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LOGIC AND REASONING

1. THE PROBLEM

Should we think of logic as a science like physics and chemistry, but more abstract and with a wider application? Or should we think of logic as having a special role in reasoning, a role that is not simply a consequence of its wider application? This is a difficult issue and I for one am unsure how to resolve it. In this paper I will try to say why certain answers are unsatisfactory.

The problem may be hard to appreciate. There is a tendency to identify reasoning with proof or argument in accordance with rules of logic. Given that identification, logic obviously has a special role to play in reasoning. But the identification is mistaken. Reasoning is not argument or proof. It is a procedure for revising one's beliefs, for changing one's view. (Reasoning also effects one's plans, intentions, desires, hopes, and so forth, but I am going to ignore that and concentrate on beliefs.) Reasoning often leads one to acquire new beliefs on the basis of one's old beliefs, but it also often leads one to abandon some old beliefs as well. There is subtracting as well as adding. The question, then, is whether logic has a special role to play in this procedure of belief revision.

Now logicians often speak of "rules of inference", by which they mean certain patterns of implication, such as *modus ponens*, which is sometimes formulated as follows: "From *p* and *if p then q*, infer *q*." Philosophers like Kneale, Dummett, and Hacking take this way of talking very seriously. They say it is a fundamental error to think of basic logical principles as axioms rather than as rules of inference.[1]

What do they mean? Logical principles are not directly rules of *belief revision*. They are not particularly about belief at all. For example, *modus ponens* does not say that , if one believes *p* and also believes *if p then q*, one may also believe *q*. Nor are there any principles of belief revision that directly correspond to logical principles like *modus ponens*. Logical principles hold universally, without exception, whereas

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the corresponding principles of belief revision would be at best *prima facie* principles, which do not always hold. It is not always true that, if one believes *p* and believes *if p then q*, one may infer *q*. The proposition *q* may be absurd or otherwise unacceptable in the light of one's other beliefs, so that one should give up either one's belief in *p* or one's belief in *if p then q* rather than believe *q*. And, even if *q* is not absurd and is not in conflict with one's other beliefs, there may simply be no point to adding it to one's beliefs. The mind is finite. One does not want to clutter it with trivialities. It would be irrational to fill one's memory with as many as possible of the logical consequences of one's beliefs. That would be a terrible waste of time, leaving no room for other things.

I assume here a distinction between explicit and implicit beliefs. Given one's explicit beliefs, there are many other things one can be said to believe implicitly. These include things that are obviously implied by one's explicit beliefs. (They may also include things implicit in the *believing* of one's explicit beliefs, but I will ignore that here.[2]) There is a sense in which one can believe indefinitely many different things with room to spare. For example, one believes that $10{,}001 + 1 = 10{,}002$, that $10{,}002 + 1 = 10{,}003$, and so on. These things are obviously implied by one's explicit beliefs. I assume that there is a limit to what one can believe explicitly and that principles of inference are principles about the revision of explicit beliefs. Considerations of clutter-avoidance rule out cluttering one's mind with trivial *explicit* beliefs; but large numbers of implicit beliefs do not by themselves produce clutter.

The point then is that, whereas logical principles like *modus ponens* are exceptionless, corresponding rules of inference are not. Sometimes one should abandon a premise rather than accept a conclusion that follows logically from what one believes. And, perhaps more importantly, there is the worry about clutter.

It might be suggested that logical principles correspond to principles of reasoning saying what one should *not* believe. In this view the connection between logic and reasoning would be mediated by the rule, "Avoid inconsistency!" But even the rule "Avoid inconsistency!" has exceptions, if it requires one not to believe things one knows to be jointly inconsistent. On discovering one has inconsistent beliefs, one might not see any easy way to modify one's beliefs so as to avoid the inconsistency, and one may not have the time or ability to figure out the best response. In that case, one should (at least sometimes) simply acquiesce in the contradiction while trying to keep it fairly isolated. I would think this is the proper attitude for most ordinary people to take toward many paradoxical arguments.

Furthermore, a rational fallible person ought to believe that at least one of his or her beliefs is false. But then not all of his or her beliefs can be true, since, if all of the other beliefs are true, this last one will be false. So in this sense a rational person's beliefs are inconsistent. It can be proved they cannot all be true together.

Still, it might be said, there is some force to the principle "Avoid inconsistency!" even if this is only a prima facie or defeasible principle which does not hold universally. It holds "other things being equal". Why isn't that enough to give logic a special role in reasoning?

A possible reply is that this is enough only if there are not similar prima facie principles for physics, chemistry, and other sciences. But it would seem there are such principles. Prima facie, one should not continue to believe things one knows cannot all be true, whether this impossibility is logical, physical, chemical, mathematical, or geological.

On the other hand, it may be that, if you know certain beliefs cannot all be true, where this is a physical impossibility, then you must know that those beliefs are incompatible with your beliefs about physics. This would mean that the basic principle can after all be taken to be "Avoid inconsistency!" and logic could play a special role in reasoning.

