preference for revisions which disturb the system least" and the idea that revision of a central element of our theory would require widespread revisions in other areas of our overall theory. This much seems clear enough. But why do some revisions to our overall theory disturb it more than others? In particular, why would revisions to central elements such as logic or mathematics "reverberate intolerably" (Quine 1990b: 15), while revisions to less central elements would not?

In sum, we have the following problem. Quine explains why we typically do not consider revising logic, despite the fact that this option is always open to us, by pointing out that logic is "central" in our overall theory of the world. But to understand this explanation, we must understand why revision of central elements of our overall theory would require widespread revisions elsewhere in the theory. I propose to tackle this problem by investigating Quine's notion of centrality in the web of belief, taking it as a constraint on a proper understanding of centrality that it will allow us to explain why revision of central elements of our overall theory woul greatly "disturb" it. As I will show, a proper understanding of Quine's notion of centrality reveals that the web of belief must have a ramified, asymmetrical internal structure in which the central elements are, in a sense to be explained, fundamental. And, as I will argue in §4, this understanding of Quine's view will allow us to see how to square Quine's confirmational holism with the idea, advanced in a number of places by Michael Friedman, that some parts of scientific theories (such as logic and mathematics) are prior to and presupposed by other parts (such as physics applied to empirical phenomena).

1.1 Centrality and Generality

Recall that our overall scientific theory, according to Quine, is like a fabric or field of force that makes contact with experience only at its edges. (Quine 1951: §VI) The "periphery" of our overall scientific theory thus comprises our observation sentences; sentences that, as it were, make direct contact with experience. Observation sentences are characterized not only by their direct contact with

experience, but also, in light of the fact that they are occasion sentences, by their particularity. This suggests that, by contrast, the central elements of our web of belief should be those which are furthest from experience and most general.[3] And this is just what we find in Quine's writings. Quine writes that

> highly theoretical statements of physics or logic or ontology...may be thought of as relatively centrally located within the total network, meaning merely that little preferential connection with any particular sense data obtrudes itself. (Quine 1951: 41)

And, in explaining that there is a "kinship" between mathematics and logic, on the one hand, and more abstract physics on the other, Quine notes that these theoretical areas are both highly general and distant from observation. Quine writes:

> The kinship I speak for is rather a kinship with the most general and systematic aspects of natural science, farthest from observation. Mathematics and logic are supported by observation only in the indirect way that those aspects of natural science are supported by observation; namely, as participating in an organized whole which, way up at its empirical edges, squares with observation. (Quine 1970: 100)

In these passages, Quine claims that logic, mathematics, and theoretical physics, the most central elements of our overall theory, are also the most general and farthest from experience.

This already shows that the centrality of a sentence in our overall theory does not simply amount to its being unlikely to be revised, contrary to what many interpreters—for instance Michael Friedman (2001: 33–34)—claim. Observation sentences and general laws of logic and mathematics are all unlikely to be revised, but only the latter are central in our overall theory. As Quine (1950: xii–xiii) notes, while we are reluctant to revise either observation sentences or general laws, our reluctance is due to two "somewhat opposite" priorities. On the one hand, observation sentences "must be guarded pretty jealously" because they serve to provide empirical content for the system as a whole. On the other hand,

general laws are usually not chosen for revision because, as I noted above, their revision would greatly "disturb" the overall system. Hence, centrality for Quine does not simply amount to unlikelihood of revision; to think otherwise is to blot out the difference between the central and the peripheral. This point will be especially important again in §2.1 and §4.1.

I have just argued that, on a natural understanding of Quine's metaphor of centrality, sentences that are central in our overall theory are highly general. In fact Quine conceives of logical laws as "the most central and crucial statements of our conceptual scheme" (Quine 1950: xiv) and as comprising most general portion of our overall theory. That is, Quine's conception of logic accords with the venerable Fregean idea that logic is the most general scientific discipline; in Quine's words, it is "a compendium of the broadest traits of reality". (Quine 1970: 96)

On Quine's view, logic comprises the most general portion of our overall theory, and this is brought out by the fact that it is specially general in two ways. To explain this, we must first explain the difference between *logical truths* and *logical laws* as Quine conceives them.

In the introduction to *Mathematical Logic*, Quine distinguishes between a narrow and a broad sense of 'logic'. (Quine 1983: 3) Logic in the narrow sense concerns *logical truths*. According to Quine, a logical truth is a true sentence that involves only logical vocabulary essentially. What he means by this is that a logical truth is a true sentence such that any uniform grammatical replacement of its non-logical vocabulary results in another true sentence. (Quine 1976a: 110) Logical vocabulary, for Quine, comprises the ordinary vocabulary of classical first-order logic. Thus, for instance, the sentence 'Tom is tall or Tom is not tall' is a logical truth (or, strictly speaking, a regimented version of this sentence is). Logic in the broader sense, by contrast, concerns *logical laws*. Logical laws are generalizations on logical truths. For example, the law of excluded middle is a generalization of the foregoing logical truth, which, Quine tells us, "may be formulated as saying that ⌜$\varphi \lor \neg\varphi$⌝ is

true for every statement φ ." (Quine 1983: 51) Let us register one important feature of this distinction. A logical truth is a true sentence of a first-order object language. A logical law that generalizes on such a logical truth is a true sentence, expressed employing schemata, in the metalanguage.[4]

We are now in a position to articulate the two ways in which logic is specially general, on Quine's view. First, each area of science includes among its truths some logical truths. This is because logical vocabulary just consists in grammatical particles like 'or' and 'not' which are "lexically neutral". (Quine 1983: 2, Quine 1986a: 58–60, 102)[5] Second, *logical laws*—generalizations over logical truths—are general in a unique way. Their generality can only be expressed in the metalanguage by employing a truth predicate defined, in the manner of Tarski, for all sentences of the object language. That is, on Quine's view, expression of logical laws requires "semantic ascent". (Quine 1986a: 10–13, 102) This is in contrast to the laws of every other discipline, whose generality can accurately be expressed, Quine contends, by universally quantified sentences of the first-order object language.

I claimed a moment ago that, for Quine, our "web of belief" has central and peripheral areas, and that the latter (observation sentences) are characterized in part by their particularity and immediate contact with experience. By contrast, the central areas are characterized by their generality and remoteness from experience. Since, as I just explained, logic is specially general on Quine's conception, this suggests that logic's centrality in our overall theory, and thus our reluctance to revise it, is to be explained by its special generality. According to Peter Hylton, logic's generality is sufficient to underwrite Quine's explanation of why we typically hold logic immune from revision. Hylton writes that

> Quine thinks that our attitude [toward mathematics and logic] can be explained, and justified, by the extreme generality of logic and mathematics: they are very widely applied; in the case of logic, universally applied. We use logic (more or less implicitly) in every branch of

knowledge, in every part of our overall theory of the world. Whenever truth is at stake, logic is applicable. (Hylton 2007: 77)

Quine explains the universal applicability of logic by appeal to its lexical neutrality; logical truths are among the truths of any discipline because only logical (hence, grammatical) vocabulary figures in them essentially. (Quine 1986a: 102) This is in part why logic and mathematics "infiltrate all branches of our system of the world." (Quine 1990b: 15) Accordingly, the suggestion seems to be that revision of logic would greatly "disturb" our overall theory because logic is applicable in every scientific domain.

We should pause to note an important unclarity in the use of 'logic' here. Logical *truths*, due to their lexical neutrality, can naturally be said to "infiltrate all branches of our system of the world". That is, each domain of our overall theory includes among its truths some logical truths. However, logical truths need not be *general* at all. Remember that a logical truth is just a true object-language sentence such that all grammatical substitutions for its non-logical components are also true. The sentence 'Vesuvius is not both dormant and not dormant' is a logical truth, but it does not appear to be in any way general or broadly applicable. Hence, it is not *logical truths* that are "extremely general" and "universally applicable", but *logical laws*. The latter are especially general because, as I noted, their expression requires semantic ascent, and are universally applicable because they have *instances* (i.e. particular logical truths that are substitution instances of the schemata employed in the statement of the logical law) in all domains of scientific theory.

