

Natural Necessity

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Introduction

Natural laws and principles are not merely true, but necessarily true, according to a common intuition. For example, the principle of energy conservation (“In all closed systems, energy is conserved”) is considered to be necessarily; it is not a mere coincidence that energy is conserved in a closed system. But what does that mean? What are the conditions for something to be necessary?

If we could give an adequate definition of the concept of natural law in non-modal terms, we could say that these are necessarily true just because they are laws. But, as we have learnt from Goodman [1955], this is impossible. The problem is to distinguish between laws and accidental generalisations; these two kinds of statements have exactly the same form (i.e., ‘for all x , if Ax , then Bx ’) when formulated in first order predicate logic and both are taken to be true. But what, then, is the difference between a law and an accidental generalisation? Since we cannot tell what we mean by a natural law by merely giving its logical form, it is hard to avoid the conclusion that the concept of natural law is a modal concept. Many have thought that the need for such a modal concept is thought to reflect a real feature in the world: laws express necessities in nature, i.e., necessity *de re*. Another way to express the same idea is to say that there is a distinction between *essential* and *accidental* properties; natural laws tell us what essential properties classes of things have.

Hume, like all empiricists, rejects this notion of natural necessity as bad metaphysics. A law is merely a regularity, a true generalised conditional, and the only acceptable necessity is logical necessity. There is no real distinction to be made between laws and other true generalised conditionals; the supposed necessity is but a projection into nature of something that exists only in our minds. Although I consider myself an empiricist, I cannot really force myself to accept this stance. Consider for example the following two statements:

#1 All spheres of U-235 are less than one km in diameter.

#2 All spheres of gold are less than one km in diameter.

Suppose for the sake of argument that both are true, so that we have two true statements of exactly the same form. Still, there is an important difference between them, a difference most simply expressed by saying that: #1 is necessary, but #2 is a contingent. This well-

rehearsed example illustrates the difference between laws and accidental generalisations and I cannot really force myself to accept that the difference is merely a projection from my mind into the world. It seems to be that the difference is objective and has to do with how the world is like. But what, then, are the reasons for making this distinction?

In what follows I shall try to find a position regarding natural necessity, which avoids both the Scylla of postulating irreducible metaphysical necessity and the Charybdis of Humean regularity account of laws.

Fundamental laws and derived laws

As a beginning, let us consider the fact that the necessity of *some* physical laws can be accounted for by referring to their derivability from basic principles. These laws are thus said to be necessary because being entailed by other laws. This could be understood in two ways. Either we can view ‘necessary’ as a sentence operator, which is shorthand for a conditional with tacit antecedent. Thus, for example, ‘the general law of gases is necessary’ could be construed as ellipsis for ‘the general law of gases follows from the principle of energy conservation (given some definitions and auxiliary assumptions)’. (The question what this law is *true of* could be left aside in this context.). There are many expressions in common language which best is understood in the same way. Suppose I say to my guest after looking up the timetable for the bus: ‘You must go within five minutes.’ (I take it that ‘must’ expresses necessity.) It is obvious that the context is such that I need not say; ‘You intend to catch the next bus, and you cannot do that unless you go within five minutes, hence you must go within five minutes.’ Or, to take another example, suppose a math student says to himself during a calculation ‘The function must be negative.’ It is obvious that ‘must’ here indicates a logical consequence from information given to him. The observation can be found in Quine [1976]

A stronger view would be to say that since the principle of energy conservation is necessarily true, all its logical consequences are necessarily true, since ‘necessarily’ distributes over logical deductions.

I doubt that any of these views are *explicitly* held by most people saying that the general law of gases is necessarily true. That doesn’t matter; the crucial thing is if it is possible to reconstruct our intuitions about natural necessity. And I hasten to add, ‘while invoking as little metaphysics as possible’.

It is immediately clear that whatever view we take we are left with the necessity of those laws, postulates and principles used as premises in derivations unexplained. I will call these

things *fundamental laws*. So what do we mean when saying that a fundamental law is necessary? A popular answer is to say that it means it is true in all possible worlds. But what is that?