I am not sure about this. Perhaps logic can play a special role in reasoning *via* inconsistency. If so, that is because of the abstractness and universal applicability of logic. Perhaps we can even define logic as the theory of inconsistency in the sense that the principles of logic are the minimum principles needed to convert all cases in which one knows certain beliefs cannot be true into cases in which those beliefs are logically incompatible with other beliefs one has. Or perhaps we can show that logic defined in some other way also has this property. But this is not the main issue I am concerned with.

I want to put aside this question about inconsistency for a moment, anyway, in order to consider whether logic should play any further role in reasoning. The question I want to consider is whether, in addition (perhaps) to playing a special role in reasoning in telling one what not to believe, logic (also) plays a special role in reasoning in telling one what one may believe.

One possibility, of course, is that logic has no such (further) special role to play. In this view logic is merely a body of truths, a science like physics or chemistry, but with a more abstract subject matter and therefore a more general application.

This is an extreme view that no one seems to hold in an unqualified way, which is surprising, since the view seems to be quite viable. Frege may seem to take the extreme view when he says the laws of logic are laws of truth and since he attacks "psychologism"; but he also says the laws of logic "prescribe universally the way in which one ought to think if one is to think at all",[3] which is to reject the extreme view. Similarly, Quine may seem to advocate the extreme view when he says logic is a science of truths.[4] But he also sees a special connection between logic and inference when he says one needs logic to get to certain conclusions from certain premises.[5] As far as I have been able to determine, other philosophers who may seem at one place to put forward the extreme view that logic is a science, a body of truths, go on some place else to say that logic has a special role to play in reasoning. I am not sure why I cannot find anyone who has unequivocably endorsed the extreme view.

It might be suggested that Lewis Carroll's story, 'What the Tortoise Said to Achilles', shows that logic cannot be treated as merely a body of truths.[6] But that is not so.

In the story, Achilles tries to get the tortoise to accept a conclusion Z. The tortoise accepts A and B but refuses to accept Z. Achilles argues that the tortoise must accept Z since he must agree that, if A and B then Z. The tortoise, being accomodating, agrees to accept C, namely, *if A and B then Z*. The tortoise also continues to accept A and B but still refuses to accept Z. Achilles then says the tortoise *must* now accept Z since this is required by logic. The tortoise agrees to accept anything required by logic and therefore accepts D, namely, *if A and B and C then Z*, but *still* refuses to accept Z. The story continues in this vein with Achilles getting the tortoise to accept more and more logical principles, E, F, G, and so on, without being able to get the tortoise to draw the final conclusion Z.

It might be said that the absurdity of the story lies in confusing a rule of inference with a premise. And, it might be said, the moral of the story is that logic is not just a body of truths but includes rules of inference as well. However, the story shows no such thing.

For one thing, there is a sense in which it is not enough for the tortoise to accept a rule of inference. Suppose the tortosie agrees to accept the rule R, "From A and B infer Z", as well as accepting both A and B. Knowing the tortoise as we do, we know he will *still* refuse to accept Z.

It might be objected that, if after accepting the rule R the tortoise does not infer Z, that shows he does not really accept R as a rule. To accept a rule of inference, it might be said, is to be disposed to draw inferences in accordance with that rule. So, once the tortoise accepts R as a rule, he will at that point finally draw the conclusion Z. The moral of Lewis Carroll's story, then, is that you need more than premises to get to a conclusion. To get from the premises to the conclusion you also need a disposition or readiness to draw a conclusion from certain premises.

That seems right; but the point has no special application to logic. In particular, it gives no reason to think that the acceptance of certain logical principles involves a special readiness or disposition to draw conclusions. To show that rules of inference are to be distinguished from further premises is not to show that rules of inference have any special relation to logic. It therefore fails to show that logic is not merely a body of truths.

Similar remarks apply to what Quine says in 'Truth by Convention'.[7] Quine argues that logic cannot be said to be true by convention, because we can have only finitely many explicit conventions and there are an infinite number of logical truths. Since we cannot have a separate convention for each logical truth, we must instead formulate general conventions to cover many cases at once. But then, Quine argues, logic is needed to get logic from our general conventions. In the same way it might be argued that logic cannot be identified with a logical theory, conceived as a body of truths, since logic would be needed to get to particular logical truths from any general logical theory. But there is a serious mistake here. What is true is that *inference* is needed to get to a particular logical truth from the general logical theory. But that shows no special connection between logic and inference.

So, as far as I can see, no serious objections have ever been raised to the view that logic is a science, like physics or chemistry, a body of truths, with no special relevance to inference except for what follows from its abstractness and generality of subject matter. (I have already observed that this abstractness and generality is what accounts for the way in which logic may perhaps always be made relevant to any case in which one sees that certain of one's beliefs cannot all be true.) So it is strange that no one has unequivocably held the extreme view that logic is simply a body of truths.

That is not to say I am going to be the first to advocate that view. I feel, perhaps irrationally, that logic must have something special to do with reasoning, even if no one has yet been able to say what this might be.

In what follows, I will describe an unsuccessful attempt of mine to develop a theory which would give logic a special role in reasoning. Although this attempt is a failure, I hope it may be instructive. I suspect that any successful theory must incorporate some of the elements of my unsuccessful approach.