This clarification allows us to throw our original puzzle into sharper relief. Now our question is: Why should rejection of a logical law "reverberate intolerably" throughout the web of belief? After all, rejecting a generalization, even a special generalization like a law of logic, does not require that we reject all of its instances. I can reject the claim that all swans are white while nonetheless retaining my beliefs regarding the whiteness of many individual

swans. Similarly, I could reject the law of excluded middle if it appears to fail in (e.g.) the outer reaches of real analysis, while nonetheless continuing to accept as true those of its instances that hold in more mundane domains. Of course, if one rejects a logical law, one cannot continue to regard all of its instances as *logical* truths, since a sentence is a logical truth if and only if it is a substitution instance of a logical law.[6] But the point I am making here is just that one could reject a logical law while still accepting many of its instances as *true* (just not *logically* true).[7] One could continue to accept instances of a rejected logical law whose truth does not depend on their logical vocabulary alone. For instance, one could reject the law of excluded middle but continue to accept the sentence 'either Tom is tall or Tom is not tall', *not* because it is a logical truth, but simply because Tom is tall (so the sentence is true by virtue of being a disjunction with a true disjunct). Hence, the fact that logical laws have instances in all domains does not *by itself* explain why revisions of logic would "reverberate intolerably" throughout the web. A logical law could be rejected while many of its instances are retained, though, of course, they may have to be demoted from the status of logical truth to (mere) truth.[8]

I just argued that the generality of logical laws does not suffice to explain why their rejection would "reverberate intolerably" throughout our overall theory. At this juncture, I'd like to consider a plausible-sounding way to resist this conclusion. Consideration of why this straightforward rebuttal is incorrect will help us better to understand what centrality amounts to, for Quine.

It is tempting to hold that the generality of logical laws really does suffice to explain why their rejection would come at such a high cost by arguing as follows. Theories, according to Quine, are deductively closed. (Quine 1975b: 321, Quine 1950: xv) And, the logical laws of our overall theory, of course, imply all of their instances (logical truths of the appropriate form).

Thus, acceptance of logical laws carries with it an epistemic commitment to accepting all of their instances, on the general principle that one is committed to accepting whatever is implied by what one accepts. But, since there are infinitely many logical truths due to the recursive grammar of our language, there are many (indeed, probably infinitely many) logical truths that we are committed to accepting *only* because they are instances of (and hence implied by) logical laws that we accept. Thus, if we give up a logical law, we will no longer be committed to accepting all of its instances. In particular, we will no longer be committed to accepting those of its instances to which we had been committed *solely because* they are instances of a logical law that we accepted. And, due to the special generality of logical laws, their instances are among the sentences of every area of our overall theory. Thus, giving up a logical law will engender changes in every area of our overall theory. And this is why rejection of a general logical law will "reverberate intolerably" through all regions of our web of belief.

This response does go some distance toward explaining why, due to their special generality, rejection logical laws would *reverberate* throughout the web, but it does not explain why this reverberation would be *intolerable*. The response we are considering assumes that, if our current best overall theorizing does not commit us to accepting a sentence, then we should not accept it. This assumption seems clearly in line with Quine's general methodology of seeking parsimony where possible. So far, so good. But then why is the reverberation resulting from the rejection of a logical law "intolerable"? According to the above response, the logical truths that we are required to give up are just those which we have no reason to accept apart from the fact that they are instances of a logical law; we accept them solely because they are instances of logical laws that we accept. In light of considerations of parsimony, then, it seems that we should be glad to be rid of our commitment to them. Far from being intolerable, the reverberation so engendered appears welcome!

Thus, while the generality of logic ensures that rejecting a logical law would alter our epistemic commitments in wide-ranging portions of our overall theory, it does not explain why this alteration would be problematic and is thus to be avoided. I conclude

that the generality of logic alone does not suffice to explain why rejection of a logical law would result in widespread and problematic changes throughout our overall theory.

1.2 Generality and Fundamentality

I just argued that the generality of logical laws does not suffice to explain why their rejection would result in widespread damage to our overall theory. What else is needed? At the end of the previous section, we considered the idea that giving up a logical law would wreak havoc throughout our overall theory because it would drastically alter our epistemic commitments. As I argued, this attempted explanation does not work. But it is on the right track. The problem with the explanation stemming from the generality of logic is that it relied on a too-narrow notion of epistemic commitment; viz., that engendered by logical consequence. By employing a broader notion of epistemic commitment, we can begin to see why revising a central element of our overall theory would "reverberate intolerably" throughout our entire theory of the world.

As I noted above, if we give up a logical law, we may nevertheless continue to accept many of its instances. But the potential problem here is that we may not be able to understand why those of its instances that we continue to accept are true. As Hylton puts it, we *use* logic throughout our theorizing. For our purposes here, there are two important senses in which we use or rely on—and are thereby epistemically committed to—logic in our inquiries.

First, we depend on logical laws in making inferences in our ongoing inquiries.[9] We make logical inferences, and accept some statements because we have inferred them, via the use of logical laws, from other statements that we accept. This practice epistemically commits us to accepting the logical laws which we employ in making these inferences. And this implies, in turn, that the position of accepting accepting ψ on the basis of having inferred it from φ by application of logical law R, but refusing to accept R is clearly unstable. Indeed, it seems that if one refuses to accept R, and cannot come up with some other principle to support the in-

ference from φ to ψ, then one must find some other reason to accept ψ[10], or to drop it altogether.[11] Thus, because part of our best inquiries involves making inferences in which we depend on logical laws—proofs of mathematical theorems provide notable examples here—rejecting a logical law would render our overall theory unstable. In the worst case, we might see no way to restore stability without giving up many hard-won theoretical statements that we would like to retain.

In addition to the fact that we depend on logical laws in making inferences, we *presuppose* logic in our theorizing in a broader sense. This is brought out most clearly by the fact that logic provides a crucial link between the periphery and the center of our overall theory. As Quine notes,

> The system of statements as a whole has experiential implications; but the individual statements, apart from the peripheral few which directly describe experience as such, are relevant to experience only indirectly through their participation in the system. It is only by way of the relations of one statement to another that the statements in the interior of the system can figure at all in the prediction of experience, and can be found deserving of revision when prediction fails. (Quine 1950: xv)

Quine goes on to observe that the relation of logical implication is conspicuous amongst these "relations of one statement to another", and concludes that "But for implication, our system of statements would for the most part be meaningless; nothing but the periphery would make sense." (Quine 1950: xv) Hence, the links supplied by logical implication are necessary for the vast interior portion of our overall theory to have any empirical content, and to be subject to empirical confirmation or disconfirmation at all.[12] It is for this reason that we presuppose logical laws in our theorizing. And this sort of presupposition also engenders epistemic commitment: The position of accepting laws of a special science without accepting the logical laws needed to link them to experience—and thus to ensure that they have empirical content—is again unstable. It is important to note that this is different from inferentially de-

pending on such laws. In accepting (e.g.) principles of biology or other special sciences we presuppose logic in the sense that logic provides the links between biological theory and observation that ensure that the former has empirical content. But we do not typically accept biological principles because we have *deduced* them from other principles by the use of logical laws.

We should note an important point of contrast between epistemic commitment engendered by logical consequence, on the one hand, and that engendered by inferential dependence or presupposition, on the other. If accepting φ epistemically commits me to accepting ψ because φ *implies* ψ, then the position of accepting φ but rejecting ψ is *logically inconsistent*. But, if I am epistemically committed to accepting a logical law because I depend on it in making inferences, or presuppose it in a broader sense, the position of rejecting the law while continuing to accept the statements that presuppose or depend on it is not logically inconsistent. Rather, this position is unstable, roughly, because I cannot understand how the statements I continue to accept can be true if the principles that they depend on or presuppose are not.

But how are we to make sense of the idea that we *use* logic— that we inferentially depend on it or presuppose it in a broader sense—on Quine's picture? A clue is given in the passage from *Philosophy of Logic* quoted above. In that passage, Quine characterizes central areas of the web of belief as "general and systematic". (Quine 1970: 100) We focused on the generality of logic and found that this alone was not sufficient to explain why logic is typically held immune from revision. What about the systematic role of logic?[13]

To begin, let's observe that for Quine, science is an extension of common sense by means of a *system*. (Quine 1957: 6) For Quine, the business of science is not the "indiscrimate amassing of truths" (Quine 1950: xi) but, rather, the construction of a unified "organized whole". (Quine 1986a: 100) Given Carnap's influence on Quine in his intellectually formative years, this is not surprising.

