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WHEN TIME IS OF THE ESSENCE: *Prior Analytics* I.15 AND *De Caelo* I.12

ADRIANE A. RINI

Abstract
Aristotle's treatment of modality and time raises many puzzles. This paper focuses on *Prior Analytics* I.15 and *De Caelo* I.12, and shows that the puzzles about time and modality in these two works are exactly the same. This means that any viable explanation of one must apply also to the other. Interpreters have offered a variety of explanations, though few attempt to relate the two works considered here. This paper combines insights from a number of scholars and offers a unified explanation of Aristotle's reasoning about time and modality in *Prior Analytics* I.15 and *De Caelo* I.12.

Consider the following argument:

(1)	Everything in the cage is a rat	T
(2)	Every monkey could have been in the cage	T
(3)	Every monkey could have been a rat.	F

This is obviously invalid. If we suppose the premises are true, we can still get a false conclusion. The basic structure of the argument is

(4) Every B is A
(5) Every C is possibly-B
(6) Every C is possibly-A.

Aristotle says (4)(5)(6) is *valid*. He even argues for its validity in *Prior Analytics* I.15. Clearly there is a problem since Aristotle counts (4)(5)(6) as valid but (1)(2)(3) appears to be an invalid instance of (4)(5)(6). And so it seems Aristotle has made a mistake. One response to this is to say 'So what? Even Homer nods. After all it is *only* a mistake about logic. In fact, it's only a mistake about *modal* logic!' But explaining (4)(5)(6) is important because

Aristotle's argument for it is crucially involved in the axiomatic basis of the modal syllogistic. A consequence is that the problem presented by (1)(2)(3) and (4)(5)(6) is a problem that crops up again and again in Aristotle's logic. But the difficulty here in the logic is not isolated from the rest of Aristotle's philosophy. Commentators have noticed a similarity between *Prior Analytics* I.15 and *De Caelo* I.12. My purpose is to discuss this parallel in detail and show that the moves in the logic are exactly the same as moves Aristotle makes in *De Caelo* I.12. One consequence is that any viable explanation of one must apply also to the other, and part of my project will be to develop a unified account of Aristotle's reasoning about time and modality in *Prior Analytics* I.15 and *De Caelo* I.12.

I

The technical name for (4)(5)(6) is usually given as Barbara XQM, and I will refer to it this way.[1] In *An.Pr.* I.15, 34a34–b2, Aristotle gives a 'proof' to establish the validity of (4)(5)(6). He gives what he calls a 'proof through impossibility.' It is a kind of *reductio* argument:[2]

> Now, with these determinations made, (4) let A belong to every B and (5) let it be possible for B to belong to every C. Then (6) it is necessary for it to be possible for A to belong to every C. (7) For let it not be possible, and (8) put B as belonging to every C (this is false although not impossible). Therefore, if (7) it is not possible for A to belong to every C and (8) B belongs to every C, then (9) it will not be possible for A to belong to every B (for a deduction comes about through the third figure). But it was assumed that it is possible for A to belong to every B. Therefore, it is necessary for it to be

[1] (4)(5)(6) is in the form of a Barbara syllogism, which means that its general form is:

Every B is A
Every C is B

Every C is A.

(4)(5)(6) has a non-modal (X) major premise and a contingent (Q) minor premise. Aristotle seems to treat the conclusion in such cases as a statement about possibility (i.e., about what is not-necessarily-not [M]) rather than a statement about contingency (i.e., about what is neither necessary nor impossible [Q]).

[2] I use Robin Smith's (1989) translation of *Prior Analytics*. In the Oxford Clarendon Series, I use Ackrill's translation of *De Interpretatione*, Barnes' *Posterior Analytics*, and Williams' *De Generatione et Corruptione*. I use the Oxford translations of *De Caelo* by Stocks and *Metaphysics* by Ross.

> possible for A to belong to every C (for when something false but not impossible was supposed, the result is impossible). (*An.Pr.* I.15, 34a34–b2)

Aristotle's explanation depends upon a principle, defended a few lines earlier: 'when something false but not impossible is assumed, then what results through that assumption will also be false but not impossible' (34a25–27). Aristotle's point is that if you wish to reason from one possibility to another, you are entitled to do so by assuming the first possibility true — that is to say, actualized — and reasoning that in that case the second possibility will also be true — that is to say, actualized. The 'reductio' form of this principle says that if a contradiction results from actualizing the possibility then the possibility could not have obtained. The principle is put to use in the 'proof through impossibility'. Following on from (4)(5)(6):

(4)	Every B is A	(1) Everything in the cage is a rat
(5)	Every C is possibly-B	(2) Every monkey could have been in the cage
(6)	Every C is possibly-A	(3) Every monkey could be a rat
Suppose		
(7)	Some C is not possibly-A	Some monkey could not be a rat
(8)	Every C is B	Every monkey is in the cage
Then		
(9)	Some B is not possibly-A	Something in the cage could not be a rat

(9) and (4) cannot both be true, so Aristotle wants to say the reductio shows we can syllogize to (6).

This is Aristotle's argument, where the step from (5)/(2) to (8) is the actualizing of a possibility. However, when we look at it more closely we can see that there is an illegitimate move here. In supposing (2) is actualized Aristotle seems to have forgotten that that changes the truth value of our initial premise (1); for in supposing that every monkey *is* in the cage we are *denying* that everything in the cage is a rat.

Patterson (1995) offers the following diagnosis: 'The problem... is that the possible truth of *each* premise of a given valid syllogism does not guarantee the possible truth of their conjunction' (p. 161). If this is right, then Aristotle's mistake is thinking that (*) is a (valid) principle of modal logic:

(*) If (possibly p & possibly q), then possibly (p & q)

On Patterson's account, Aristotle makes the mistake earlier in the text, at *An.Pr.* 34a5–6:

> It must first be explained that if it is necessary for B to be when A is, then when A is possible B will of necessity also be possible.