2. AN ATTEMPT AT A THEORY

I began with the plausible idea that, if logic has a special role to play in reasoning, that must be because it has a special role to play in the construction of arguments. For it seems that logic does play a role in argument and, furthermore, it seems that argument, calculation, and proof seem at least sometimes to facilitate reasoning. This suggested to me that, if I could understand how argument facilitated reasoning, that might begin to help me see how the use of logic might facilitate reasoning.

I did not assume at the beginning that logic must play a role in all reasoning or even in all argument. For example, I allowed for the possibility that logic is best conceived as a calculus, like the usual arithmetical calculus, or like algebra, or like the use of differential equations, so that learning logic was to learn a special technique. Learning the relevant technique would involve learning to construct arguments in a certain way. Some of one's reasoning might exploit that technique whereas other reasoning might not. Or it might be that everyone uses some sort of logic in constructing arguments, at least sometimes. I wanted to leave this question open. However logic was to be envisioned, the question worrying me was how the logical construction of arguments could facilitate belief revision.

My next thought was that implication would have to be the key. In a valid argument, the premises imply the conclusion, and each step of the argument is the acknowledgement of an implication. Furthermore, it seems that other sorts of calculation can all be treated as techniques for discovering or exhibiting implications. Given certain data, we calculate a certain result, i.e., we calculate that those data imply that result. So I thought that I might be able to understand how argument and calculation facilitate reasoning if I could understand how the appreciation of implications can facilitate reasoning. But why should the recognition of implications be important in reasoning?

This is a difficult question because in a way implication seems so *obviously* relevant to reasoning. One is inclined to wonder how anything could be *more* relevant. So here it is important to recall the points with which I began. It is not always true that one may infer anything one sees to be implied by one's beliefs. If an absurdity is implied, perhaps one should stop believing something one believes instead of accepting the absurdity. And, even if the implication is not absurd and does not conflict with other beliefs, considerations of clutter-avoidance limit how many implications of one's beliefs one can accept.

It might be suggested that implication is relevant to one's reasoning because of one's interest in believing what is true. If one believes *A* and *B* and one sees that *A* and *B* imply *C*, then one knows that, if one's beliefs in *A* and *B* are both true, a belief in *C* would also be true. So, if one has some reason to have a position on *C*, one has a reason to believe *C*. More exactly, one's reasons for believing *A* and *B*, together with one's reasons for believing they imply *C*, along with one's reasons for wanting to take a position on *C* can give one reasons to believe *C*.

The trouble with this suggestion is that it seems to beg the question or perhaps involve the sort of regress that afflicts the tortoise and Achilles. The suggestion seems to be that, in order to infer *C* from one's beliefs in *A* and B, one needs to believe also that, if *A* and *B* are both true, then *C* is also true. Then given certain other conditions one can infer that *C* is true, so one can safely accept *C*. This begs the question since it already assumes that recognition of an implication can mediate reasoning: one infers that *C* is true because the truth of *C* is implied by the truth of *A* and *B* and the proposition that *A* and *B* imply *C*. And a regress threatens, since the suggestion seems to imply that this last inference depends on a prior inference to the truth of "C is true," where that inference depends on another prior inference, and so on.

Furthermore, we might modify the suggestion by substituting considerations of probability for truth and turn the argument into an argument *against* inferring what is (merely) implied by what one believes. If *A* and *B* logically imply *C*, then the probability of *C* will often be smaller than either the probability of *A* or the probability of *B*. This will be true, for example, if *C* is the conjunction of both *A* and *B*, if *A* and *B* are even slightly independent and neither is certain. Indeed, accepting logical implications of one's beliefs could lead one to accept propositions that are quite improbable.

Probabilistic reflections of this sort might be thought to show one should never flatly believe anything but should instead assign one's conclusions varying degrees of belief. And, if one must believe things in an all-or-nothing way, it might be suggested one should adhere to a purely probabilistic rule, believing only what has a sufficiently high probability on one's evidence.

I have argued elsewhere against this sort of probabilistic approach to reasoning. Finite creatures like us cannot operate probabilistically except in very special cases. One problem is that the use of probability can involve an exponential explosion in memory and computation required. Furthermore, the practical uses to which one's basic beliefs are put constrains one's reasoning in a nonprobabilistic way to favour conclusions having to do with means to one's ends; more generally, it leads one to favor conclusions of a roughly explanatory character. One also needs to keep one's overall view of things fairly coherent. For creatures like us, inference must in a sense always be "inference to the best explanation".[8]

Now the question I have raised was how implication might be relevant to reasoning. I have been trying to show that this is a real issue whose answer is far from obvious. That is to prepare you for the hypothesis I arrived at, namely, that implication is relevant to reasoning because it is relevant to explanation.

My previous study of inference had suggested that inference is always "inference to the best explanation" or rather "inference to the best overall view", where relevant factors are conservation, coherence, and satisfaction of desires.[9] Conservatism is a factor in the sense that one should not change one's view without a positive reason for doing so and, in changing one's view, other things being equal, one ought to minimize such change. Coherence is at least in part explanatory coherence. One tries to increase the intelligibility of what one believes, trying to explain more and leave less unexplained. Because of conservatism, one tries to make minimal changes that will do this. One also tries to make minimal changes that promise to promote the satisfaction of one's desires, although that is a factor I cannot discuss here.