On Carnap's conception—itself in turn owing largely to Frege, whose lectures on this topic Carnap attended in the summer of 1914—the central aim of scientific inquiry is to obtain "well-founded, systematically coherent knowledge". (Carnap 1963: 7) The idea of a system as the distinguishing mark of science is a very old one; Quine inherits it proximally from Carnap, but ultimately from Aristotle. This idea of a systematic science has recently been termed the "classical model", and its adherents also include the likes of Arnauld, Leibniz, Bolzano, and Frege.[14]

Two features of the "classical model" of systematic science are important for our purposes here. First, on the classical model, a systematic science contains systematically *fundamental* elements; elements which are presupposed in all other areas of science. On the classical model, that is, the structure of science is approximately that of an axiomatized system. (de Jong and Betti 2010: 186) Second, on the classical model, the various domains of science are characterized in part by differing degrees of generality. Importantly, the systematically fundamental elements are the most general elements of the system.[15] For instance, Frege, a well-known adherent of the classical model, understands the foundations of arithmetic to be the most general "laws of thought", i.e. the laws of logic. (Frege 1950: §3,5,14)

As I will now argue, Quine subscribes to a version of the classical model himself. In particular, what is central in the web of belief—thus least likely to be revised—are those scientific laws that are most general *and* most systematically fundamental. We presuppose or depend on these systematically fundamental elements in all areas of our overall theory; in Quine's words, they "support or underly, in a logical way," (Quine 1990a: 63) the rest of our theorizing. Logical laws are presupposed because without the links that logic provides between theory and experience, the statements in the "interior" of our theory would make no sense. In addition, we depend on logical laws in making inferences throughout our theorizing. As I noted in §1.1, giving up a systematically fundamental element like a logical law does not *require* that one give up

any of its instances, but it does put pressure on the coherence of one's overall theory. This is because systematically fundamental elements play a crucial role in *unifying* our overall theory; in making it into an "organized whole" or, if you will, a *system* which differentiates it from mere "indiscriminate amassing" of truths of common sense. To give up such systematically fundamental parts of our overall theory as logical laws, say, is just to give up our theory—an organized, unified, systematic whole—altogether.[16]

1.3 The Systematic Structure of the Web of Belief

I just argued that, on Quine's view, our overall theory of the world contains systematically basic elements—among which logical laws figure prominently—which are presupposed by the rest of the overall theory. Because logical laws are presupposed by our current best theorizing, we are epistemically committed to accepting them. It is important to see that this is *not* to claim that logic is unrevisable, period. What is being claimed here is that, on Quine's view, we *currently* can see no way to give up the logical laws that we accept and still sensibly conduct our successful scientific inquiries in other areas. It is consistent to hold that, while we cannot *currently* make sense of revising logic, we may nevertheless someday be able to do so. Quine's claim that logic is in-principle revisable just amounts to a refusal to rule out, on philosophical grounds, any future course that may be taken by "scientific method, unsupported by ulterior controls." It amounts, in other words, to a refusal to predict—or prescribe—the future of science.

Let me sum up a bit. Due to their special generality, logical laws are *applicable* in all reasoning. But, as I argued, their general applicability alone does not account for their methodological indispensability. The general applicability of logical laws makes it *possible* for them to be generally indispensable. But logical laws are *actually* indispensable because we exploit their universal applicability by actually relying on them in our reasoning in all areas. Laws of other disciplines thus depend on or presuppose logical laws because laws of special sciences are formulated or established

in part via the use of logical laws. Logical laws are thus systematically basic in our overall theory of the world. They are the most general elements of our overall theory, and they are indispensable in all of our inquiries.

I have just argued that to understand why, on Quine's view, revision of the most general parts of our overall theory would require widespread revision in other areas, we must take our overall theory to have well-founded, asymmetrical, ramified internal structure. These considerations suggest the following picture of the structure of scientific theory. Our overall scientific theory has a systematic structure in which some elements—principles that are highly general and remote from experience—are basic in that systematic structure. This structure is ramified and asymmetrical in that non-fundamental sentences systematically depend on fundamental sentences. I will refer to this as the *systematic structure* of our overall theory. If an image is wanted, picture our web as more like a wheel whose edges make contact with experience, and whose spokes are possibly intersecting "tree-like" structures growing up from the center to the edge.

This picture allows for ready interpretation of Quine's claim that rejection of logical laws would "reverberate" throughout the entire structure: because they are systematically basic in our current best overall theory, we are (currently) unable to make sense of the rest of our theory without them. Due to logic's central location, the reverberation resulting from the rejection of a logical law would be "intolerable" since it would undermine the entire theoretical edifice built upon it. This, finally, explains why we are so loath to revise logic, even in the face of "recalcitrant" experience: revisions of logic would require significant and wide-ranging revisions of our overall theory, and thus, in light of "our conservative preference for revisions which disturb the system least" (Quine 1950: xiii), we are likely to choose less drastic measures.

2. The Official View

In the previous section, I outlined Quine's answer to the question why the laws of logic and mathematics appear to have an unusual necessity, and why we are loath to revise them. The metaphor of a web of belief with central and peripheral nodes, exhibiting asymmetrical systematic structure, plays an integral role in this explanation. But, in "Two Dogmas in Retrospect", he writes:

> Clearly my metaphor needed unpacking, and that was largely my concern in the ten years between Two Dogmas and Word and Object. (Quine 1991: 272)

It is clear from the context of this quotation that Quine took *Word and Object* to contain the unpacking of this metaphor in "more consciously and explicitly naturalistic" terms. In light of this, I call the naturalistic account given in *Word and Object*, "Epistemology Naturalized", and some of Quine's other mature work—primarily published in the period spanning approximately 1960 to the 1986—the *Official View*. In the remainder of this section, I will briefly describe Quine's official, naturalistic, view of the epistemology of logic. My concern here is to shed enough light on Quine's official view to assess whether and how its austere resources can suffice to capture the systematic structure of the metaphorical "web of belief" that they are to replace.

In "Epistemology Naturalized", Quine informs us that "[e]pistemology is concerned with the foundations of science." (Quine 1969: 69) But he takes great pains to differentiate his understanding of *foundations* from that of his predecessors. In criticizing Carnap's project of rational reconstruction, Quine famously asks

> why all this creative reconstruction, all this make-believe? The stimulation of his sensory receptors is all the evidence anybody has had to go on, ultimately, in arriving at his picture of the world. Why not just see how this construction actually proceeds? Why not settle for psychology? (Quine 1969: 75)

Quine proposes that we settle for psychology, and understand epistemology as a branch of that latter discipline; as the study of ourselves as natural objects doing science. The task of the naturalized epistemologist is to understand the linguistic/psychological relationship between the "meager input" of our sensory experience and the "torrential output" of theory. (Quine 1969: 83) That is, Quine recommends that epistemology be transformed into the study of how it is that we arrive at the theories we do. The foundations of science, naturalistically understood, are our "conceptual firsts" (Quine 1960: 4) and the structure of scientific theory, inasmuch as is there is such a thing, is determined by the causal history of our creation of it. Elsewhere, Quine calls this the "genetic approach." (Quine 1975a: 74) Epistemology thus understood is denuded of any considerations of rationality, explanation, or justification; it is not concerned, to use a distinction well-marked by Frege, with what justifies our theoretical pronouncements but, instead, with how we arrived at them.[17] To put the point in another idiom, Quine seems to be claiming that the context of discovery, not that of justification, should be the object of epistemological study. Understood in this way, the only theoretical structure that is recognizable to Quine's naturalized epistemology is of a strictly psychological (and in particular, genetic/historical) character. The logic of science, with its attendant systematic structure and asymmetrical priority relations, has no place in Quine's naturalized epistemology.[18]

How, on this naturalistic view, is the apparent necessity of logic to be explained? The pertinent Quinean slogan here is that logic is obvious. Quine claims that he uses 'obvious' in its ordinary behavioral sense—a statement is obvious to a person just in case the person would unhesitatingly assent to it in normal circumstances. But, as Quine is quick to point out, the status of obviousness is not unique to logical truths. 'If there have been black dogs, then there have been black dogs' is no more obvious, in the sense of meeting with unhesitating assent, than is 'there have been black dogs'. What *is* special about logical truths is that *all* logical truths are ob-

vious. The important idea here is that all logical truths are at least *potentially* obvious. After all, no logical truth containing 47,000 characters will meet with unhesitating assent upon presentation; unhesitating bafflement is more likely. However, such a truth is potentially obvious. This is because, Quine remarks, there is a complete proof procedure for logical truths (recall, as I emphasized in §1.1, that we are in first-order classical logic with identity); any logical truth can be formally derived by a sequence of individually obvious steps. (Quine 1986a: 83)

One reason that logic may be obvious, Quine thinks, is that assent to simple logical truths is strongly conditioned in learning the use of logical expressions like 'and' and 'not'.[19] Further, this explains why we are unlikely to revise logic, since any such revision would require overcoming strongly conditioned associations. And, finally, that we are unlikely to revise logic is just what its centrality amounts to, and centrality in this sense explains the apparent "necessity" of logic.