As he continues, Aristotle makes it very clear that A must stand for *two* propositions.

> Next, one must not take 'when A is, B is' as if it meant that B will be when some single thing A is. For nothing is of necessity when a single thing is, but instead only if at least two things are, that is, when the premises are so related as was stated concerning deductions (34a16–19).

Patterson points out that Aristotle's proof requires the joint possibility of both premises, while he is only entitled to assume that 'possible' applies to the two premises separately: (possibly p) and (possibly q). Returning to (4)(5)(6), premise (4) 'everything in the cage is a rat' is possible because it is given as true, premise (5) 'every monkey *could have been* in the cage' is obviously about possibility. So, by (*), the conjunction (everything in the cage is a rat & every monkey is in the cage) is possible. Therefore the conclusion (6) 'every monkey could have been a rat' is possible.

In fact Aristotle himself seems to be troubled about (4)(5)(6). After setting out his reductio 'proof,' Aristotle tries to explain what he takes to be wrong with (4)(5)(6).[3]

> One must take 'belonging to every' without limiting it with respect to time (μὴ κατὰ χρόνον), e.g., 'now' or 'at this time', but rather without qualification (ἁπλῶς). For it is also by means of these sorts of premises that we produce deductions, since there will not be a deduction if the premise is taken as holding only at a moment (κατὰ τὸ νῦν). For perhaps nothing prevents man from belonging to everything in motion at some time (for example, if nothing else should be

[3] Immediately following the indirect 'proof' we find at 34b2–5 what purports to be a direct proof of the same syllogism 'through the first figure.' But there is a question whether the proof described is really a proof of Barbara XQM or a proof of a different syllogism, Barbara QXQ [QXM]. Most commentators bracket lines 34b2–5, and Ross (1949) dismisses the passage as 'the work of a rather stupid glossator.' Patterson (1995) takes the passage 34b2–5 to be a proof of Barbara XQM that illustrates the modal principle that if p entails q, then if p is at worst false, q is at worst false. See Patterson p. 165. However nothing in the present paper hinges on linking such a modal principle to the passage 34b2–5.

> moving), and it is possible for moving to belong to every horse, but yet it is not possible for man to belong to any horse. Next, let the first term be animal, the middle term moving, the last term man. The premises will be in the same relationship, then, but the conclusion will be necessary not possible (for a man is of necessity an animal). It is evident, then, that the universal should be taken as holding without qualification, and not as determined with respect to time. [*An.Pr.* I.15, 34b7–18]

This passage has caused Aristotle's interpreters quite a lot of difficulty. Many take the passage as some kind of restriction on (4)(5)(6); Tredennick reads it as a *rejection* of (4)(5)(6). Patterson (p. 174) doubts its authenticity and suggests it might be excised. But, however cryptic, this passage is the most explicit discussion Aristotle gives linking his conception of time to his modal syllogistic. Part of my aim is to make clear how this passage is a key to understanding Aristotle's reasoning.

One reason why *An.Pr.* I.15 is the focus of so much attention comes from the fact that the general structure of the chapter is not always obvious, and this has allowed plenty of room for interpreters to disagree. Here is one way to understand the main logical moves:

(a) At 34a5–6, Aristotle sets out the principle (*) If (possibly p & possibly q), then possibly (p & q). Aristotle presents (*) as though it were a valid principle, but in fact it is not. He then employs (*) in his account of Barbara XQM, (4)(5)(6), and hence produces an illegitimate proof, at 34a34–b2.

(b) At 34b7–18, Aristotle seems to reconsider his proof of Barbara XQM and tries to remedy the error in the logic, turning to some ideas he holds about *time* and using them to help construct counter-examples to Barbara XQM.

Taking (a) and (b) together keeps with the spirit of Tredennick's reading. But together (a) and (b) give the text a different structure than what Patterson sees. Patterson focuses on (a) and excises (b), and so regards chapter I.15 as setting out a logical principle (*) that Aristotle adheres to and employs. The working hypothesis in this paper is that *both* (a) and (b) are part of the development of Aristotle's logical principles. Perhaps a good way to think of (a) and (b) is as representing different layers in this development.

So what is going on in *An.Pr.* I.15, 34b7–18? Without a doubt the passage is a warning not to pick premises that hold only at a time. In the passage

Aristotle gives two sets of terms which illustrate the danger of trying to syllogize from premises that hold only at a time. The first set of terms is man, moving, horse. The second set is animal, moving, man. When Aristotle puts these terms in (4)(5)(6) he gets conclusions that are *impossible*. The first set of terms gives:

(C_1) All moving things are men
All horses are possibly moving
All horses are possibly men.

This is just like my example of the rats in the cage in (1)(2)(3). The conclusion is *impossible*. No horse is possibly a man because horses are essentially not men; their nature excludes their being men.

The second set of terms gives:

(C_2) All moving things are animals
All men are possibly moving
All men are possibly animals.

As a counter-example this seems a bit weird, because we want to say that, surely, whatever is necessary is possible. But Aristotle clearly does not think that is the case here — he says 'but the conclusion will be necessary *not* possible (for a man is of necessity an animal).' In this passage 'possible' is ἐνδεχόμενον. Aristotle has two senses of ἐνδεχόμενον, and as a rule he is very precise about which sense he uses, though here there is some question about which is right. Sometimes ἐνδεχόμενον means not-necessarily-not (the logician's M); other times it means neither necessary nor impossible (the logician's Q). Aristotle often refers to this Q-possibility as 'possible according to the determination.' He gives his definition at *An.Pr.* I.13, 32a20: 'I use the expressions 'to be possible (ἐνδέχεσθαι)' and 'what is possible (τὸ ἐνδεχόμενον)' in application to something if it is not necessary but nothing impossible results if it is put as being the case (for it is only equivocally that we say that what is necessary is possible).' According to Aristotle, no man is a possible animal because every man is by necessity an animal. This requires that 'possibly' in the conclusion means 'contingently,' i.e., Q, not M. In my own discussion I will use 'possible' only when I mean M ('not-necessarily-not') and will use 'contingent' when I mean Q. (See note 1.)