Possible worlds

Modal logicians claim to have a general explanation of necessity and possibility. The basic idea goes back to Leibniz, who once explained ‘necessarily true’ as ‘true in all possible worlds’. The critic will immediately ask: what is a possible world? This expression seems to be just as modal as ‘necessary true’ and as much in need of explanation. The modern possible world semanticists claim to have an answer. A possible world is described in non-modal terms using set theoretical language. One postulates a set of worlds, some of which are possible, some not, and define ‘necessary true’ as true in all possible worlds, and ‘possibly true’ as true in at least one world.

But what, then, is the difference between a possible and an impossible world? The answer is usually given in terms of a relation called ‘accessibility’ and obtaining between our actual world and all possible worlds and only those. A possible world is in this theory just a name for a member of the set of accessible worlds. Hence, the modal distinction necessary/contingent has been transformed to a distinction between two subsets of the set of possible worlds. Formally this solves the problem of giving a semantic interpretation of the alethic modalities without using modal expressions. The price is of course the introduction of the relation ‘accessible’; under what condition is a postulated world accessible from our world? Unless we are given a non-modal characterisation of this relation, this cannot be sufficient as a characterisation of the meaning of ‘necessary’, as said of laws. We have replaced one conundrum, the meanings of ‘necessity’ and ‘possibility’, with another, viz. the meaning of ‘accessibility’. Of course, the analysis solves the formal problem of giving a semantic of modal predicate logic in non-modal terms. But this is not my problem; my problem is rather ontological and epistemological. What reasons do we have for distinguishing between necessary and accidental true generalised conditionals and what is a possible world?

Lewis’ account

David Lewis has an account of accessibility [Lewis 1973], but it presupposes the concept of natural law; a possible but non-actual world is accessible from our actual world just in case our natural laws are true in that world. This works since he has an independent analysis of

natural laws. But, of course, it is of no use for our present purpose since that would make the account circular.

But why not adopt Lewis account of laws? The basic problem was to analyse the concept of natural law and necessity came in as a distinguishing trait between laws and accidental generalisations. But an account of natural laws not using necessity would solve our problem.

Lewis' idea is in outline that a natural law is an axiom in the future simplest complete theory of nature. This conception is an elaboration of Mill's account of laws. I have some sympathy for this idea; my intuition that for example the principle of energy conservation is a fundamental natural law contains the belief that we will probably never give it up; it will still be a foundational element in physics even in the far future. However, Lewis' theory has severe weaknesses, as is pointed out by van Fraassen [Van Fraassen 1989, 51 ff.]. His criticism is that since there are innumerable many true theories about the world (van Fraassen takes underdetermination of theory by evidence for an established fact), we should pick out the theory that best combines simplicity and strength. And in fact we have three independent criteria; simplicity, strength and balance between these desiderata. There is strong reason to assume that simplicity and strength pull in opposite directions; adding one more postulate to a theory increases strength but decreases simplicity. Hence the locution 'the simplest complete future theory about the world' does not pick out any single theory. I think van Fraassen's critique is hitting and Lewis' account of natural laws is not satisfying. Hence, this way of avoiding necessity in the analysis of natural laws is not successful.

Necessity as logical consequence

Even the strongest critics of modalities and essences accept the notion of logical necessity as sufficiently clear and metaphysically innocent. They argue that logical truth is a perfectly clear concept and one can identify logical necessity with logical truth (and logical possibility as non-contradiction with the logical axioms). So there is, according even to empiricists, one sense in which 'necessary' is acceptable.

In a recent paper Scott Shalkowski [Shalkowski, 2004] argues that anti-essentialists are mistaken in thinking that logical necessity (and logical possibility) should be granted such a privileged status. He concludes his paper by saying that

“What we cannot have is an attitude that logical necessity is straightforward and innocent and comes at little theoretical cost because it is given by model theory, as though the model theory were itself independent of metaphysical commitment. The

metaphysics of logic must be confronted even if one adopts the position that logic is the most general science. The semantics for ordinary logic is general, but it is certainly not metaphysically neutral, a point most easily missed when the range of logics is not fully appreciated. I conclude that there is no philosophical advantage to admit only logical necessity, as it is traditionally and classically understood, as one's favoured modality, and that essentialism should be viewed with far less suspicion than is common. " [2004, 82].