That this is the official story on logic is well-marked by some key changes in wording between the first and fourth editions of *Methods of Logic*. In the preface to the first edition (published in 1950, and republished in 1972 as an essay entitled "The Role of Logic in Explanation" (Quine 1972)), Quine describes prediction, empirical test, and revision as follows.

> The system as a whole is under-determined by experience, but *implies*, given certain experiences, that certain others should be forthcoming. When such predictions of experience turn out wrong, the system *has to be* changed somehow. (Quine 1950: xii, my emphasis)

What Quine says here is quite in keeping with the picture of confirmational holism in "Two Dogmas," with its attendant metaphor of a web of belief. By contrast, in the fourth edition (1982), he describes the process from the perspective of naturalized epistemology.

> A sensory stimulation elicits some closely associated statement and the associations then reverberate through the system of statements, activating at length another peripheral statement whose sensory associations *make us expect* some particular further stimulation. Such, schematically, is the mechanism of prediction. When prediction fails, we question the intervening network of statements. (Quine 1982: 2, my emphasis)

Note the contrast between these two passages. In the first passage, implication is said to play a role in prediction, but in the second, implication drops out and is replaced by associative connections. On the official view, it appears, predictions are merely caused by conditioned associations between sensory stimulations, and revisions are the result of weaker associations being severed to restore equilibrium.

2.1 Apparent Gaps Between the Metaphor and the Official View: The Obvious and the Indispensable

Despite Quine's attempt to "unpack" the metaphor of the web of belief in the naturalistic terms spelled out above, this official view apparently fails to fit the metaphor in two important ways. The task of this section is to make clear this apparent tension in Quine's view. In §3 I explain that this tension is *merely* apparent, and that Quine's sophisticated naturalism does allow him to retain the notion of systematic structure that played such a pivotal role in his explanation, as discussed in §1, of why we are so loath to revise logic.[20]

First, not all sentences that are obvious are central in our web of belief. Accordingly, obviousness is too coarse-grained to explain the "air of necessity" (Quine 1986a: 100) of logic (and thereby to explain why we are loath to revise it).[21] As Quine himself notes, simple logical truths like 'if there have been black dogs, then there have been black dogs' are just as obvious as non-logical "stimulus-analytic" truths like 'there have been black dogs'. Despite the fact that both of these sentences are obvious by Quine's lights, only the former appears to be necessary. However, on the official view, it

appears that we are given *the same* explanation for our being reluctant to reject logical truths and observation sentences: both types of sentence are obvious in the sense that we have a tendency unhesitatingly to assent to them, and this tendency is the result of our being conditioned to assent to those sentences in the learning the simplest parts of our language. Accordingly, rejecting either a logical truth or an observation sentence would require overcoming strongly conditioned speech dispositions, and this explains why we typically do not reject those types of sentences. But, in earlier work in which he employs the metaphor of the web of belief, Quine gives rather *different* explanations for our reluctance to revise or reject logical truths on the one hand, and observation sentences on the other. In the preface to *Methods of Logic*, he explains that we do not typically revise logical laws because they are so fundamental to our conceptual scheme, whereas we do not typically reject observation sentences because these are needed to secure empirical content for our overall theory.[22] These are importantly different explanations, and this difference is blotted out by simply classifying both as "obvious".[23]

Second, there are sentences that we accept which are *not* obvious, and which we are nonetheless loath to revise. Some laws of mathematics (and especially) of set theory, for instance, are not even potentially obvious in Quine's view.[24] Nonetheless, we are reluctant to revise them. Why is this? In §1, I showed how Quine answers this question by appealing to the systematic structure of our "web of belief". We are reluctant to revise our mathematical theories because of their broad applicability throughout the rest of our systematic science. Revision of such broadly applicable laws would require widespread revision in other areas, and would thus be a desperate move. That is, we are reluctant to revise such laws because they are *indispensable* in our current theorizing; we can currently see no reasonable way to give them up, since giving them up would require rejecting the vast bulk of our current theory and starting over. But, as I've just noted, not all laws that are theoretically indispensable are obvious in a behavioral sense.[25] Hence, of

course, we cannot explain our reluctance to revise such laws by appeal to the fact that they are obvious. The explanation, it appears, must appeal to their fundamental place in the systematic structure of our overall theory of the world.

The central point here is that the genetic structure of a theory simply does not mirror its systematic structure. And Quine recognizes this point; he puts it nicely in an early paper—"Truth by Convention"—(originally published in 1936).

> Viewed behavioristically and without reference to a metaphysical system, [the contrast between the *a priori* and *a posteriori*] retains reality as a contrast between more and less firmly accepted statements. . . There are statements which we choose to surrender last, if at all, in the course of revamping our sciences in the face of new discoveries; and among these there are some which we will not surrender at all, so basic are they to our whole conceptual scheme. Among the latter are to be counted the so-called truths of logic and mathematics. . . (Quine 1976b: 102)

As Quine correctly notes, there is no *behavioristically* relevant difference between observation sentences and laws that are systematically fundamental in our overall theory. Both are such that we are unlikely to give them up. This insight plays an important role in Quine's rejection of the analytic/synthetic distinction. But it also appears to create a tension in Quine's overall view, because it blots out the difference between the methodological roles that observation sentences and fundamental laws play in in our overall theory; a difference that Quine himself acknowledges. (Quine 1950: xii–xiii) What's basic in the genetic structure will be obvious, while what's basic in the systematic structure will be indispensable. But, as I've argued, not everything indispensable is obvious, nor is everything obvious indispensable.

Further, Quine recognizes this disconnect between genetic and systematic structure throughout his career. In "Mr. Strawson on Logical Theory," Quine writes:

Philosophy is in large part concerned with the theoretical, non-genetic underpinnings of scientific theory; with what science could get along with, could be reconstructed by means of, as distinct from what science has historically made use of. (Quine 1953:446)

Given Carnap's influence on Quine, especially early in his career, Quine's recognition of this distinction is not surprising. In his 1934 article "The Task of the Logic of Science", Carnap reports that the task of the logic of science is to

analyze the concepts, sentences, proofs, and theories that appear in different scientific fields, and. . . do this not so much from the point of view of the historical development of science as from the logical point of view. (Carnap 1987: 46)

And,

the object of the logic of science is science itself as an ordered complex of sentences. Everything that can be said about organisms and organic processes has to be said by biology as an empirical science; there are not, in addition, philosophical sentences of "natural philosophy" about "life". But it is perfectly sensible to conduct a logical investigation into the concepts, hypotheses, and theories of biology, and this is part of the logic of science. (Carnap 1987: 47)[26]

As Carnap conceives it, the logic of science has as its going concern the investigation of the systematic—as opposed to genetic/historical—structure of scientific theories.[27]

Furthermore, even at the height of his apostasy from Carnap's teachings, Quine continued to recognize a distinction between the systematic and genetic structures of our scientific theories. In *Word and Object*, the *locus classicus* of his official view, we find: "Analyze theory-building how we will, we all must start in the middle." (Quine 1960: 4) We cannot, of course, start in the middle of the genetic/historical process of theory-building; for that we begin at the beginning. What Quine is claiming, I think, is that our "conceptual firsts" concerning "medium-sized dry goods" are in the middle of the systematic structure of our overall theory. As such, they are not

systematically central or fundamental.[28] Finally, in *The Roots of Reference*, Quine admits that

Even a perfected psychology of science would not aspire to keep causal track of the minds at the advancing front of natural science. This would be no great loss; for the psychological theory is concerned rather with the basic phenomenon of scientific knowledge than with its latest variations. And anyway the minds at the advancing front are themselves aware of what they are doing. (Quine 1973: 130)

By Quine's lights, even a perfected psychology of science need not amount to a complete naturalistic story of how we produce the "torrential output" of theory. This makes it clear that Quine does not take his naturalistic official view to capture without remainder the content of his earlier metaphors. In particular, as I've argued, the centrality of logical laws is not a matter of obviousness, but a matter of their fundamental role in our overall systematic science. But how can Quine make sense of this systematic structure within the strictures of his overall naturalism? Is there a place for "the logic of science" in Quine's official view?[29]

3. Systematic Structure From the Engaged Perspective

The problem just raised is that Quine seems hold that our overall scientific theory has a systematic structure that is importantly different from its genetic structure, and hence that Quine's naturalistic official view does not seem to make good on his earlier metaphors. We can begin to see how Quine can accept this duality of theory structure by considering a similar problem.