Most commentators take the conclusion to be about M-possibility, following Aristotle's remarks in I.15, 33b27–33 and 34b27–31. See for instance Ross (1949), Smith (1989), and Thom (1996). Let's suppose for the moment that Aristotle is trying, via (C_1) and (C_2), to establish the validity of Barbara

XQM and the invalidity of Barbara XQQ. Taking Aristotle this way saddles him with two problems. First, (C_1) and (C_2) together are 'overkill' — to show that a Q-conclusion does not follow all Aristotle needs to do is show that *either* 'every C cannot be A' *or* 'every C must be A.' He does not need to show *both*. Second, and more serious, the overkill here automatically invalidates Barbara XQM — and if Aristotle does not notice that, then he is making a bad mistake. For if Barbara XQM were valid then he has a sense of possible according to which a horse *could* be a man. But there is no sense of possible for Aristotle (neither 'according to the determination' [Q] nor 'not according to the determination' [M]) by which a horse can be a man. And in fact a reason against attributing this mistake to Aristotle is found by noting how he continues. He seems to think the problem with Barbara XQM has something to do with *time*. So let's suppose that Aristotle notices that (C_1) invalidates Barbara XQM, that he is troubled by this, and that the passage 34b7–18 is an attempt to rectify the problem.

How might time help? Aristotle's explanation, at 34b7–18, is that when we choose premises that hold only at a moment, we cannot always make valid deductions. That is, we cannot syllogize. So we want to know what is it about a premise that makes it hold only at a time? In the case of Aristotle's counter-examples, the premises that hold only at a moment (*κατά τὸ νῦν*) are 'all moving things are men' and 'all moving things are animals.' These premises have a subject term in common: 'moving thing' (*κινούμενον*). Take the premise 'all moving things are men.' It is not always true. One way to think of it is that the subject 'moving thing' is in effect '*now* moving things.' 'All *now* moving things are men' is true now (when nothing else is moving, 34b12), but it will be false tomorrow when, say, horses move.[4] So the premise is only *sometimes* true.[5] Aristotle at least sketches a solution in *An.Pr.* I.15, 34b7–18. He thinks that if we choose premises which hold *at all times* we can avoid the problem. But the terms he offers do not give unrestricted (*haplos*) premises. We need to chose terms in a way that does not restrict the time at which the premises hold.[6] The following example helps make this clearer:

[4] See *Physics* IV,11; VI,3 for a similar explanation of 'true at a moment.'

[5] Not all propositions that have accidents as subjects are like this. For instance, 'all red things are colored' is *always* true because 'colored' is part of the meaning of 'red.'

[6] This means that requiring unrestricted (*haplos*) premises is, in effect, a restriction on our choice of terms. Such a restriction is not surprising. Throughout the modal syllogistic we find Aristotle restricts modal terms. See Rini (1996 and 1998). See also Tredennick (1938, p. 188).

(10)	Every bird in antarctica is a penguin (always)	[Every B is A (always)]
(11)	Every albatross could be (a bird) in antarctica	[Every C is possibly B]
(12)	Every albatross could be a penguin	[Every C is possibly A]

Now our premises hold without respect to time, and so they seem to follow Aristotle's instructions in *An.Pr.* I.15. But we *still* have a syllogism which is plainly invalid. We can suppose the premises are true, but our conclusion is still impossible — no albatross could ever be a penguin. Aristotle, however, wants Barbara XQM valid.

II

But all is not lost. There are still ways we might validate Barbara XQM. The *Principle of Plenitude* provides one way of doing just that.

Mignucci (1972)[7] and Hintikka (1973) attribute to Aristotle the following principle:

(A) If it is possible that p, then at some time it is the case that p
(B) If it is always the case that p, then it is necessary that p.

These are the *Principle of Plenitude*. Hintikka tells us that (A) and (B) capture a special connection between time and modality — a connection he thinks Aristotle routinely uses. (A) and (B) are modally equivalent. For our purposes here it will do to focus on (A). The idea is very simple — any thing that is possible will at some time be realized. For instance, if it is possible for Socrates to sit, then there is some time at which Socrates actually sits.

Look at what happens if we apply the principle of plenitude to the syllogism above.

(13) Every bird in antarctica is a penguin (always)
(14) Every albatross is sometimes in antarctica
(15) Every albatross is sometimes a penguin.

[7] Unfortunately I have not been able to access a copy of Mignucci's book. Patterson (p. 161) reports that 'Mignucci... contends that Aristotle appeals to a principle that if p is possible, then p will at some time be true.'

This is valid, but it is only trivially valid. The problem in this case is that the *plenitizing* has the consequence that the premises cannot be true together. For Aristotle this means there is no syllogism.

Notice that in each of Aristotle's own counter-examples, (C_1) and (C_2), only the B term is an accident; the A term is an Aristotelian substance term. If we are to have a true conclusion the A term cannot be a substance term. For if φ is such a term, then φ is equivalent to $L\varphi$, and $\sim\varphi$ is equivalent to $L\sim\varphi$.[8] When A is 'man' we get the false (M and Q) conclusion 'all horses are possibly men'; when A is 'animal' we get the false (Q) conclusion 'all men are possibly animals.' To produce a valid instance of Barbara XQM with true premises then *both* A and B must be accidental terms. B has got to be an accident if the premise 'All C's are possibly B's' is a *true* premise. If B were a substance term, then by his own lights Aristotle would count 'All C's are possibly B's' as *false*, because that is exactly what he *does* do with the conclusion in his counter-examples. So any non-trivial example of Barbara XQM will have to have two accidental terms, A and B. Aristotle's own examples, because they have only one accidental term, will never be non-trivial. Aristotle does not have a notion of trivial validity, but he may be aware that without better terms he cannot syllogize: A similar problem arises in the parallel discussion of Celarent, prompting Aristotle to remark, there, that 'the terms should be better chosen' (*An.Pr.* I.15, 35a3).