The core of Shalkowski's argument is this. Logical consequence is defined in terms of truth tables. Suppose that such truth tables represent no modal information at all. Then their content is no more than that no proposition is both true and false and none manages to be neither, hence we have no reason to think that had the world been different, not all members of an inconsistent set of propositions would have been true. Reductio arguments would not tell us anything about how the world might be. But, in fact, we take it for granted that no matter how the world is like, or would have been like, it cannot correctly be described by an inconsistent set of propositions, which shows that not even logic is metaphysically neutral.

I agree with Shalkowski's general point that logic is not metaphysically neutral. But I'm not convinced that we should say that it contains modal information. Modality *de re* introduces distinctions between essential and contingent properties (or kinds of predication) and it is not clear to me that such a distinction is implicit in using truth tables as the analysis of logical consequence. But Shalkowski is right in claiming that classical logic is not metaphysically neutral. In fact, this is a point made by Dummett in several papers. He has pointed out that accepting the principle of bivalence is the characteristic trait of realism and the common feature of various kinds of anti-realism is that they reject the general validity of this principle (and hence the validity of double negation elimination). And, since the dispute between realism and antirealism is perhaps the most basic metaphysical dispute, it follows that a metaphysical dispute has implications for which logical principles one accept as valid. [Dummett 1991, preface]

Dummett's argument is in short that realism means that any well-formed statement is either true or false independently of our capacity to recognize which is the case. It follows that every well-formed statement is either true or false, hence bivalence. But antirealism denies that; to be an antirealist in a particular area of discourse is to deny that truth is evidence-transcendent. Dummett suggests that instead the anti-realist should define truth in terms of

canonical verification. Since there are statements (in fact there are many) which we have neither evidence for or against, it follows that the antirealist cannot say they are true, nor that they are false, hence bivalence as a general principle is rejected.

I think this is a good characterisation of the dispute between realism and antirealism and it is perfectly clear that questions of logical validity are not independent of metaphysics. But, to repeat, I don't see that this is dispute about modalities.

My own reasons for being sceptical about necessity and possibility is their lack of clarity, not primarily their metaphysical character and I think the same is true of many other sceptics. But logical necessity, interpreted as logical consequence, is sufficiently clear, and that's why we don't hesitate to use this notion, no matter it's metaphysical content, since we can state the different metaphysical positions in terms of different attitudes to a clearly stated principle.

Objects and predication

Let's return to the fundamental problem of giving an analysis of the necessity of fundamental laws. What reasons could be given for saying that the connection between two predicates, those occurring in the antecedent and consequent in a fundamental law of the canonical form, is necessary? The notion of essential attribution comes easily to our minds and this is connected, I will now suggest, to individuation of objects. My starting point is, perhaps astonishingly, Quine's own views.

Quine was always deeply sceptical about modal logic. In one paper his final argument was that modal logic leads us to what he called 'the metaphysical jungle of Aristotelian essentialism' [Quine 1953, 176]. His complaint was, I guess, that the modal distinction necessary/contingent, as applied to predicates, lacked clear criteria. Or perhaps he tacitly assumed that the evidence for saying that a statement is necessarily true cannot differ from the evidence for its being simply true and hence the distinction should be dismissed by any empiricist. As far as I know he didn't bother to argue against essentialism.

Aristotelian essentialism is the claim that objects have some of its properties by necessity, others contingently. It could be formalised as

$$\exists x(\Box Fx \& Gx \ \& \ \neg \Box Gx)$$

Realism about universals is not the fundamental issue here. A nominalist denying that properties exist could instead formulate the idea as a distinction between essential and non-essential predication.

Quine was certainly correct in his claim that modal logic presupposes Aristotelian essentialism, but was he similarly correct in taking this to be a reductio argument against

modal logic? I think not. In fact, I can see the outline of an argument in favour of a distinction between essential and contingent predication (and a fortiori a way of introducing necessity *de re* in the regimented language) in some other of Quine's writings. It goes like this.

Quine, like most philosophers of language, takes the sentence as the basic entity in semantics, because only sentences are true or false, and it is with truth and falsity we must start. What we can observe when people use language is whether they dissent or assent to an utterance, i.e., we can observe whether others take a sentence to be true or false. *Reference* and *meaning* are subordinate.