This is a brief sketch of the sort of conception of reasoning I had arrived at. I wanted to see how logic might be relevant to reasoning conceived in that way.

One obvious connection is that inconsistency is presumably an extreme form of incoherence. Perhaps that is why we ought to try to avoid inconsistency. It is a special case of trying to avoid incoherence, of trying to make our view as coherent as possible. The fact that coherence is not the only factor in reasoning, conservatism being another factor, would account for why it is sometimes rational to continue to believe things one knows to be jointly inconsistent. For, it may be that, in order to free oneself from all threat of inconsistency, one would have to abandon too much of one's prior beliefs, which would conflict strongly with conservatism. Conservatism can have one continue to accept inconsistent beliefs even though that leaves one with a view that is extremely incoherent in certain respects.

So, one way in which logic is relevant to reasoning may be that inconsistency is an extreme form of incoherence which reasoning seeks to avoid, other things being equal. But this does not yet address the central issue, namely, why seeing that something follows logically from one's beliefs should be relevant to accepting that consequence. It may be why one should refrain from accepting the denial of that consequence, but it does not indicate why one should sometimes positively accept the consequence itself.

At this point, I recalled that explanations often take the form of arguments. We sometimes explain something by showing that it is implied by certain other things. We sometimes understand something by seeing that it is thus implied. Reflections on this led me to the following hypothesis:

1. We sometimes accept arguments as explanations of their conclusions.

If this is right, and if logic is specially relevant to argument, this would point to a second way in which logic was specially relevant to reasoning, over and above any relevance it may have via inconsistency.

Now, sometimes one accepts an argument as explaining something one already accepts. This is inference to the best explanation in the strict sense: one accepts something as the best explanation of one's evidence.[10] There are also cases in which one accepts an argument as explaining something one did not previously accept in terms of things one did previously accept. This is not to accept something as explaining one's evidence but is, as it were, to accept something as explained by one's evidence. Inferences about the future have this form. One infers the sugar will dissolve in one's tea because sugar is soluble in tea. One infers Albert will be in Washington tomorrow because he now intends to be there and nothing is going to change his mind or prevent him from being there.

Thinking about such cases, I was led to the following hypothesis:

2. Whenever one infers C because C is implied by one's prior beliefs B, one accepts C as part of an argument from B to C, which one accepts as an explanation.

Hypothesis 2 is very strong. It implies that any argument that could reasonably lead one to accept its conclusion is a possible explanation.

As soon as I thought of this hypothesis, I remembered the serious objections that have been raised to deductive nomological accounts of explanation, objections which would also seem to apply to hypothesis 2. Consider Bromberger's flagpole example.[11] Bromberger observes that there is a relationship between the height of a flagpole, the angle of the sun, and the length of the flagpole's shadow. Given any two of these quantities, one can deduce the third. In one case this deduction yields an explanation, but it does not seem to do so in the other two cases. One might explain the length of the shadow by citing the height of the flagpole and the angle of the sun; but it does not seem one could normally explain the height of the flagpole by citing the length of the shadow and the angle of the sun,[12] although one could *infer* the height of the pole from the length of its shadow and the sun's angle. Nor does it seem one could normally *explain* the angle of the sun in terms of the height of the flagpole and the length of its shadow, although one could *infer* the angle of the sun from the height of the flagpole and the length of its shadow. In the last two cases, one accepts a conclusion as the conclusion of an argument that does not seem to be explanatory.

Of course, one might infer the height of the flagpole or the angle of the sun as part of the best explanation of the length of the shadow. But that would involve accepting a different explanatory argument whose conclusion was a conclusion about the length of the shadow. It would seem one can also infer the height of the flagpole more directly on the basis of an argument whose conclusion concerns the height of the flagpole, not the length of the shadow. It is this argument which does not appear to be explanatory, contrary to hypothesis 2.

Here is another example. "The man in the red shirt once climbed Mount Whitney. Jack is the man in the red shirt. So Jack once climbed

Mount Whitney." One might infer that Jack once climbed Mount Whitney on the basis of this argument. However, the argument does not explain why Jack climbed Mount Whitney, nor are there materials in the argument for explaining either why Jack is the man in the red shirt or why the man in the red shirt once climbed Mount Whitney.

In thinking about this, it occurred to me to try to distinguish causal explanations, broadly construed, which explain why something happened or why it is the way it is, from explanations that (I feel like saying) merely explain why it is true that something happened or is the way it is. I am not very happy with this way of stating the distinction, but the point is that the argument about Jack may be a kind of explanation after all. It does not explain why he once climbed Mount Whitney, what led him to do it, but it does in a sense explain why it is true that he climbed Mount Whitney. Similarly, although a calculation of the angle of the sun from the length of the shadow and the height of the pole does not explain why the sun is at that angle in the sense of explaining what causes the sun to be at that angle, the calculation does in some sense explain why it is true that the sun is at that angle.

To see that there really are noncausal explanations of this sort, consider mathematical explanations. To understand why there is no greatest prime number is to understand why it is true there is no greatest prime number. It is not to understand what causes there to be no greatest prime number. It is not to understand what leads to this being the case.