Can we validate Barbara XQM non-trivially - i.e., with premises that can be true together? Consider Barbara with accidental terms:[9]

(16)	Every bus driver is employed (always)	[Every B is A (always)]
(17)	Every student is possibly a bus driver	[Every C is possibly B]
(18)	Every student is possibly employed	[Every C is possibly A]

The *plenitized* version of this is:

(19) Every bus driver is employed (always)
(20) Every student is sometimes a bus driver

[8] Rini (1998) calls this the 'Substance Principle' (p. 569, n. 10) and illustrates its use in Aristotle's logic.

[9] It isn't obvious whether (16)(17)(18) is valid or not. Even with accidental terms and true premises, Barbara XQM might arguably have a false conclusion:

Everything looking at a clown is laughing (always)	T
Every cat can look at a clown	T
Every cat can laugh	F.

Of course the *plenitized* version of this will be valid, just as the *plenitized* version of (10)(11)(12) — i.e., (13)(14)(15) — is valid.

(21) Every student is sometimes employed.

(19)(20)(21) is valid and non-trivial — it is easy to imagine a situation in which both premises and conclusion are true. First, consider the premises: (19) and (20) *can* be true together. It is always true that every bus driver is employed — i.e., for any person x at any time t, if x is a bus driver at t, then x is employed at t. And we can suppose that every student sometimes drives a bus. That is, for any person x and for any time t, if x is a student at t, then x drives a bus at some t'. So (19) and (20) can be true together in a way that (13) and (14) cannot. And so perhaps we are getting closer to an answer.

III

It will help to separate out two different principles at play here. First, there is Aristotle's warning against choosing temporally restricted premises: Don't choose a premise that holds only at a time; choose premises that are true without qualification (*haplos*). In the present context that seems to mean we ought to choose premises that are true *always*, i.e., at all times. But this restriction alone does not validate Barbara XQM.

Second, there is plenitude. 'Every albatross could be in antarctica' is a premise about possibility — 'every albatross is possibly in antarctica.' When we use plenitude, we replace the modal premise with a temporal premise, to the effect that 'every albatross (actually) is sometimes in antarctica.'

But, plenitude is not trouble free, and there is controversy about whether or to what extent the principle of plenitude is part of Aristotle's reasoning.[10] *On Interpretation* 9 raises serious questions about how closely Aristotle adheres to plenitude. Consider *On Interpretation* 9, 19a13–14:

> For example, it is possible for this cloak to be cut up, and yet it will not be cut up but will wear out first.

This is very clearly about a possibility that will not be realized, and so it looks like a straightforward rejection of plenitude. Hintikka, thinking that plenitude is a fundamental part of Aristotle's reasoning, suggests that plenitude does not apply to individual objects which can go out of existence; plenitude applies to *kinds of things*:

> The possibility of a particular cloak's being cut up is a possibility concerning an individual object, and not a possibility concerning

[10] Waterlow (1982) and Judson (1983) discuss the matter in detail.

> kinds of individuals or kinds of events. Nor does the unfulfilled possibility Aristotle mentions remain unfulfilled through an infinity of time, for when the cloak wears out, it goes out of existence, and no possibility can any longer be attributed to it. Thus Aristotle's example does show that the 'genuine' possibilities which the principle says are actualized do not for him include possibilities concerning individual objects which only exist for a certain period of time. [Hintikka, (1973, pp. 100–101)][11]

Take another example to catch the full effect of Hintikka's claim: It is possible for Winston Peters to turn gray, but in fact Winston will never turn gray. Let's suppose that he will die before he ever turns gray. Plenitude says if it is possible that he goes gray, then there is some time at which he goes gray. But in fact he will never reach such a time. Still, it is possible for Winston to turn gray. It is possible for him because there is somebody *else* who actually does turn gray. If Winston's father *is* gray, that may be enough to justify Winston's *capacity* to be gray.

Aristotle believed that the actual is prior to the possible. He says so in many places. *Metaphysics* Θ.8, 1049b17ff., makes the case particularly well:

> ...the actual which is identical in species though not in number with a potentially existing thing is prior to it. I mean that to this particular man who now exists actually and to the corn and to the seeing subject the matter and the seed and that which is capable of seeing, which are potentially a man and corn and seeing, but not yet actually so, are prior in time; but prior in time to these are other actually existing things, from which they were produced. For from the potentially existing the actually existing is always produced by an actually existing thing, e.g. man from man, musician by musician; there is always a first mover, and the mover already exists actually.

Extending the idea to our present examples, if it is possible for a particular cloak to be cut up, but this particular cloak will never really be cut up, then there must be something else that is actually cut up. And if Winston is potentially gray, but never actually gray, then his potential grayness must be

[11] There is, however, some evidence that a restriction against finitely existing objects is sometimes inappropriate. In *An.Pr.* A.13, 32b5–22 Aristotle does include possibilities concerning individual objects, objects which he clearly takes to exist for only a finite period of time. He gives an example: it is possible 'for a man to turn gray or grow or shrink.' And he notes parenthetically that 'this does not have continuous necessity because a man does not always exist, but when there is a man he is either of necessity or usually doing these things.' This sort of possibility includes what is possible for individuals with only finite existence.

produced by something which is actually gray. But while there may be good reason to think Aristotle might believe something like kind plenitude in this sense, kind plenitude does not help in *An.Pr.* I.15 because kind plenitude will not validate Barbara XQM. We need unrestricted (A)(B) plenitude to do that. If we use kind plenitude then 'every albatross could be (a bird) in antarctica' at best gives '*some* albatross will be in antarctica.' (Or, if the relevant *kind* is bird, then we would get 'some bird will be in antarctica.') In our non-trivial Barbara XQM, 'every student is possibly a bus driver' at best gives 'some student is sometimes a bus driver.' Kind plenitude would disallow Barbara XQM, which has a universal conclusion; instead, we would only have an existential conclusion. So the version of plenitude that has the power to validate Barbara XQM is unrestricted (A)(B) plenitude; kind plenitude is not strong enough to do that.