An atomic sentence is composed of a singular term and a general term, a predicate. The singular term identifies the object (person, event, state of affairs or whatever) we are talking about and the general term predicates something about the object. When we say that a sentence is true, we thereby say that the singular term *refers* to an *object* and that this object *satisfies* the predicate forming the rest of the sentence.

But why should we adopt the usual analysis of sentences as being made up of singular terms, referring to objects, and predicates? It is natural, but is it mandatory?

Quine's answer is *no*. We need not view all meaningful talk to be about objects. A sentence such as 'it's raining' could just as well be seen as conveying the information of a feature, 'rain', in the vicinity. In such a case nothing is gained by postulating an object, Quine claims and I agree.

What then is the distinction between talking about mere features and talking about objects? Posed in this way there is no real distinction; talking *about* a feature or a thing is to perform a predication, i.e., we identify something (a feature or an object) and say something about it. The point is rather that describing language use as talk about features instead of objects is meant to indicate a way of talking in which no separation between noun and predicate has occurred. We could begin the analysis by viewing a sentence as an unstructured linguistic unit, which we accept or reject (assent or dissent). Hence, we should rather ask, what is the crucial step towards the analysis of this undivided unity into two parts, noun and predicate? Quine's answer is that this step is taken when starting to use *essential pronouns* [1995, ch. 3]. Essential pronouns are those, which cannot be replaced by nouns without change of meaning. Quine's example was 'Look, there's a raven. *It* is black.' If we say instead, 'Look, there's a raven. A raven is black', we have not said that the very *same thing* is a raven and is black. The information contained in the two sentences 'Look, there's a raven' and 'A raven is black' could be formulated as 'ravenhood occurs' and 'ravenhood and blackness co-occurs'. No individual object need be assumed. But when we use 'it' essentially,

we first identify something by a description and then say something else about *it*, and that means introducing the concept of an object, as distinct from mere variable features.

An object is thus a thing, which has at least two properties; one property is needed for identifying it (by a definite description) and another property is predicated of it in a declarative sentence.¹ Strawson, by the way, arrives at the same conclusion, using a somewhat different argument [Strawson 1959, 23].

The final step in reification, introduction of objects, is taken when we start talking about identity of objects, according to Quine. Think about abstract objects; why should we assume any such things? Why, for example, do we postulate numbers, a kind of abstract objects, as referents of their names, the *numerals*? The answer is that an object can have several descriptions and names, and these refer to one and the *same* thing. Objects have identity criteria and this is true of all kinds of objects. But then, from where do we get these identity criteria?

Quine's discussion of Theseus's ship indicates an answer. When the adventurer Theseus had returned to Athens his ship was kept as a museum boat in the harbour of Piraeus. From time to time rotten planks had to be replaced, thus triggering the question 'would it still be Theseus's ship when every plank has been exchanged?' Quine's answer is that the question has to do with the identity criterion associated with the general term 'ship'. And since we use spatio-temporal continuity considerations and not sameness of substance when individuating among physical objects, we tend to say that still it is the same ship. His basic point is that 'Any coherent general term has its own principle of individuation, its own criterion of identity among its denotata.' [Quine 1981, 12]. Language use determines what to count as one and the same thing.

This insight seems to me to be fundamentally correct, although there are problems of identity among purported 'quantum objects' such as photons or electrons. I have discussed this elsewhere [Johansson 2006, ch. 3], my conclusion being that we should accept Quine's position and hence say that photons and the like are not individual things, they are mere portions of conserved quantities.

¹ One might object that some objects are referred to by their names and since these lack descriptive content one cannot generally say that we need two properties for identifying something as an object. I think there are arguments against this stance, but since names never occur in generalised conditionals, this is irrelevant for my purpose in this paper.

Individual objects, things, be they physical visible objects, physical invisible objects or abstract ones, are thus in a sense theoretical constructions needed for making full sense of our language use. (From an evolutionary perspective one might guess that this reflects features in the world, since our cognitive apparatus has developed by continuously adapting to traits of the world, which are important for survival and reproduction. This is an argument for realism, but outside the scope of the present discussion.) And we may add, they are basic elements in our ontology. Objects, in the most general sense of the word, are what we talk about.