To take a different example, one of my daughters, who had been intrigued by her cousin Aaron, finally came to understand why Aaron was her cousin. "He is my cousin," she explained to me, "because his father is your brother." I believe her explanation was not of the causal sort. It explained not how it came about that Aaron was her cousin, but why it is true that Aaron is her cousin.

To take yet another example, consider explaining a particular instance in terms of a generalization. Or consider Newton's explanation of Kepler's laws. Such explanations are not causal. A generalization does not cause its instances, nor do Newton's laws show how the planet's came to observe Kepler's laws. Explanations of this sort explain why something is so without explaining what causes it to be so or what leads to its being so.

The suggestion, then, is that arguments which lead one to accept their conclusions explain why something is true rather than what caused it to happen. The contrary impression, for example, that calculating the angle of the sun does not explain why the sun is at that angle, arises because the calculation does not yield a causal explanation but only an explanation why it is true the sun is at that angle.

I repeat that this terminology is not very good. It is meant only to be suggestive. The point is that there seems to be a kind of noncausal explanation that can take the form of an argument. Arguments which lead one to accept their conclusions may be explanations of this sort rather than of the causal sort.

However, it is not important what terminology is used. The suggestion is that explanations of a sort that are clearly explanations have something in common with arguments that can figure in reasoning. They can both facilitate reasoning because they are both ways of connecting propositions that can lend coherence to one's beliefs. Although I prefer to say that arguments are explanations, which explain why something is true, anyone who objects to this terminology can interpret it as saying that arguments can induce such coherence.

But this still does not address the main issue. Even if implication is relevant to reasoning because implication can be explanatory (or can induce coherence), that is not yet to assign a special role in reasoning to logic, unless logic can play a special role in explaining why something is true (or in inducing coherence).

In thinking more about this, I considered the familiar idea that certain logical implications are immediately obvious and that other, nonobvious, logical implications can always be mediated by a series of obvious logical implications. In fully explicit arguments or proofs, each step should be an immediately obvious consequence of premises and/or previous steps. Logical rules of "natural deduction" atempt to characterize these immediately obvious steps.[13] This suggested to me that the special role of logic (if there is one) might depend on something about the immediately obvious implications that are captured by rules like the rules of natural deduction. I was therefore led to the following hypothesis:

3. Certain implications can facilitate inference because they are immediately explanatory or express immediately intelligible connections of the sort that yield coherence.

All such implications are obvious. One sees immediately that they hold.

This is not to say every obvious implication is necessarily "immediate". One might be able, as it were, to combine several intermediate steps in one thought. Furthermore, one might rely on certain unstated other premises.

It may not be easy to say whether an implication is immediate in this sense. Consider, for example, "Today is Friday, so tomorrow is Saturday." Is that an immediate implication in the relevant sense, or does it involve intermediate steps and unstated premises, such as that Saturday is the day after Friday and that tomorrow is the day after today? I saw I would have to address this issue. But first I thought I should try to relate hypothesis 3 to logic. So I proposed the following hypothesis:

4. There are basic logical implications which are immediately explanatory (immediately intelligible).

These immediately intelligible logical connections would presumably include implications covered by the basic principles of natural deduction, such as *modus ponens* ("*p* and *if p then q* implies *q*").

3. LOGIC AND LANGUAGE

I was now faced with the problem that my hypotheses were so far untestable. I had no way to distinguish immediate implications from other obvious implications; no way to say whether "Today is Friday, so tomorrow is Saturday" was an immediate implication. It was therefore unclear what it could mean to say that certain logical implications were immediate, at least if this was supposed to say more than that they were obvious implications.

Furthermore, I needed an independent criterion of logic. Otherwise it would be possible to trivialize hypothesis 4 by counting all immediate implications as logical implications. For example, if "Today is Friday, so tomorrow is Saturday" represents an immediate implication, nothing so far said would prevent it from counting as a logical implication. But, if one can in this way count every immediate implication as logical, that trivializes the claim that logic plays a special role in inference, given hypotheses 1–3.

A distinguished tradition suggests the following further hypothesis:

5. Logical implications hold by virtue of logical form, where this is determined by the grammatical structure and logical constants involved.

So, for example, consider the following implication: "If it is raining, the picnic is cancelled. It is raining. So the picnic is cancelled." This counts as a logical implication by the present criterion since the implication holds by virtue of the logical form of the propositions involved, given that "if . . . then" represents a logical constant.[14]

Famously, Hypothesis 5 does not provide an adequate criterion of logic in the absence of a way to distinguish logical constants from other terms. Whether we should count "Today is Friday, so tomorrow is Saturday" as a logical implication depends on whether or not "today", "tomorrow", "Friday", and "Saturday" are logical constants (in a kind of tense logic). What determines the logical constants?