IV

Hintikka locates 'a kind of proof' for (apparently unrestricted) plenitude in *De Caelo* I.12.

> A man has, it is true, the capacity at once of sitting and of standing, because when he possesses the one he also possesses the other; but it does not follow that he can at once sit and stand, only that at another time he can do the other also. But if a thing has for infinite time more than one capacity, another time is impossible and the times must coincide. Thus if anything which exists for infinite time is destructible, it will have the capacity of not being. Now if it exists for infinite time let this capacity be actualized; and it will be in actuality at once existent and non-existent. [*De Caelo* I.12, 281b16–23]

But, as Aristotle goes on to explain, this is impossible — nothing can both be and not be at the same time. And so anything that exists for an infinite time cannot be destructible. Suppose Socrates is actually sitting at t_1. He still has (at t_1) the capacity to stand even while he is sitting. That capacity is unrealized at t_1 but might be realized at some other time t_2. So at t_1 possibly Socrates is standing, even though he is actually sitting. That is:

(22) [(Possibly not-sitting) at t_1] & [(sitting) at t_1]

But Aristotle is worrying about a thing's having a capacity for an infinite time — 'if a thing has for infinite time more than one capacity, another time is impossible and the times must coincide.' So 'sitting' in (22) needs to be

upgraded to 'always sitting' to get (23):

(23) [(Possibly not-sitting) at t_1] & [always sitting]

Aristotle appears to take (23) as false.

A number of interpretations have been put forward to explain what is going on here. These interpretations fall into two general categories — negative and positive. Either Aristotle has made a bad mistake (one which, presumably, he would retract if anyone were to point it out to him), or Aristotle is here reasoning according to certain principles which correctly entail the falsity of (23). On the positive side are Jaakko Hintikka and Sarah Waterlow. Waterlow (1982) attributes to Aristotle a notion of 'relative temporalized possibility' which she finds at work here. Hintikka (1973) finds plenitude at work here. If Aristotle believes all possibilities will be realized at some time, then (23) really is impossible. This is because according to plenitude at some time t_2 Socrates will not sit, and yet he always sits. Plenitude takes us from (23) to (24):

(24) [Not sitting at t_2] & [always sitting].

But (24) is impossible. The problem with this answer has been noted by others: This cannot be a *proof* of plenitude, because it *assumes* plenitude.

C. J. F. Williams and Lindsay Judson accuse Aristotle of varying degrees of logical errors. Williams (1965) suggests that Aristotle's mistake is to read (22) as though it were (25):

(22) [(Possibly not-sitting) at t_1] & [(sitting) at t_1]
(25) Possibly (not-sitting at t_2 & sitting at t_1)

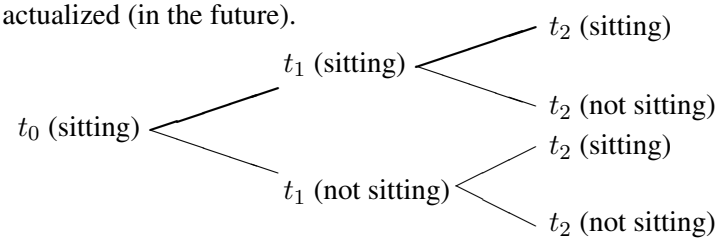
This leads him to read (23) as though it were (26):

(23) [(Possibly not-sitting) at t_1] & [always sitting]
(26) Possibly (not-sitting at t_2 & always sitting)

(25) could be true, but (26) could not be. It is clear that Williams' analysis of *De Caelo* is very similar to Patterson's analysis of *Prior Analytics*. The crucial difference is that Williams is dealing with (explicitly) temporal propositions. Recall that on Patterson's analysis it looks as if Aristotle's mistake is going from [(possibly p) & (possibly q)] to [possibly (p&q)]. However, note that, here, in (25) Aristotle allows that p and q can be realized at different times. The addition of the temporal qualifications helps make clear exactly

where the problem arises. Aristotle only gets into trouble when one capacity is realized at all times, or *haplos*.[12]

While (25) is *one* way of showing that a man has two capacities at t_1, it is not the *only* way the matter can be analyzed. If you think of time as a line that unrolls, then you certainly might say that anything possible will happen at some point *on that line*. But another way you might explain future possibilities is to say that there are 'branching futures' — that is, there are various ways the future might happen, various possible time lines into the future, only one of which will be realized. We then say that you have a *capacity* to do something at a time if you do do it in a *possible future* of that time. According to Williams, Aristotle's goof is the failure to realize that even if Socrates is in fact sitting at a time he might not have been sitting *even at that very same time*. On the branching futures model, Socrates could be sitting at t_1 in one branch and not sitting at t_1 in another branch. Here is how it would work: From any point in time, future possibilities branch out. Most of the branches represent future possibilities that will remain unrealized, but one branch is realized. This is the branch which represents the possibilities which are actualized (in the future).