In the midst of our best theorizing, we quantify over objects—pencils, quarks, and economies—and, as is well-known, Quine holds that such quantification carries with it ontological commitment to the existence of such objects.[30] Nonetheless, according to Quine, if we take a naturalistic stance toward our own theorizing, we see that these objects are mere "myths" and "cultural posits". (Quine 1951: 41) Thus, Quine seems both to accept and repudiate

physical objects. The resolution of this tension is to be found in Quine's attitude of scientific naturalism; that is, in Quine's "recognition that it is within science itself, and not in some prior philosophy, that reality is properly to be identified and described." (Quine 1981: 474) In §6 of *Word and Object*, Quine writes:

> Everything to which we concede existence is a posit from the standpoint of a description of the theory-building process, and simultaneously real from the standpoint of the theory that is being built. Nor let us look down on the standpoint of the theory as make-believe; for we can never do better than occupy the standpoint of some theory or other, the best we can muster at the time. (Quine 1960: 22)

Even if, understood from a naturalistic perspective, the objects over which we quantify are posits, this does not make them any less real, since our only resources for judging existence are those of our current best overall theory.[31]

This suggests an analogous solution to our interpretive problem. Understood from the "external" perspective of naturalized epistemology—that is, "from the standpoint of a description of the theory-building process"—we find no physical objects, and no systematic structure in our overall theory, but only mere "manners of speaking". (Quine 1981: 474) Nonetheless, in the course of *using* our theory—that is, from the "internal" perspective of an inquirer engaged in the pursuit of truth—we posit physical objects, and we take the parts of our overall theory to be related to one another in various systematic ways. This point is in some respects unsurprising. As Quine emphasizes, our overall theory is *man-made* (Quine 1951: 39), and this goes not only for its contents but also our understanding of how those contents are related to one another.

But why, if it is legitimate to understand one's theory as systematically structured, from the first-person point of view of a theorist engaged in scientific inquiry, is it not also legitimate to understand one's theory with a full-blown analytic/synthetic distinction between sentences of that theory? Quine's response is that of course we *could* draw such a distinction, but doing so would be

epistemically no better, for us, now, than positing the existence of Zeus. That is, drawing an analytic/synthetic distinction would not contribute to "working a manageable structure into the flux of experience."[32] (Quine 1951: 41) Quine's central criticism of the analytic/synthetic distinction is just that it makes no explanatory contribution to our overall theory.[33] By Quine's lights, one reason that an analytic/synthetic distinction makes no explanatory contribution is that it doesn't distinguish between sentences that are of great systematic import and sentences that are merely, we might say, trivially true.[34] This point may look familiar. Indeed, as I urged above, this is precisely the reason why *obviousness* fails to capture the notion of centrality in the web of belief. For Quine, I have argued, obviousness cannot adequately explain why we are loath to reject laws that are central in the systematic structure of our overall theory of the world. And now we can see that, by Quine's lights, analyticity cannot either, and for essentially the same reasons. Instead, our reluctance to revise laws that are central in our overall theory is explained precisely by their central role, so far as we can currently see, in our best practices of inquiry.

Thus, what distinguishes the distinctions of systematic structure that we see from the perspective of engaged inquiry from an analytic/synthetic distinction is that the only the former make an explanatory contribution to our overall theory. But what contribution is this, exactly? Its explanatory contribution consists in its helping us clarify and streamline our scientific theories and investigations. For Quine, our overall scientific theory (or "conceptual scheme") is "a tool, ultimately, for predicting future experience in the light of past experience." (Quine 1951: 41) Our posit of a systematic structure in our theory is instrumental in making it possible for us to refine this tool; to make it an instrument even better suited for the use to which we put it.[35] This refinement of our overall theory—in the form of simplification and clarification—is the aim of reduction and regimentation; it is the task of logic. (Ebbs 1997: 128–129) As Quine puts it,

The important thing is to understand our instrument; to keep tab on the diverse presuppositions of diverse portions of our theory, and reduce them where we can. It is thus that we shall best be prepared to discover, eventually, the over-all dispensability of some assumption that has always rankled as *ad hoc* and unintuitive. (Quine 1980b:117)

By refining and clarifying our overall theory, we can better come to understand what, exactly, our theoretical commitments are. But refinement of this sort cannot take place if our theory has no structure to simplify, no terms to reduce to more systematically fundamental ones, no idle elements (upon which nothing depends) to be eliminated. And, Quine does not regard the refinement and clarification of our conceptual scheme as being of merely instrumental value. Rather, the task of refining our overall theory is not different in kind from the task of any other body of scientific inquiry. For Quine, the purpose of regimentation is to contribute to the "simplification and clarification of logical theory", and this goal of conceptual clarification is "not to be distinguished from a quest of ultimate categories, a limning of the most general traits of reality."[36]

Importantly for our purposes here, the simplification of our overall theory by means of regimentation and reduction is what the logic of science amounts to. For one thing, reduction is eliminability *in principle*—we can genuinely reduce a concept that is nonetheless *psychologically* indispensable.[37] Even if, understood naturalistically, the structure of a theory is just the causal history of its creation, a simplification of that theory constitutes an *improvement* of it, wherein its systematic structure is depicted along clearer conceptual and explanatory lines. Simplicity, in other words, is a matter not primarily of psychology, but of systematic structure.[38]

Thus, for Quine, from the engaged perspective of inquirers employing scientific method, our overall theorizing has systematic structure; structure that does not mirror the process by which we get from "meager input" to "torrential output". But this theorizing does not amount to mere "make-believe" since it is *part* of, and not prior to, our best current overall scientific theory. Thus, there is a place in Quine's philosophy of science for the task that Carnap

called "the logic of science". As Quine puts it in his 1934 lectures on Carnap, "the logic of science" consists in "the analysis, criticism and refinement of the *methods* and the *concepts* of science," and it is this task that "Carnap regards as the defensible province of philosophy." (Quine 1990a: 103, emphasis in original) I have argued here that Quine regards the logic of science, in the sense just described, as a legitimate task of philosophy, just as Carnap did. The difference between Carnap and Quine on this point is simply that Quine's naturalism is more thorough—the logic of science, as Quine conceives it, is a legitimate enterprise that is not in any sense *prior* to science but, instead, being integral to scientific method, is part of science itself.[39]

This characterization of Quine's view also allows us to explain how Quine can make sense of robust relations between sentences of our overall theory, including the relation of logical implication, in spite of his rejection of determinacy of meaning. Understood from the point of view of naturalized epistemology, of course, there is no systematic structure to be found in our overall theory. This is because our overall theory is, on this naturalistic understanding, simply "a fabric of sentences variously associated to one another and to non-verbal stimuli by the mechanism of conditioned response."(Quine 1960: 11) Recall, further, that these naturalistic considerations also provide Quine's argument against the determinacy of meaning. Meaning is indeterminate, for Quine, because speech dispositions (conditioned verbal responses to various stimuli) under-determine translation manuals. So, from the perspective of naturalized epistemology—"from the standpoint of a description of the theory-building process"—there are no relations of implication, and no determinate meanings; instead we have the bare behavioral facts of conditioned associations and speech dispositions.

But things look different to us when we *use* our theories. We take our sentences to have sufficiently clear meanings, and to have robust theoretical relations between them. And it is only from this first-person perspective that, for Quine, considerations of systemat-

ic (as opposed to genetic) structure in our overall theory make sense.[40] As such, implications and dependence relations between statements are internal to our theorizing. They would not be captured by even a completed psychology of science, but *we* who are making use of the theory—"the minds at the advancing front of natural science"—"are aware of what [we] are doing." (Quine 1973: 130) From our first-person perspective, logic is of central importance to our own understanding of what we are doing, which explains why revision of logical laws would result in widespread damage to our overall system. In the midst of our theorizing, we may legitimately hold fixed logical laws, even if their centrality disappears from view when we adopt the third-person perspective of naturalized epistemology.[41]

4. Holism and Internal Structure

In §1, I explained how Quine understands our overall scientific theory to have a systematic structure in which some sentences depend on or are supported by others. Such relations are asymmetrical, so our system of science has a ramified, "foundational", structure. As I've argued, this picture of the structure of science allows us to see why some alterations to the structure are more damaging than others, and in particular, why revisions to logical laws would require widespread alterations in other parts of our overall theory. I have just explained how Quine can square this picture with the picture of naturalized epistemology that he develops in his mature works. But we must still face another puzzle. If, as I've argued, our overall theory has asymmetrical priority structure, in what sense is this structure a holistic *web* at all?