We could arbitrarily determine the logical constants by simply listing the terms we want to count. Somewhat less arbitrarily, we could use some sort of technical criterion to distinguish logic from other subjects and to pick out the logical constants. There are many different ways to do this, yielding many different demarcations, so that what counts as logic according to one technical criterion may fail to count as logic according to another. For example, the logical constants might be identified as those terms whose meaning can be completely determined by introduction and elimination rules of a certain sort in a Gentzen-style sequent calculus. Or they might be identified as those terms whose meaning can be completely determined by such introduction and elimination rules in a system of natural deduction. Hacking claims the former method would count the classically valid implications as logical, whereas the latter would count as logical only those that are intuitionistically valid.[15]

Now, since I was concerned with the idea that logic has something special to do with reasoning, I was disinclined to adopt an arbitrary or purely technical characterization of the logical constants. It seemed to me the identification of the logical constants should reflect something about our practices, about what our reasoning is or at least should be. So, it seemed wrong to me to appeal to the sequent calculus, which plays no obvious role in ordinary reasoning. And, although natural deduction is a plausible candidate for something that plays a role in ordinary reasoning, I was not happy to *begin* with an account of logic that immediately yielded intuitionistic rather than classical logic. And I was similarly unhappy with other relatively arbitrary or technical ways I could think of to specify the logical constants.

Now, philosophers and linguists occasionally discuss the "logical forms" of sentences of natural languages, and every once in a while it even seems that interdisciplinary collaboration in this area might prove fruitful (although this may be an illusion). This suggested to me the following hypothesis:

6. The logical constants are grammatically distinctive in a way that has something to do with their special role in reasoning.

For example, Quine suggests that logical constants belong to small classes that are closed in the sense that it is not easy to add new terms to these classes, whereas nonlogical terms belong to large open classes to which new terms are added all the time.[16] Quine makes this suggestion about a regimented formal language, but it seemed to me the suggestion might be applicable as well to a natural language like English. The suggestion takes the logical constants to be relatively fixed, in the way that grammar is. Since the principles of logic are determined by grammatical form plus the logical constants, this suggestion would treat logic as relatively fixed as compared with theory. Changes in the logical constants and therefore changes in logic would be possible, just as changes in the grammar of the language are possible, but these changes would be unusual as compared with changes in theory due to changes in belief and in new theoretical terminology.

I liked this. It fitted in with the idea that logic has a different function from theory, so that changes in logic would involve different sorts of changes from changes in theory. It also nicely fitted in with the idea that, although one's explicit beliefs are finite, they represent infinitely many things implicitly, by implication, where the means of representation, logic, is fixed in a way that the varying explicit beliefs are not. So, I was inclined to accept Quine's suggestion and apply it to natural languages.

Stating the suggestion accurately requires some care. Not every small closed grammatical class is a class of logical constants. Prepositions in English form such a class but some of them are probably best treated as nonlogical predicates, "between" and "over" for example. What is needed is to assign words to *logical* categories, like proposition, name, one-place predicate, two-place sentential connective, quantifier, and so on. We need to consider the class of words representing atomic members of a given logical category. Then we can put forward the following hypothesis:

7. The logical constants are those words which belong to small closed classes of atomic members of logical categories.

By this criterion, "and" will count as a logical constant, since the relevant class of atomic sentential connectives is small and closed; "between" will count as a nonlogical term, since the relevant class of atomic relations is large and open, even if it is hard to add more *prepositions* to that class. I could say more about the idea behind hypothesis 7, but I won't since I have discussed it elsewhere.[17] For our purposes, the details of hypothesis 7 are not important. I put the hypothesis forward only as an example of a way to elaborate hypothesis 5.

Notice that, however hypothesis 5 is elaborated, it will imply that some of one's reasoning is or ought to be influenced by the language one speaks. Some reasoning will depend in part on recognition of an immediate logical implication, where one recognizes the implication *because* it is an instance of a basic logical principle. What makes the implication a logical implication is that it holds by virtue of logical form, in other words by virtue of the grammatical form and logical constants of the propositions involved. So what is relevant will be how the propositions are expressed in language. In a sense, then, the relevant reasoning must be reasoning in language.

I did not mind this result. I was already inclined to believe that there are at least two important uses of language, its use in communication and its use in calculation or reasoning. I had earlier noticed, for example, that, although many philosophers believe that meaning is use, some take the relevant use to be calculation, theorizing, verification, confirmation, and so on, and others take the relevant use to be communication and speech acts. Surely both sides are pointing to important aspects of language.[18]

I should say I am not at all attracted by the idea that thought is always in language. I believe most thought is not in language and that even thought in language may be only partly in language and partly in some other form of representation. Of course, by "language" here I mean a language one speaks, like English. If we say there is a "language of thought" (which is something I sometimes say), then the point is that, in my view, the language of thought includes the language one speaks and also includes other things as well.

Can there be logical constants in the language of thought that are not part of the language one speaks?[19] I saw I had better assume not. Work in linguistics gives some reason to think sentences of a natural language have a fairly determinate grammatical structure, and this work gives at least some idea of what that structure might be. There is no work of any sort that would suggest anything similar for sentences of the language of thought. So, I saw that, if I was to have any hope of avoiding unconstrained speculation, I had better assume this:

8. Logical constants are terms in a natural language one speaks.

Now, if hypotheses 5–8 are correct, it might seem we could speak of the logic of a given language, the logic determined by its grammar. But that would be true only if there was a unique grammar of the language, which furthermore determined a unique logic. This does not seem to be so. It would still seem that various competing accounts of the logic of a natural language like English are compatible with hypotheses 5–8. Consider for example how time and tense might be treated in the logic of English. One analysis might invoke a tense logic with logical constants like "past", "future", "before", "after", "today", and maybe even "Friday", and "Saturday". A different analysis would appeal to a more classical logic plus a nonlogical theory of time. It is not obvious that grammatical considerations favor one of these analyses over the other.