In the diagram above, the actualized possibilities are linked by a bold line. On the bold line, Socrates is *always* sitting, but *even on the bold line* he has the capacity to not sit because he does not sit at t_1 and at t_2 *on other lines*. But if the bold line were the *only* line, and Socrates is always sitting on the bold line, then he cannot have the capacity to not sit. One way of taking the matter then is to suppose that Aristotle understands the possible as something that can be realized (for no contradiction results from realizing a possibility, *An.Pr.* 34a25–27). This makes good sense on a branching futures model. But if Aristotle does not admit unrealized futures, and only admits the bold line, then it would seem that the only way a possibility could be realized is in the actual future, giving us (24).

Judson (1983) finds Aristotle committing a 'monstrous error.' Judson calls the mistake the '*insulated realization manoeuvre*,' or 'IR manoeuvre' for short:

[12] Patterson (p. 163) refers to the relevant passage from *De Caelo* I.12, but not in connection with this point.

> Aristotle here [*De Caelo* 281b2–25] seems to think that his test can be applied to a candidate for possibility *without regard to whether the supposition of its holding requires changes in what else can be taken to be true*... the realization of the possibility (or exercise of the capacity) is supposed in complete insulation — causal and logical — from anything else which is taken to hold. (I do not, of course, mean to suggest that Aristotle calmly thought out this manoeuvre as I have characterized it, and took it to be a perfectly sound analytical tool; rather, it is simply what his fallacious way of arguing here amounts to.) [Judson (1983, p. 230)]

If the IR manoeuvre is the correct analysis of the *De Caelo* passage, then the IR manoeuvre would seem also to explain the puzzle about Barbara XQM in *An.Pr.* I.15. The explanation then is very different from the explanation based on plenitude. It goes like this. Aristotle argues that Barbara XQM is valid:

(4) Every B is A
(5) Every C is possibly-B
(6) Every C is possibly-A

In accounting for its validity, he supposes something which he says is false but not impossible. That is, he supposes the possibility in (5) realized. This is our (8): All C is B. But when Aristotle supposes this possibility is realized, he uses the IR manoeuvre. He supposes the possibility actual '*without regard to whether the supposition of its holding requires changes in what else can be taken to be true.*' Consider again the earlier example where A is rat, B is in the cage, and C is monkey. If our premises are true, then everything in the cage is a rat, and all monkeys are possibly in the cage. When Aristotle supposes this possibility realized, he does so 'in complete insulation... from anything else which is taken to hold.' If it is true that everything in the cage is a rat (and rats are not monkeys), then it cannot be true that all monkeys are (actually) in the cage.

As we have seen, Aristotle may have seen some of the problem. For requiring the premises to be *haplos* means that everything in the cage is *always* a rat, so that *whenever* we realize the possibility that every monkey is in the cage, we are in trouble. In the *De Caelo* case, it is only if Socrates is *always* sitting that the realization of his capacity to stand is blocked by the IR manoeuvre. Formally, Judson's IR manoeuvre for the *De Caelo* passage is also very like Patterson's analysis of the *An.Pr.* passage. The important difference is that, as in the case of Williams, Judson's analysis makes essential use of time. For when something has a capacity at one time, the realization of

that capacity can take place at another time. Aristotle's fallacious reasoning in *De Caelo* is about time; the realization of a possibility is understood as realization at some time or another. This is explicit in Aristotle's argument.

Could a developmental story be told? Let us suppose that Judson is right about the IR manoeuvre. Unrestricted (A)(B) plenitude does not feature in *On Interpretation* 9, which, in the traditional ordering, is the earliest work mentioned here. Generally, *An.Pr.* is considered to be an earlier work than *De Caelo*, but Williams (1965, pp. 213–214) considers dating *De Caelo* before the *Analytics*. Suppose that *De Caelo* is earlier and that Judson is right about the IR manoeuvre in *De Caelo*; then perhaps by the time Aristotle came to write the *Prior Analytics* he had gotten the IR manoeuvre fixed in his mind as part of his logical machinery. Another possibility (and one that would sit better with Patterson's analysis) is simply that *An.Pr.* 34b7–18, was added later, after *De Caelo* was written and after Aristotle got hung up about time.

V

Whatever is going on in *An.Pr.* I.15, it is the same puzzle we encounter in *De Caelo* I.12. Both of these passages can be explained in either of *two* ways: positively, by plenitude, or negatively, by attributing to Aristotle a mistake, like Judson's IR manoeuvre or the logical confusion Williams describes.[13] So the question is whether plenitude is just the result of a mistake or whether it is an assumption which is part of the basis of Aristotle's thought. Hintikka would appear to be arguing that Aristotle does not make a mistake. And that is the issue I will turn to now. Does plenitude rescue Aristotle from a mistake?

One way we might test plenitude is by looking at its broader effect on Aristotle's syllogistic. If plenitude is part of Aristotle's general reasoning, then at least it ought to be consistent with his syllogistic reasoning. In order to see how well plenitude fits the logic, we need to look first at how we might translate the modal syllogisms into predicate logic. Assuming plenitude,

[13] Notice that if we accept the IR manoeuvre, then we retain all the force of plenitude since plenitude follows from the IR manoeuvre. To see this suppose that Socrates is always sitting. Suppose also that Socrates has the capacity not to sit. The IR manoeuvre says it is consistent to realize this capacity at some time or other. So suppose that it is realized. Then there is a time at which Socrates is not sitting. The IR manoeuvre allows that this can be realized without changing anything else which is taken to hold. The IR manoeuvre would tell us that it is consistent to realize the possibility of Socrates not sitting even if he is never not sitting. But to realize the possibility of not sitting in conjunction with his always sitting is *not consistent*. As Judson says, 'the IR manoeuvre is absurd.'