Objects of vision

There is a parallel story to be told from the perspective of cognitive psychology. Petra Stoerig [Stoerig, 1996] has analysed a great number of records of people with different kinds of visual disabilities. She has discerned three stages in our processing of visual stimuli: i) to have visual experiences, ii) to see an object, iii) to recognize an object.

To have visual experience is to be consciously aware of seeing. Ordinarily this awareness is awareness of something, of visual objects. However, one can in fact be visually aware of seeing without seeing anything in particular. This is true of people born blind due to defects in signal transport from eye to brain, but operated so that the brain receives signals from the retina. After operation those people report that they ‘see’ in the sense of having visual phenomenal experiences, but they cannot say what they see. Their brains can’t organize incoming stimuli into distinct visual objects. This tells us that some sort of activity of the brain is necessary in order to organize the stimuli.²

But most people’s brain can organize incoming stimuli into a structure of one or more objects against a background. As the focus of attention shifts, we become aware of new objects.

The final step in the processing of the visual information is to compare the object observed with a visual memory bank and a semantic memory so we can tell what kind of object we are seeing. This process may fail, as is illustrated by patients suffering for example of Alzheimer’s disease. Some of those people can discern objects against a background, but can’t tell what kind of object they see. (Oliver Sachs gives an example in his book ‘The man who mistook his wife for a hat’. This was an elderly patient of his who suffered from a

² The question was touched upon in a letter from Molyneux (dated March 16, 1693) to Locke where he discusses whether someone born blind who has learnt to distinguish a ball from a die by touch could distinguish them visually if he can see after an operation. Locke discusses the matter in *An Essay concerning Human Understanding*, II, IX, i.

progressing agnosia; he lost his ability to recognise faces, landscapes, scenes and other visual objects. Sometimes when looking at his wife he could not say for sure what kind of object he was looking at [Sachs 1970, ch. 1].)

This last step, to recognize an object, is to categorize the object. There is latitude for choice here, as indicated by several well-known figures often used in cognitive psychology, for example the famous duck-rabbit, which can be seen either as a duck or a rabbit. Observe the use of ‘see as’!

There is a short step to generalize this to cognition in general, and thus to all kinds of objects. Identifying an object means identifying it as an object of a particular kind, i.e., we categorize it. The categories are indicated by general terms. Individual things, objects, are the referents of our singular terms. Singular terms are definite descriptions, names or pronouns. The story clearly indicates that definite descriptions are primary and names and pronouns are secondary, both from a logical and a cognitive perspective.

It is thus a mistake to think that objects are given to us completely independent of our cognitive and linguistic processes. This sounds perhaps unintuitive and in opposition to sound empiricism, but it is not. Quine points out that empiricism went wrong when taking individual objects as the basic things in epistemology:

“British empiricism was dedicated to the proposition that only sense make sense.

Ideas were acceptable only if base on sense impressions. But Tooke appreciated that the *idea* idea itself measures up poorly to empiricist standards...the basic proposition of British empiricism would seem to say that words make sense only insofar as they are definable in sensory terms.” [Quine 1981, 68]

Quine’s conclusion was, to repeat, that sentences are the smallest units which can be compared with sensory experience. Since a sentence, taken as a whole, (‘holophrastically’ is Quine’s term) can be analysed in several different ways, no single ontology can be picked by mere identifying which sentences one accepts as true. This is his famous ‘inscrutability of reference’ thesis.

In another paper Quine shows how to change ontology by construing what he calls ‘proxy functions’ by which we can go from one domain of discourse to another without violating any logical or observational restrictions. He concludes:

“Structure is what matters to theory, and not the choice of its objects. F.P. Ramsey urged this point fifty years ago, arguing along other lines, and in a vague way it had

been persistent theme in Russell's *Analysis of Matter*. But Ramsey and Russell were talking only of what they called theoretical objects, as opposed to observable objects.

I extend the doctrine to objects generally, for I see all objects as theoretical. This is a consequence of taking seriously the insight that I traced from Bentham – namely, the semantic primacy of sentences. It is occasion sentences, not terms, that are to be seen as conditioned to stimulations.” [Quine 1981, 20]

Assuming objects as referents of our singular terms, or what comes to the same thing, as values of variables when our statements are expressed in first order predicate logic, is thus intimately connected to predication; it is two sides of the same coin. It follows that the domain of discourse cannot be viewed as something given to us independently and in advance of predication.