To get a better grip on our problem, let's briefly consider another characterization of a foundationally structured systematic science, that of Frege's conception of arithmetic. Tyler Burge describes it nicely:

The basic truths are laws at the foundation of a justificational structure. The other truths receive their justification by being logically derivative from the basic ones. And the basic ones carry their justification intrinsically, in that their truth can be justifiably recognized from the nature of those truths, in justificational independence of consideration of other truths. (Burge 1998: 339)

On this view, justification is structurally asymmetric—some truths are justificatorily prior to others—and the structure is well-founded—some beliefs are fundamental. These structural points also apply to Quine's view. Systematic structure is asymmetrical, and some sentences (in particular, those of greatest generality, i.e. the logical laws) are basic or fundamental in the structure. However, it is important to see that the picture characterized by Burge actually comprises two distinct theses. First, there is a thesis about the *structure* of a systematic science:

Structure: The structure of a systematic science is foundational in that some, but not all, laws are derivative from others.

Second, there is a thesis about the *source* of justification:

Source: A law is justified *because* it is either foundational (and thus immediately justified) or is derivative from laws that are foundational.[42]

The first is a thesis about the structure of justification, whereas the second is a thesis concerning how the nodes of the structure are justified (i.e. concerning why, for any particular node, it is in the structure). The puzzle arises because it appears that these theses are inseparable; in particular, it appears that the foundational structure of scientific knowledge requires that our knowledge of the foundations and of the laws that rest upon them have different sources.

But this is incorrect. We can now see that the picture I am imputing to Quine *is* foundational in the sense that some regions of the structure depend on, or are supported by, others; that is, it is

structurally foundational. However, the view that our overall scientific theory is structurally foundational is compatible with *confirmational holism*, which is the view that, strictly speaking, only entire theoretical systems can be confirmed or disconfirmed. To see why, note that the claim that our overall scientific theory is a thesis concerning the *structure* of the entity that is subject to confirmation, whereas confirmational holism is a theory concerning the *source* of confirmation, i.e. concerning the way in which parts of the structure are confirmed or disconfirmed. It is consistent to hold that (1) some parts of the structure of our overall theory depend on others, but (2) only entire structures of theory are confirmed or disconfirmed by experience.[43] Not only is this position consistent, it is, as I have argued, Quine's actual view. Quine holds, in keeping with the tradition of Frege and Carnap, that the structure of scientific knowledge is in a sense foundational. But he departs radically from his predecessors in insisting that this differentiated structure does not correspond to any principled distinction between various means by which parts of the structure are confirmed or disconfirmed. That is the epistemological upshot of Quine's rejection of the analytic/synthetic distinction. In Quine's view, all elements of our total theory are confirmationally, but not structurally, on a par.

In fact, this distinction between the structural and the confirmational simply amounts to the distinction that Quine draws between the "conceptual" and "doctrinal" sides of epistemology. (Quine 1969) Quine thinks that the doctrinal task of epistemology—the task of determining what is true—simply dissolves into "scientific method itself, unsupported by ulterior controls." (Quine 1960: 23) That is, Quine's logic of science has nothing to say about confirmation other than "do some science!" And of course, confirmational holism really doesn't say anything informative about confirmation.[44] By contrast, Quine writes approvingly of the conceptual side of epistemology, which he characterizes as being "concerned with clarifying concepts and defining them, some in terms of others." (Quine 1969: 69) As I argued above, this is precisely the aim of the logic of science that Quine approves of; the aim of delin-

eating and clarifying the systematic structure of our overall scientific theory.[45]

4.1 Holism and Confirmation

Quine's view of the epistemology of science thus combines his radical confirmational holism with a more traditional foundational view of systematic structure. In closing, I wish to use this conclusion to explain why an important objection to Quine's holism, perhaps most clearly articulated by Michael Friedman (Friedman 2001; 2002), misses the mark. Consideration of this objection will allow us to shed further light on some important nuances in Quine's view. In fact, as I will argue, Quine's holistic account can accommodate Friedman's central insights concerning the methodologically differentiated structure of scientific theories, while nonetheless maintaining that, strictly speaking, only theories as wholes are subject to empirical confirmation or disconfirmation.

According to Michael Friedman, Quine's holistic empiricism provides an inadequate picture of science. Friedman holds that on Quine's view our overall theory is a flat, unstructured (or at least structured only in a genetic/historical sense) conjunction; that there are no functional distinctions to be drawn between its elements since, on the holistic picture, the theory as a whole confronts the "tribunal of experience" as a "corporate body". Friedman argues that this holistic picture cannot make sense of revolutionary advances in sciences. It should therefore be rejected, Friedman contends, in favor of a view in which the special functional roles of some parts of our overall theory are given pride of place by marking those parts out as *constitutively a priori*; as necessary presuppositions of the formulation and empirical application of our theories and, as such, immune from straightforward empirical disconfirmation.

I will now argue that our discussion of the internal structure of the web of belief in the previous sections reveals that Friedman is mistaken in two important respects. First, a proper understanding of Quine's holism shows that it has asymmetrical internal structure

of just the sort needed to make sense of Friedman's examples of revolutionary advances in science. Second, this shows that Friedman's insights—and they are genuine insights—concerning the special functional role played by some statements in our overall theory can be accommodated by Quine's holistic picture, and thus it does not follow that these statements must be constitutively a priori and therefore immune from straightforward empirical disconfirmation. I will conclude by pointing out that holism solves a problem left unresolved by Friedman's account—namely to explain how we can be justified in accepting the basic principles of our current best overall theory—while nonetheless accommodating Friedman's central insights.

It will be adequate for our purposes here to discuss one of Friedman's examples: the revolutionary advances that Newtown made in the development of his gravitational physics. Friedman identifies the following three distinct revolutionary advances.

1. The mathematics of the calculus,
2. the three laws of motion, and the new conceptions of the notions of force and quantity of matter that they encapsulate, and
3. the inverse square law of universal gravitation.

Friedman points out that these advances are *functionally asymmetrical* in Newton's new physics. To take the most straightforward illustration of this point, consider Newton's second law of motion, according to which force is the product of mass and acceleration: $F = ma$. Acceleration is instantaneous rate of change, and calculus is required in order to capture this notion mathematically (indeed it was designed in order to solve precisely this problem). Thus, Friedman points out, the mathematics of the calculus is required for the very formulation of the laws of motion. It is clear that this marks an asymmetry between the calculus and the laws of motion.

One way to capture this asymmetry is to say that Newton's laws of motion *presuppose* the principles of the calculus, where this entails that accepting the laws of motion epistemically commits one to accepting the principles of the calculus. This is brought out by the fact that the position of accepting Newton's laws of motion but failing to accept the principles of the calculus would render one's position unstable.[46] To see this, note that without the principles of the calculus that allow you take the derivative of a function, you can't make sense of the 'a' term in the second law. This is because the 'a' term is supposed to represent instantaneous rate of change, and is therefore captured mathematically by the derivative of velocity as a function of time. Further, this presuppositional relation between the principles of the calculus and the laws of motion is *asymmetrical* since accepting the calculus does not epistemically commit one to accepting the laws of motion. It would be a perfectly legitimate position to accept the principles of the calculus and fail to accept the laws of motion.[47]

Friedman claims that this and other functional asymmetries between different parts of revolutionary theories cannot be captured by Quine's holistic model, and hence, that Quinean holism cannot make sense of revolutionary advances such as those exemplified by Newton's mathematical physics. According to Friedman, Quine understands the structure of science as a vast *conjunction* of accepted sentences which confronts experience *en bloc*. By Friedman's lights, the only internal distinctions that Quine can draw between parts of the web concern degrees of *entrenchment*; that is, Quine can distinguish between those parts of our overall theory that we are more or less willing to revise only by appeal to force of habit, roughly speaking. Accordingly, the only sense that Quine could make of the asymmetry between the calculus and the laws of motion, for instance, is that the former is more entrenched than the latter. But as Friedman points out, this simply isn't true in revolutionary cases. *Neither* the calculus nor the laws of motion were entrenched at all; that's in part *why* Newton's new physical theory was *revolutionary*!

The moral that Friedman draws from this supposed failure of Quinean holism is that we should embrace the broadly Carnapian view according to which these functional asymmetries between parts of our theories are to be marked by a sharp division between

the *framework* of our theories only within which is it possible to mathematically formulate and apply physical laws to empirical phenomena. As Friedman puts it "careful attention to the actual historical development of science, and, more specifically, to the very conceptual revolutions that have in fact led to our current philosophical predicament, shows that relativized a priori principles of just the kind Carnap was aiming at are central to our scientific theories." (Friedman 2002: 182) But, as I will now endeavor to show, this conclusion is too hasty.

Let me begin by enumerating three central points about which I believe Friedman is correct.