Another example would be how adverbs in general are to be analyzed logically. In one analysis there is an adverbial logic in which adverbial modifiers form a large open logical class. This class includes the word "not", so that "not" fails to count as a logical constant in this analysis. An alternative analysis treats most adverbs, but not "not", as predicates, so that for example the use of "suddenly" is analyzed as an application of the predicate "sudden" to an event. This dispute can be vigorously pursued, but it seems to me that grammatical considerations alone are insufficient to settle the issue.

And, as long as logic remains indeterminate, hypotheses 1–8 are themselves indeterminate and untestable.

4. COLLAPSE OF THE THEORY

Now one way to get testability and also to treat logic as having a unique role in reasoning would be to put forward the following strong hypothesis:

9. All immediately intelligible implications expressed in language are logical implications.

This would imply that all obvious implications expressed in language either are logical implications or depend on unstated obvious assumptions, where one recognizes that the implication follows logically given those assumptions.

If hypothesis 9 is accepted together with the previous hypotheses, an empirical study of how easy it is for people to recognize implications of various sorts might help determine what the logic of our language is, since, given hypothesis 9, these empirical results might not be compatible with all the analyses permitted by grammar. The trouble is that hypothesis 9 is too strong given the earlier hypotheses. It gives us testability at the price of refutation.

The problem is that there are patterns of obvious implication that are not going to be counted as logical by the grammatical criterion and which cannot be treated as involving a series of logical steps from unstated obvious assumptions. I am thinking here of such patterns as "S knows that *P*, so *P*" or "It is true that *P*, so *P*." People do, or can come to, treat instances of these patterns as obvious implications. Furthermore, the obviousness of the implications does not depend in any significant way on the complexity of the proposition *P*.

This is a problem, because the implications are not just due to the grammatical forms of the propositions involved but depend on the words "know" and "true". The implications do not hold if other words replace these words. Neither "*S* believes that *P*" nor "It is unlikely that *P*" implies "*P*". But "know" and "true" are not logical constants. That is ruled out by the grammatical test. Both words are best treated as members of large open classes of atomic members of some logical category. "Know" should be classed with "believe", "hope", "fear", "expect", "regret", and so on, which are not logical constants. And "true" should be classed with "unlikely", "probable", "possible", "delightful", "surprizing", and so on.

So our hypotheses imply that these patterns of logical implication are not logical patterns. That means, by hypothesis 9, they depend on hidden premises, on unstated obvious assumptions. The needed premises will be part of a theory of knowledge or of truth.

These premises either are explicitly believed or are themselves obvious consequences of other things explicitly believed, in which case the latter things are the basic assumptions appealed to. Since one's explicit beliefs must be finite, recognition of instances of these patterns of implication must depend on acceptance of some sort of finite theory of knowledge and theory of truth. Now, it would seem that, given anything like classical first-order quantificational logic, a finite theory of either sort adequate to account for all instances of the relevant pattern will require connecting arguments that become more complex as *P* becomes more complex. So, given first-order logic, hypothesis 9 predicts a fairly rapid decline in obviousness for instances of the pattern as the complexity of *P* increases. As already noted, that prediction is false. Therefore, our hypotheses require that the logic of the language, in this case English, cannot be classical first-order quantificational logic. We need to assume a logic which will allow each instance of the pattern to depend fairly simply on some unstated assumption.

More precisely, we need a second-order logic that would allow one to express the assumption, "For all *P*, if someone knows that *P*, then *P*." With that as an implicit assumption, each implication of the pattern can be derived in two steps, first getting the relevant instance of the implicit assumption, then applying *modus ponens*.

The trouble is that English does not appear to involve second-order logic, at least in this way. The crucial assumption, "For all *P*, if someone knows that *P*, then *P*," is not as stated expressed in ordinary English. Indeed it would seem to have no ordinary means of expression. The closest one can come is "If someone knows something, it is so." But that would seem to be a purely verbal variant of "If someone knows something, it is true." That is not what we want, as is evident from the fact that we need also to account for implications of the pattern "It is true that *P*, so *P*."

It is sometimes argued that English *does* allow higher-order quantification. If that were so, it would be some confirmation of the hypotheses I have stated. But I am doubtful. Strawson notes that we say things like "Albert is everything one would want in an assistant."[20] However, that construction is marginal and its interpretation is obscure. Grover, Camp, and Belnap suggest that "it is true" might function as a "pro-sentence", which is related to a sentence as a pronoun is to a noun phrase, functioning logically as a variable taking sentence position.[21] This would imply that the statement, "If someone knows something, it is true," is the way to express in English the proposition. "For all *P*, if someone knows that *P*, then *P*." But this seems wrong as an account of how "true" functions in English.[22]

So, I reluctantly conclude that some immediate implications are nonlogical, the ones just discussed and perhaps many others as well. This means that hypothesis 9 must be rejected; logic is not the only source of immediate implications. But then we cannot constrain logico-grammatical analysis by means of data concerning the implications people find obvious. So, it remains unclear whether the grammatical criterion will single out a unique logic of English. And that means we will not be able to say what the boundaries of logic are. So we end up with no nonempty hypothesis concerning the special role of logic in reasoning. This attempt to make sense of that idea ends in failure. Whether there is some other way to make sense of that idea I cannot say.