What comes out of this is that predicates are the vehicles by which we construct objects. Russell once thought that there were exceptions, a kind of irreducible ‘logical objects’, those things we had ‘knowledge by acquaintance’ of, in contrast to ‘knowledge by description’. But we have no need for this distinction.

Relations between scientific predicates

In ordinary language there are no fixed relations between predicates; this is a lesson from the later Wittgenstein and Quine. Wittgenstein formulates his point by saying that there are no such things as necessary and sufficient criteria for the use of general terms, only family resemblances. I think he is right when it concerns *ordinary language*. [Wittgenstein 1953, §§ 67 ff]

But one aspect of doing science is to be more precise, to sharpen the criteria for application of general terms. In natural science all, or most, central general terms are explicitly defined. For example, all physical quantities are encoded in the SI-system. These definitions are stipulations and it follows that the criteria for application of the predicate in definiendum are part of those for the application of the predicate in definiens.

Some fundamental laws in physics express relations between quantities. Maxwell's equations, for example, state numerical relations between charges, currents, electric and magnetic fields. Or, to take a still more abstract example, Schrödinger's equation expresses a complex relation between three quantities: the time derivative, the spatial derivatives of a state function and the potential field acting on that state function.

It is clear that such laws, when fully analysed and expressed in first order logic have the form ‘for all objects x , x satisfies A, iff it satisfies B’, where A and B are attributions of physical quantities. For example, Maxwell’s first equation

$$\nabla E = \frac{q}{\varepsilon},$$

tells us that an object has charge q iff the field gradient (∇E) equals q/ε .³ Why is such a relation always true? The simple-minded empiricist would say, ‘it’s a brute fact, that’s the way nature is’. This is not convincing. How, for example is it possible that this relation always holds, and holds exactly?

A closer inspection reveals that in the SI-system only one electromagnetic quantity (current) is defined in an explicit operational definition. The rest are implicitly defined by our acceptance of a number of physical laws. It is not difficult to draw the conclusion that Maxwell’s equations, which uses four quantities (charge density, current, electric field, magnetic field), best is viewed as joint implicit definitions of those quantities not earlier defined. A fuller argument is given in my [2005].

There are other fundamental laws of a somewhat different nature. We have for example the principles of energy, momentum and angular momentum conservation. They have the form ‘in any closed system, x is conserved’, where x is replaced by energy, momentum or angular momentum. Why is that so? Why are precisely these quantities conserved in a closed system?

A simple but correct answer is ‘because that’s what we mean by a closed system.’ An illuminating episode is the discussion following the results of a series of collision experiments (the collisions were what we now call weak interaction) in the thirties. We now know that neutrinos are produced in such interactions and neutrinos carry energy, but these particles were not detectable at that time. Hence, the results of the experiments suggested that energy were lost in the interaction. Furthermore, since the system *appeared* to be closed, some suggested that the principle of energy conservation must be given up after all. But the majority followed Dirac, who instead claimed that a hitherto unknown and undetectable

³ Some philosophers prefer to analyse laws as relations between universals. This is appealing, in particular when thinking of relations between quantities. The claim is further that these relations in turn entail first order conditionals. However, this detour to relations between universals is no solution to our problem, as van Fraassen [1989, ch. 5] points out.

particle were produced and this particle carried the missing energy. He was right and in the fifties one was able to corroborate the existence of neutrinos.

The first lesson to be learned is that when confronted with a purported counter instance to a statement of the form ‘for all x , if Ax , then Bx ’, we have two options: either to reject the generality as false, or to reject the assumption involved in the purported counter instance, viz. that the observed object satisfies the predicate in the antecedent. The second lesson is that when it comes to fundamental laws, we have reason to suspect that the second alternative is the correct one. Or perhaps we should say that, rather than giving up a fundamental law with all its dire consequences, we most often prefer to rethink the criteria for application of the predicate in the antecedent. The third lesson is that lacking independent criteria for determining whether an object satisfies the antecedent, this law functions as a partial implicit definition of the concept in the antecedent. In this particular example, ‘closed system’ means that energy, momentum and angular momentum are conserved.