(L) A belongs to every B of necessity
(X) A belongs to every B,

would be equivalent to the following:[14]

(L_1)	For any x, if x is B at time $t*$, then for any t, x is A at t	$\forall x(Bxt* \supset \forall tAxt)$
(X_1)	For any x, if x is B at time $t*$, then x is A at $t*$	$\forall x(Bxt* \supset Axt*)$

where $t*$ is a particular moment in time — i.e., $t*$ is 'now ($\tau\grave{o}$ $\nu\hat{v}\nu$).' So, (L_1) and (X_1) are *plenitized*, but non-*haplos* translations. Another possibility is that our translations ought to be both *plenitized* and *haplos*. So, perhaps, the following would be better:

(L_2)	For any x and any time t, if x is B at t, then for any t', x is A at t'	$\forall x\forall t(Bxt \supset \forall t'Axt')$[15]
(X_2)	For any x and any time t, if x is B at t, then x is A at t	$\forall x\forall t(Bxt \supset Axt)$

These seem to be similar to what Patterson (pp. 177) attributes to Nortmann (1990).

In order to evaluate how well plenitude works in the apodeictic syllogistic, we need to test it in the apodeictic syllogisms themselves. The crucial premise is the assertoric premise. First translate it according to (X_1). If (L_1) is used then, Barbara LXL (*An.Pr.* 30a17–23) and Barbara XLL (30a23–33) would be:

Barbara LXL [(X_1)(L_1)] (valid)	Barbara XLL [(X_1)(L_1)] (invalid)
$\forall x(Bxt* \supset \forall tAxt)$	$\forall x(Bxt* \supset Axt*)$
$\underline{\forall x(Cxt* \supset Bxt*)}$	$\underline{\forall x(Cxt* \supset \forall tBxt)}$
$\forall x(Cxt* \supset \forall tAxt)$	$\forall x(Cxt* \supset \forall tAxt)$

Using (X_1) and (L_1) translations, Barbara LXL comes out valid and Barbara XLL comes out invalid — just as Aristotle says they must.[16] But, consider

[14] You do not need plenitude to get from (L) to (L_1), but you do need it to get from (L_1) to (L).

[15] This is equivalent to $\forall x(\exists tBxt \supset \forall t'Axt')$, though nothing here turns on this.

[16] Using (X_1) and (L_2) will fail to validate Barbara LXL.

Barbara XQM using (X_1) together with (M_1) for propositions about possibility and (Q_1) for propositions about contingency:

(M_1) For any x, if x is B at time $t*$, then for some t, x is A at t $\quad \forall x(Bxt* \supset \exists tAxt)$

(Q_1) For any x, if x is B at $t*$, then x is A at some t and not A at some other time t' $\quad \forall x(Bxt* \supset (\exists tAxt \& \exists t' \sim Axt'))$

Barbara XQM [(X_1)(Q_1)(M_1)]

$$\frac{\forall x(Bxt* \supset Axt*) \quad \forall x(Cxt* \supset (\exists tBxt \& \exists t' \sim Bxt'))}{\forall x(Cxt* \supset \exists tAxt)}$$

Barbara XQM comes out invalid because we cannot assume that $\exists tBxt$ is realized *at the same time as* $t*$. We also need to consider *haplos* readings of possible and contingent propositions:

(M_2) For any x and any t, if x is B at t, then for some t, x is A at t $\quad \forall x \forall t(Bxt \supset \exists tAxt)$

(Q_2) For any x and any t, if x is B at t, then x is A at some t and not A at some other time t' $\quad \forall x \forall t(Bxt \supset (\exists tAxt \& \exists t' \sim Axt'))$

Barbara XQM [(X_1)(Q_2)(M_2)]

$$\frac{\forall x(Bxt* \supset Axt*) \quad \forall x \forall t(Cxt \supset (\exists tBxt \& \exists t' \sim Bxt'))}{\forall x \forall t(Cxt \supset \exists tAxt)}$$

This is not valid for the same reason as before: we cannot assume that $\exists tBxt$ is realized *at the same time as* $t*$.

If we follow Aristotle's instructions in *An.Pr.* 34b7–18, we need to chose premises that hold *haplos* (at all times), which seems to mean that we need something like (X_2). Using (X_2), (Q_1) and (M_1) we have:

Barbara XQM [$(X_2)(Q_1)(M_1)$] (valid)
$\forall x \forall t(Bxt \supset Axt)$
$\underline{\forall x(Cxt* \supset (\exists tBxt \& \exists t' \sim Bxt'))}$
$\forall x(Cxt* \supset \exists tAxt)$

Similarly, (X_2), (Q_2) and (M_2) give a valid Barbara XQM:

Barbara XQM [$(X_2)(Q_2)(M_2)$] (valid)
$\forall x \forall t(Bxt \supset Axt)$
$\underline{\forall x \forall t(Cxt \supset (\exists tBxt \& \exists t' \sim Bxt'))}$
$\forall x \forall t(Cxt \supset \exists tAxt)$

Using (X_2) for the assertoric premise validates Barbara XQM whether we translate the Q and M propositions using (Q_1) and (M_1) or (Q_2) and (M_2).[17] But there is a catch: (X_2) also validates Barbara XLL whether (L_1) or (L_2) is used:

Barbara XLL (L_1)	Barbara XLL (L_2)
$\forall x \forall t(Bxt \supset Axt)$	$\forall x \forall t(Bxt \supset Axt)$
$\underline{\forall x(Cxt* \supset \forall tBxt)}$	$\underline{\forall x \forall t(Cxt \supset \forall tBxt)}$
$\forall x(Cxt* \supset \forall tAxt)$	$\forall x \forall t(Cxt \supset \forall tAxt)$

So if we use (X_2) then we cannot get the apodeictic syllogistic right, because there is no real difference between a true non-modal proposition of the form given in (X_2) and a true apodeictic (L) proposition. But Aristotle clearly states that *there is* a difference between the invalid Barbara XLL and the valid Barbara LLL.[18] Hintikka thinks this a problem for the apodeictic syllogistic because he thinks the principle of plenitude is central to Aristotle's modal reasoning:

[17] If (Q_2) is the right way to translate the contingent proposition, then plenitude will not validate Barbara XQQ, but it will validate Barbara XQM. Any invalid modal instance of Barbara XQM will have a corresponding *plenitized* version with at least one false premise. If the M-conclusion 'every C is possibly-A' is false, then the *plenitized* conclusion 'every C is sometimes A' is false. But if the *plenitized* syllogism is valid and the conclusion is false, then a premise had to be false.