NOTES

[1] "The representation of logic as conceived with a characteristic of sentences, truth, rather than of transitions from sentences to sentences, had deleterious effects both in logic and philosophy." Michael Dummett, *Frege: Philosophy of Language*, Duckworth, London, 1973, pp. 432–433. Dummett's remark is quoted with approval by Ian Hacking, for whom "logic is the science of deduction" in accordance with "rules of inference" like Gentzen's introduction and elimination rules. See Ian Hacking, 'What Is Logic?' *Journal of Philosophy* **76**, 285–319, quoting from pp. 292–293; and Gerhard Gentzen, 'Investigations into Logical Deduction', a translation of a 1935 paper by M. E. Szabo in *The Collected Papers of Gerhard Gentzen*, North Holland, Amsterdam, 1969, pp. 68–131. See also W. C. Kneale, 'The Province of Logic', in H. D. Lewis, *Contemporary British Philosophy*, Third Series, Allen and Unwin, London, 1956.

[2] For an example, see my "Reasoning and Evidence One Does Not Possess', *Midwest Studies in Philosophy* **5**, 1980, 163–182, esp. p. 172.

[3] Gottlob Frege, *Grundgesetze* (1893), partial translation by M. Furth, *The Basic Laws of Arithmetic*, University of California Press, Berkeley, 1967, pp. 12–13.

[4] W. V. Quine, *Methods of Logic*, Holt, Rinehart, and Winston, New York, 1972, pp. 1–5.

[5] Quine, *Methods of Logic*, p. 39, and 'Truth by Convention', in *The Ways of Paradox*, Random House, New York, 1966, pp. 70–99. I will say more about this article in the text below.

[6] Lewis Carroll, 'What the Tortoise Said to Achilles', *Mind* **4**, 1895, 278–280.

[7] Cited in note 5.

[8] Gilbert Harman, 'Reasoning and Explanatory Coherence', *American Philosophical Quarterly* **17**, 1980, 151–159.

[9] Actually, it is probably an exaggeration to say "best" here. Herbert Simon observes

that it is often more reasonable to "satisfice" than to maximize. See Herbert A. Simon, *Administrative Behavior*, 3d ed., The Free Press, New York, 1976, e.g., p. xxviii; 'A Behavioral Model of Rational Choice' reprinted in Herbert A. Simon, *Models of Thought*, Yale Univ. Press, New Haven, 1979, e.g., p. 11. It may be better to say one infers a satisfactory explanation, if one can think of one, without one's normally attempting to find the best explanation.

[10] Perhaps it would be more accurate to say this is inference to *satisfactory* explanation of one's evidence.

Here, of course, I am using the term "explanation" to refer to what one grasps when one understands why something is, was, or will be the case. I say one grasps an explanation when one grasps something of the form "*A* because *B*." There is another sense in which an explanation is a speech act, an *explaining*. In the second sense, one can explain only what one already believes to be the case. But in the first sense, in which I am using the term "explanation," one can come to see that something one already knows about will be responsible for and will therefore account for and explain something about which one was previously ignorant.

[11] Sylvain Bromberger, 'Why Questions', in R. G. Colodny (ed.), *Mind and Cosmos*, Univ. of Pittsburgh Press, Pittsburgh, 1966.

[12] Bas van Fraassen observes that such an explanation might be possible if the pole was constructed so as to cause a shadow of that length when the sun is at that angle. But, of course, that is not the usual case. See Bas van Fraassen, 'The Pragmatics of Explanation', *American Philosophical Quarterly* **14**, 1977, 143–50.

[13] See Gentzen, 'Investigations into Logical Deduction'.

[14] And given that "if ... then" represents a sentential connective. In fact, there are reasons for a different analysis in which *modus ponens* is not a principle of logic. See Gilbert Harman, "If and Modus Ponens: A Study of the Relations between Grammar and Logical Form', *Theory and Decision* **11**, 1979, 41–53.

[15] Ian Hacking, 'What is Logic?', 292–293.

[16] W. V. Quine, *Philosophy of Logic*, Prentice-Hall, Englewood Cliffs, 1970, pp. 28–29, 59.

[17] Gilbert Harman, 'If and Modus Ponens'.

[18] Gilbert Harman, 'Three Levels of Meaning', *Journal of Philosophy* **65**, 1968, 590–602.

[19] Here I am indebted to Kit Fine.

[20] P. F. Strawson, *Subject and Predicate in Logic and Grammar*, Methuen, London, 1974, p. 33.

[21] D. L. Grover, J. C. Camp, and N. D. Belnap, 'A Prosentential Theory of Truth', *Philosophical Studies* **35**, 1979, 289–297.

[22] Sarah Stebbins, 'Necessity and Natural Languages', *Philosophical Studies* **35**, 1979, 289–297.

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