We can reformulate this conclusion as follows: the criteria for satisfaction of the predicate in the consequent are members of the set of criteria determining when a particular object satisfies the predicate in the antecedent. This resembles Kant’s statement that a judgement is analytically true if the predicate is *contained* in the subject.

The main argument against Kant’s idea is that there are simply no such concepts with strict criteria of application; this is the content of Quine’s, Wittgenstein’s and many others criticism of the notion of analyticity. This criticism is in my view convincing when it regards concepts in common language; the notion of containment cannot be made precise in that realm. But the situation is different in a well-structured theory such as physics. In such theories the core concepts are rigorously defined, explicitly or implicitly. Some quantities are defined by giving operational procedures and the rest are defined using those basic quantities; hence the laws and principles function as implicit definitions of introduced quantities. These definitions are *necessary relative to our acceptance of the theory* in the sense that our accepted theory cannot be formulated without the concepts introduced by these definitions. This stance does not entail any deeper metaphysical commitments.

When Quine out of hand dismissed Aristotelian essentialism he might have thought of a general analysis of necessities expressed in natural language. If so, I agree with Quine. But this rejection does not apply to well-structured theories like those in physics; in those cases we have rather clear criteria of application of theoretical terms and in some cases those for one term are part of those for another one. In those cases we could justifiably say that the objects talked about have some of their properties by necessity, some others contingently.

But let's not interpret this kind of natural necessity as in principle nonrevisable. Quite the contrary; it is clear that if we, for some reason, would reject present physical theory in favour of another we would reject (some of) its laws and at the same time we would reject those concepts utilised when expressing the laws. The conclusion is that the necessity of the fundamental laws must be understood as *relative necessity*, viz., they are necessary relative to our present beliefs. Using a different argument Putnam arrived at a similar view in his [1962].

Conclusion

Physical systems have many properties, some necessary and some contingent. The necessary properties are those, which are part of criteria of identity for the objects talked about. Objects (cells, particles, waves, systems or any kind of things we quantify over) are implicitly defined by those fundamental laws, which hold for these objects. These laws are necessarily true, because they are partial definitions of theoretical concepts.

Laws are necessary, but that does not imply total unrevisability. However, it does entail that a law cannot be revised while leaving greater parts of the theory to which it belongs unchanged. To use Quine's picture of a web of beliefs making contact with observations at the edges only, we may say that fundamental laws are at the centre of the web and any change leads to revisions at the entire web, or nearly so. The necessity of fundamental laws is relative to our knowledge.

In this respect natural necessity is just like logical necessity. Consider a conclusion of an argument, which we don't accept. We are extremely reluctant to doubt the logical steps, although it has happened. Similarly, we are very reluctant to give up a law, in particular a fundamental law in case of contradictory evidence; we usually put into question other assumptions. The distinction between necessary and contingent truths is an epistemic distinction; it indicates differences in our willingness to reject a statement as falsified. Look again at #1 and #2. If we would hit upon a planet made up of pure gold, we would be astonished, but simply reject #2 as false. Not so if we would hit upon a purported counter example to #1: we would, I dare to say, not reject it, but instead reject the counter example as really constituting a counter example. There are always other options than simply taking counter instances for brute facts and Kuhn once claimed that the normal attitude is not to reject basic laws and principles; when doing what he called 'normal science' we do not give them up. Only when the weight of anomalies becomes unbearable the entire conceptual system is given up.

Understood in this way, I see no convincing arguments for distinguishing between logical and natural necessity. If logical necessity is acceptable as sufficiently clear, natural necessity, as here explicated, also is.

From this view nothing concerning nominalism, realism or idealism follows. A strong metaphysical realist can add that the conceptual or relative necessity of our natural laws reflects a deeper necessity inherent in the physical world. A realist rejecting this strong metaphysics can say that there is an external world independent of our thoughts, concepts and cognitive acts, but since the necessity of the fundamental laws are relative to our present knowledge, we cannot say that the carving up of the world by our present theory is eternal; a better theory about the world is always possible. A nominalist can claim that if we have been lucky enough of construing a true theory, the objects identified by this theory are the real ones, but he need not commit himself to the existence of properties; he rejects that we can quantify over predicates and view them as representing real properties. Instead of a distinction between essential and contingent properties, the nominalist can distinguish between essential and non-essential predication.

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