[18] Obviously the Q and M translations do not enter into this.

> As a consequence [of the principle of plenitude], whatever is always true is true necessarily according to Aristotle.
> Now, Aristotle also insists that universal assertoric (non-modal) premisses, i.e. premisses of the form
> (I) A applies to all B,
> have to be understood with no limitation with respect to time, for instance so as to be restricted to the present moment. (See *An.Pr.* I 15, 34b7–18.) What this means is that premisses like (I) will have to take in all individuals, past, present, and future. From the principle of plenitude it therefore follows that if (I) is true, it is necessarily true. [Hintikka, (1973, pp. 136–137)]

Appealing to both plenitude and the *haplos* requirement, Hintikka interprets the universal affirmative non-modal (X) premise and the apodeictic (L) premise the same way: $\forall x \forall t(Bxt \supset Axt)$. Without a meaningful distinction between Xs and Ls, the apodeictic syllogistic falls apart, but the apodeictic syllogistic is usually regarded as far more coherent than the problematic syllogistic, and so even if we take the principle of plenitude to be part of Aristotle's thought, that does not rescue him from a confusion in his modal thinking.[19]

VI

By combining the contributions of a number of authors I have tried to show how the same confusions in Aristotle's temporal reasoning occur in two apparently different works in such a way that a consideration of each throws light on the other. (This provides more evidence for not isolating Aristotle's modal logic from the rest of his philosophy.) Patterson offers an analysis of Barbara XQM that focuses specifically on the passage *An.Pr.* I.15, 34a34–b2, but his account of Barbara XQM does not hinge on Aristotle's talk of *haplos* premises in 34b7–18, nor does it reflect the similarity with *De Caelo* I.12, 281b16–23. Williams and Judson offer interpretations of the *De Caelo*

[19] Such a conclusion may not worry Hintikka who is inclined to think that the modal syllogistic is inconsistent anyway, though, of course, Hintikka does not attribute to Aristotle the same confusion as Judson does. For a full discussion of the apodeictic syllogistic, see Rini (1998). Someone might claim that *in the apodeictic syllogistic* a universal affirmative X-proposition has the form given in (X_1). But *in the problematic syllogistic* a universal affirmative X-proposition has the form given in (X_2). Patterson (p. 167, n. 28) reports that Geach (in an unpublished manuscript) considers some such move. But in the absence of any other evidence that Aristotle translates his modal propositions differently, this response hardly makes the syllogistic any less coherent than Hintikka thinks it is.

passage that help explain the role time plays in Aristotle's reasoning, but they do not develop an analysis of the *An.Pr.* passage. Hintikka provides an analysis of both *De Caelo* and *Prior Analytics* via plenitude, but as Hintikka notices plenitude does not preserve the coherence of the apodeictic (necessary) syllogistic.

This seems to me to be as far as the issue can be taken in purely logical terms. To go further, one would need, I think, to look more closely at Aristotle's struggles with time in works such as *Physics* and *Metaphysics*.

School of History, Philosophy and Politics
Massey University
Private Bag 11-222
Palmerston North
New Zealand
E-mail: A.Rini@massey.ac.nz

References

Hintikka, Jaakko. 1973. *Time and Necessity: Studies in Aristotle's Theory of Modality.* Oxford: Clarendon Press.

Judson, Lindsay. 1983. 'Eternity and Necessity in *De Caelo* I.12.' 217–255 in *Oxford Studies in Ancient Philosophy* I, (ed. Julia Annas). Oxford: Clarendon Press.

Mignucci, M. 1972. *On a Controversial Demonstration of Aristotle's Modal Syllogistic: An Enquiry on Prior Analytics A.15.* Padua: Editrice Antenore.

Nortmann, Ulrich. 1990 'Ueber die Stärke der aristotelischen Modallogik.' *Erkenntnis* 32, pp. 61–82.

Patterson, Richard. 1995. *Aristotle's Modal Logic: Essence and Entailment in the Organon.* Cambridge: Cambridge University Press.

Rini, Adriane. A. 1996. 'The *Aristotelicity* of Thomason's Semantics.' *Logique et Analyse*, No. 155–56 , pp. 255–70.

Rini, Adriane. A. 1998. 'Is There a Modal Syllogistic?' *Notre Dame Journal of Formal Logic* 39:4 (Fall 1998), pp. 554–72.

Ross, W.D. 1949. *Aristotle's Prior and Posterior Analytics. A Revised Text with Introduction and Commentary.* Oxford: Clarendon Press.

Smith, Robin. 1989. *Aristotle: Prior Analytics translated, with introduction, notes, and commentary.* Indianapolis: Hackett Publishing Company.

Thom, Paul. 1996. *The Logic of Essentialism: An Interpretation of Aristotle's Modal Syllogistic.* Dordrecht: Kluwer Academic Publishers.

Tredennick, Hugh. 1938. *The Organon, I: The Categories, On Interpretation, Prior Analytics.* [Translation of *Prior Analytics* is by Tredennick.] Cambridge, Mass.: Harvard University Press (Loeb Classical Library).

Waterlow [Broadie], Sarah. 1982. *Passage and Possibility: A Study of Aristotle's Modal Concepts.* Oxford: Clarendon Press.

Williams, C.J.F. 1965. 'Aristotle and Corruptibility.' *Religious Studies* I, pp. 95–107 and 203–215.