1. There are functional asymmetries between mathematical and logical principles and other theories that presuppose them. These functional asymmetries cannot be captured by degrees of entrenchment (which are genetic/historical in character). Accordingly, we should not understand our overall scientific theory as a vast, unstructured conjunction.

2. Laws and theories that presuppose mathematics and logic lack empirical content (and therefore cannot be *tested* by observation at all) unless they are in some way connected to observation.

3. Consideration of scientific revolutions reveals that our overall scientific theory has *foundations* in the sense that there are parts of our overall theory revision of which would require a "genuine expansion of our space of intellectual possibilities". (Friedman 2002:190) What makes an advance revolutionary is precisely that it makes it possible for us to see a way to do without a theoretical claim that we previously could see no way to give up. But, the foundations of our scientific theories need not be any more "certain" or "epistemically secure" than any other parts of our overall theory. They do not have any special *epistemic* status. (Friedman 2002: 190)

As I read Quine, he can accept all of these points. But, of course, Quine cannot accept the claim that there is a sharp distinction to be drawn between functionally *a priori* framework principles and empirical principles that are subject to confirmation or disconfirmation on empirical grounds. Thus, to defend the coherence of my reading, it is necessary to show that the above claims do not imply Friedman's overall conclusion that fundamental logical and mathematical principles are consitutively *a priori framework principles* which are thus immune to empirical disconfirmation. Let us consider these points in turn.

First, as I argued in §1, Quine does think that there are functional asymmetries between various parts of our overall theory. Theorizing in the special sciences presupposes logic, but not conversely. Our overall theory has systematic internal structure. And, as I argued in §§2–3, Quine does not relinquish this view in favor of mere degrees of psychological entrenchment. In using our theory, Quine holds, we do not (and should not) regard it simply as an unstructured conjunction. Instead, we regard it has having rich systematic structure in which certain general principles—such as those of logic, mathematics, and theoretical physics—play a systematically fundamental role and are presupposed in all other areas of our overall theory. But, it is important to note, this does not require that we treat those principles as having an *a priori* status; that is, status of being immune to empirical confirmation or disconfirmation. It requires only that, in considering how to revise our theories in the face of recalcitrant experience, we bear in mind the substantial cost of revising their systematically fundamental portions.

Second, Quine agrees that laws or theories of the special sciences presuppose mathematics and logic for both their formulation and application to empirical phenomena. Indeed, the links between logic and experience necessary for application to empirical phenomena (and thus subjection to empirical test) are necessary for giving any empirical content to those laws or theories at all. In fact, as I argued in §1.2, this is one reason why logical laws are presupposed by all of our other theorizing. Just as on Friedman's picture, logical laws are required in order to coordinate empirical phenomena with the rest of our overall theory. But, unlike on Friedman's picture, this does not require that logical laws are *a priori*.

Third, Quine holds that the systematically basic elements of our overall theory are indispensable, where this amounts to the claim that we currently see no way to give them up and still make sense of what we are doing. Thus, to revise these fundamental elements would precisely require that we come to see a new way to conduct our inquiries—a way independent of those elements that are currently systematically basic—that we could not see before. That is, it would require a revolutionary advance and a "genuine expansion of our space of intellectual possibilities". But this difficulty—that we currently can see no way to give up those principles that we currently hold as systematically fundamental—does not imply that these principles have any special epistemic status. And this is precisely what I pointed out in §2.1.

As these three claims illustrate, systematically basic principles play a special role in our overall theorizing. We employ and presuppose them throughout our reasoning, and partly because of this, in normal situations of testing, we hold them fixed. That is, these principles have a special *methodological* status for us: Because of their fundamental role in our theorizing, we can currently see no way to give them up, and thus do not typically select them as candidates for revision. But this does not imply that these principles are immune to confirmation or disconfirmation on empirical grounds. At most, it implies that we cannot currently see how empirical considerations could tell against these fundamental principles. But that is just because, to do that, we would need new principles to take their place; we would need a revolution.

This response to Friedman's challenge shows, I think, the power and interest of Quine's "web of belief" model of science. For, this picture accommodates the venerable and attractive idea that our overall scientific theory is structurally asymmetrical—and in particular that some parts of our theory are fundamental in our theorizing—while simultaneously accepting Quine's powerful arguments for the claim that no confirmationally relevant carving-up of our overall theory is possible. In addition, this picture allows us to explain why it is epistemically reasonable for us to accept the systematically basic elements of our overall theory. They are not simply conventionally adopted and not therefore immune from internal rational critique, as Friedman's picture suggests. Rather, it is reasonable for us to accept these principles because they are confirmed holistically; they are confirmed by the fact that they play a ineliminable (so far as we can currently see) role in our best current overall theory.[48]

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Notes

1 Quine does moderate this holism in "Two Dogmas in Retrospect" (Quine 1991), but the essential point, for our purposes here, remains unchanged. Thanks to an anonymous referee for this journal for reminding me of this point.

2 Quine makes similar statements elsewhere. A good example is (Quine 1976b: 102).

3 Indeed, Quine seems to equate generality and remoteness from experience. That is, the more general a bit of theory is, the more remote it is from experience. This idea, first explicitly articulated by Aristotle in the *Posterior Analytics* (I.2, 72a), has been tremendously influential. We will discuss this connection further below.

4 For further discussion of this point, see (Ricketts 2004: 196–197) and (Goldfarb 2001: 27).

5 This is not intended, of course, as a *criterion* for logicality. Despite the fact that there are well-known theoretical problems concerning a criterion for sorting logical from non-logical expressions (the classic treatment is (Tarski 1986)), Quine is perfectly content to simply give a list. And, not surprisingly, it turns out that the logical vocabulary on his list consists of (some) grammatical particles.

6 See (Quine 1986a: 50). Of course, some logically true sentences may be instances of more than one logical law. For example, any instance of the law of testability, $\neg\varphi \lor \neg\neg\varphi$, is also an instance of the law of excluded middle, $\varphi \lor \neg\varphi$. Accordingly, one could reject the law of excluded middle while still accepting the law of testability (i.e. one could adopt *testability logic* as it is sometimes called), and thus still hold that instances of the law of testability are *logical* truths.

7 Of course, in so doing, one would also have to revise one's understanding of what a logical truth is. This may involve a revision of one's logical vocabulary, for instance.

8 Arnold and Shapiro (2007: 294) provide some helpful discussion of this point. They take this to show that Quine is incorrect in claiming that rejection of a logical law could cause widespread damage in our overall theory. But Arnold and Shapiro are mistaken on this point, as I show in §1.2. The possibility of demoting a logical truth rather than rejecting it altogether makes it more difficult, but not impossible, to explain why rejection of a logical law would result in widespread theoretical damage, on Quine's picture.

9 I defend this claim, and explain how to understand the sense of dependence at issue, in other work.

10 Or determine that one does not need a reason to accept ψ.

11 This is one reason why foundational crises (in e.g. mathematics) are crises. If one wishes to accept, e.g. the Heine-Borel theorem, but one refuses to accept the choice principle employed in its proof, then it appears that one must find some other suitable principle, or find an entirely different proof, or renounce one's acceptance of the theorem. This is the uncomfortable position that the French analysts found themselves in after Zermelo pointed out that the proofs of their most important theorems appeared to rely on the very choice principle that they vehemently opposed. For helpful discussion of this point, see (Shapiro 2009).

12 Quine explicitly makes this point in (Quine 1986b). He writes: "[G]iven the second dogma, analyticity is needed to account for the meaningfulness of logical and mathematical truths, which are clearly devoid of empirical content. But when we drop the second dogma and see logic and mathematics rather as meshing with physics and other sciences for the joint implication of empirical consequences, the question of limiting empirical content to some sentences at the expense of others no longer arises."

[13] To ward off undue confusion, I will note here that systematicity and generality go together, for Quine, and indeed for all adherents to the "classical model" of systematic science. Indeed, as I point out again at the end of §1, logic must be specially general in order for it to play the special systematic role that it does. I am teasing apart these two features of logic here only because I wish to show that Quine appeals to the systematic role of logic, and not *just* its generality, to explain why logical truths are not typically given up in the face of recalcitrant experience. Thanks to an anonymous referee for this journal for pressing me to clarify this point.

[14] For recent helpful discussion of the classical model of systematic science see (de Jong and Betti 2010, Lapointe 2010, Tsou 2009). For some discussion of Quine's relation to this tradition in particular, see (Ricketts 2004).

[15] This conception is especially prominent in Aristotle's view of a systematic science. Many of Quine's remarks suggest that he views the various domains of science as being (at least roughly) *ordered* by generality, so that, e.g. logic and mathematics are more general than physics, which is in turn more general than history or economics. (Quine 1950: xiii) Perhaps, as an anonymous referee for this journal suggests, the most promising way to understand this is in terms of the scope of applicability of the vocabulary particular to respective scientific domains. So, for instance, logic is more general than mathematics because all logical vocabulary is applicable to sentences of mathematics, but not vice-versa. This strikes me as a promising avenue for further research, but for my purposes here, I assume only that logical laws are more general than those of any other discipline, and that these laws are general in a special way, as I explained above.

[16] Thus, Hylton is correct in claiming that, for Quine, "changing our logic would be tantamount to tearing up our whole theory of the world and starting again." (Hylton 2007: 78) It is my hope that the discussion of the internal structure of the web of belief undertaken here explains why Hylton's claim is true.

[17] See Frege (1950: §3).

[18] For an excellent articulation and defense of this reading of Quine, see Ricketts (1982).

[19] In *Philosophy of Logic*, he writes that "Naturally the habit of accepting [logical] truths will be acquired hand in hand with grammatical habits. Naturally therefore the logical truths, or the simple ones, will go without saying; everyone will unhesitatingly assent to them if asked. Logical truths will qualify as obvious, in the behavioral sense in which I am using this term, or potentially obvious". (Quine 1986a: 102) In "The Nature of Natural Knowledge" we find: "We learn the grammatical construction 'p and q' by learning, among other things, to assent to the compound only in circumstances where we are disposed to assent to each component. Thus it is that the logical law of inference which leads from 'p and q' to 'p' is built into our habits by the very learning of 'and'.. . . Thus, in general, the acquisition of our basic logical habits is to be accounted for in our acquisition of grammatical constructions." (Quine 1975a: 78) See also (Quine 1973: §§20, 21).

[20] Thanks to the anonymous referee for this journal, whose comments helped me to clarify what I am claiming in this section.

[21] On the "necessity" of logic as Quine uses the term, see also (Quine 1950: xii).

[22] We find this in both the first (1950) and fourth (1982) editions.

[23] Additionally, in his 1934 lectures on Carnap, Quine writes that: "there are more and less firmly accepted sentences prior to any sophisticated system of thoroughgoing definition. The more firmly accepted sentences we choose to modify last, if at all, in the course of evolving and revamping our sciences in the face of new discoveries. And *among* these accepted sentences which we choose to give up last, if at all, there are those which we are not going to give up at all, so *basic* are they to our conceptual scheme. These, if any, are the sentences to which the epithet 'a priori' would have to apply." (Quine 1990a: 65)

Notice that the sentences that are basic to our conceptual scheme are simply *among* the sentences which we choose to give up last, if at all. For further discussion of this point, see also (Hylton 2001: 268).

[24] Recall that Quine thinks that all logical truths are obvious because they admit of a complete proof procedure. Interestingly, Quine seems to take completeness to be the criterion of potential obviousness. In contrasting mathematics with logic, Quine writes that mathematics "is not potentially obvious throughout; it does not even admit of a complete proof procedure." (Quine 1986a: 98) This echoes an earlier remark of Quine's concerning what he terms an important contrast between logic and set theory; namely the the former is obvious because it admits a complete proof procedure, and the latter, lacking a complete proof procedure, is not. (Quine 1976a: 111)

[25] On this point, it's worth noting that in discussions of centrality in the web of belief, Quine typically lumps logic and mathematics together. But, in discussions of obviousness, mathematics (and especially set theory) is either conspicuously absent, or explicitly claimed to be not obvious. I conjecture that this is because Quine takes completeness to be a mark of obviousness; see previous note.

[26] In a letter to Quine, Carnap reports (Quine and Carnap 1990: 154) that he has sent Quine a "pamphlet" detailing some of the main ideas of Part V of *The Logical Syntax of Language*; it is clear that he is referring to the above-quoted 1934 article. So it is very likely that Quine was familiar with this article (and, of course, he was quite familiar with LSL).

[27] It seems likely that Carnap inherited this idea from Frege, in whose work the importance of this distinction is repeatedly highlighted, but I will not pursue this point further here.

[28] I think it's instructive to compare Russell, from his *Introduction to Mathematical Philosophy*, on this point. That Quine read Russell, and this book in particular, during his intellectually formative years is well-known. Quine reports as much in his autobiography. Russell writes: "The most obvious and easy things in mathematics are not those that come logically at the beginning; they are things that, from the point of view of logical deduction, come somewhere in the middle". (Russell 1993: 2) It seems to me that Quine is thinking along similar lines.

[29] See (Sher 1999) for additional illuminating discussion of this question.

[30] See, for instance, Quine (1980c;b).

[31] This paragraph is heavily indebted to Ebbs (1997: §22).

[32] Or, more accurately, would not contribute *better* than other options we have available.

[33] See Quine (1951: §IV), Quine (1976a: §III).

[34] On this point, see (Putnam 1979).

[35] And this use is, as Quine puts it, "the technology of truth-seeking" (Quine 1986b: 664) or "the technology of deduction." (Quine 1994: 143)

[36] The paragraph from which these quotations are taken is worth quoting in full. "To implement an efficient algorithm of deduction is no more our concern, in these pages, than was the implementation of communication. But the simplification and clarification of logical theory to which a canonical notation contributes is not only algorithmic; it is also conceptual. Each reduction that we make in the variety of constituent constructions needed in building the sentences of science is a simplification in the structure of the inclusive conceptual scheme of science. Each elimination of obscure constructions or notions that we manage to achieve, by paraphrase into more lucid elements, is a clarification of the conceptual scheme of science. The same motives that impel scientists to seek ever simpler and clearer theories adequate to the subject matter of their special sciences are motives for simplification and clarification of the broader framework shared by all the sciences. Here the objective is called philosophical, because of the breadth of the framework concerned; but the motivation is the same. The quest of a simplest, clearest overall pattern of canonical notation is not to be distinguished from a quest of ultimate categories, a limning of the most general traits of reality. Nor let it be retorted that such constructions are conventional affairs not dictated by reality; for may not the same be said of physical theory? True, such is the nature of reality that one physical theory will get us around better than another; but similarly for canonical notations." (Quine 1960: 161)

[37] Quine agrees. See (Quine 1969: 76).

[38] It is, of course, a matter of psychology which structures we find more simple and why.

[39] Or, more cautiously, Quine *thinks* that his naturalism is more thorough than Carnap's. On Carnap's view, the logic of science involves the development and investigation of language systems, or frameworks, within which scientific inquiry can then be conducted. Thus there is a distinction between properly scientific inquiry (which is *internal* to a framework) and the logic of science (which is *external* to a framework). (Carnap 1956) In "Two Dogmas", Quine famously argues against this distinction and claims that, in so doing, he "espouse[s] a more thorough pragmatism." (Quine 1951: 43)

[40] Ebbs (2014) points out an interesting parallel between Carnap and Quine here. The parallel is that the psychologization of epistemology plays the same role for Quine as the arithmetization of syntax plays for Carnap. In both cases, the point is to show that the "logic of science" is just part of science itself; viz., is just a part of psychology or arithmetic, respectively. Nonetheless, in order to actually make use of a theory or "language system" we cannot regard it as simply psychology or arithmetic, respectively, any more than we can regard the objects over which we quantify as simply "myths" or "cultural posits."

[41] Interestingly, this conclusion also shows that, for Quine, the descriptive project of naturalized epistemology does not supersede the normative project of the logic of science. Both have important places in our overall theoretical picture of the world. Ironically, this means that Quine would likely find fault with many of the latter-day "naturalized epistemologists" whose work he inspired. For more discussion of this point, see also (Johnsen 2005), who reaches this conclusion by rather different means.

[42] Here we assume that the 'derivative from' relation is transitive.

[43] And, hence, the parts of the structure are all confirmed in the same way, viz., derivatively by virtue of belonging to the structure.

[44] Indeed, Quine's introduction of confirmational holism in §V of "Two Dogmas" is accompanied by his despairing of saying anything informative about confirmation: "I am impressed also, apart from prefabricated examples of black and white balls in an urn, with how baffling the problem has always been of arriving at any explicit theory of the empirical confirmation of a synthetic statement." (Quine 1951: 39)

[45] On this point see also Quine's remarks on regimentation, quoted above. (Quine 1960: 161)

[46] As I discussed in §1.2, *one* way in which accepting φ can epistemically commit one to accepting ψ is if φ has ψ as a logical consequence. But as the example under consideration makes plain, it is not the only way. Accepting φ can epistemically commit one to accepting ψ if φ *presupposes* ψ in the sense noted above.

[47] Indeed, this was roughly Leibniz's position.

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