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Is There a Modal Syllogistic?

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Abstract Aristotle's modal syllogistic has been described as "incoherent," "a failure," "a realm of darkness." Even the gentler critics claim that it is inconsistent. I offer an interpretation according to which validity in the modal syllogistic is always obtained by substituting modal terms in the nonmodal syllogistic, and restricting the principles of modal conversion. In this paper I discuss the apodeictic syllogistic, showing that the restrictions I propose are powerful enough to do all the work Aristotle requires and, in fact, are supported by a close analysis of Aristotle's text. The upshot of this is that there is for Aristotle no separate modal syllogistic.

Aristotle's modal syllogistic has been described as "incoherent" (Striker [11]), "a failure" (Łukasiewicz [4]), "a realm of darkness" (Patzig [7]). The interesting question to ask is *Why*? The answer proposed in this paper is that for Aristotle there is not a separate modal logic.

Much recent scholarship on Aristotle's modal syllogistic takes a *de re* analysis of modality as the right way to interpret Aristotle's modal logical expressions. But not everyone agrees with this. In *The Development of Logic* [3], Kneale and Kneale charge that a *de re* interpretation of Aristotle's modals is "clearly wrong." They give the following reason.

> If modal words modify predicates, there is no need for a special theory of *modal* syllogisms. For there are only ordinary assertoric [nonmodal] syllogisms of which the premises have peculiar predicates. ([3], p. 91)

The point of the Kneales' complaint against giving Aristotle's modal syllogistic premises a *de re* interpretation is that such an analysis makes the modal logic appear trivial—it is then only a version of the nonmodal syllogistic with modally qualified *terms*. The Kneales do not think the modal syllogistic is trivial and so they reject a *de re* analysis.[1]

Some of the *de re* analyses that have been proposed are certainly not open to the Kneales' complaint. Johnson [2] and Thomason [13] each offer a semantics for McCall's axiomatization of the modal syllogistic [5].[2] Both take Aristotle's modal operators always as *de re* operators on terms, but on the accounts Johnson and Thomason

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give, the modal syllogistic clearly is not trivial. Their work shows that getting the logic to come out right requires *special modal logical rules*. Examples of two such special rules are (1) and (2):[3]

(1)	$\exists x(Bx \& Ax)$	$\rightarrow$	$\exists x(Bx \& LAx)$	([13], p. 120)
(2)	$\forall x(Bx \rightarrow LAx)$	$\rightarrow$	$\forall x(L \sim Ax \rightarrow L \sim Bx)$	([13], p. 123)

I call these modal rules special because they cannot be gotten by uniform substitution of modal for nonmodal terms. So, what makes them special also makes them nontrivial in the sense of the Kneales' complaint. If special modal rules are required to get Aristotle's logic right, then clearly a *de re* account of the modal syllogistic is *not* completely trivial. There is, however, a problem with this approach: (1) and (2) and other special modal rules admit results that plainly do not sit well with some of Aristotle's discussions about necessity and possibility. For instance, (1) would allow the move from 'some man is white' to 'some man is necessarily white'. For Aristotle the first is true but the second false.

There is a long tradition of scholarship that treats Aristotle's logic as if there are no restrictions on what we choose as our modal syllogistic terms. I do not think that is right; I think Aristotle himself often relies on what are ultimately semantic considerations when he accepts and rejects modal syllogisms. My aim in the present paper is to show that the right semantic restrictions on the principles of modal conversion are powerful enough to do all the work. So, instead of taking the Kneales' point as an objection to Aristotle, I want to take their point as a starting place and suggest that 'peculiar predicates' are exactly what Aristotle has in mind. If substituting modal for nonmodal terms in assertoric syllogisms can get us exactly those syllogisms Aristotle says are valid and none of the ones he says are not, then there is a sense in which the Kneales are right and the modal syllogistic is trivial. Of course, if it is trivial in this sense, then we will not need anything like (1) and (2) in order to capture Aristotle's meaning. Instead, any modal rules should be only modal versions (that is, substitution instances) of ordinary nonmodal rules, so there is no separate logic of modality for Aristotle. There is only *one* logic.

Aristotle considers syllogisms involving three modal qualifiers: 'necessity', 'possibility', and 'contingency'. It will help to use the logician's L, M, and Q to represent these, and I will follow McCall in using X to designate an assertoric (nonmodal) proposition. In the present paper I will limit my discussion to the apodeictic syllogistic—the part that is about syllogisms from necessary premises. I am concerned with that portion of Aristotle's logic that McCall deals with in his system L-X-M. This, of course, leaves out the problematic syllogistic. For the sake of brevity, it seems best to leave that for another day.

Consider Aristotle's nonmodal syllogisms. These are listed in Table 1. The first figure is axiomatic for Aristotle—he explains that the validity of the first figure is "obvious." He proves most of the second and third figure syllogisms by conversion back to the first figure. The conversions needed here are XA-conversion, XI-conversion, XE-conversion.

Table 1: *Assertoric Base*

First Figure:	Second Figure:	Third Figure:
Barbara XXX $\begin{array}{l} \forall x(Bx \rightarrow Ax) \\ \forall x(Cx \rightarrow Bx) \\ \hline \forall x(Cx \rightarrow Ax) \end{array}$	Cesare XXX $\begin{array}{l} \forall x(Bx \rightarrow \sim Ax) \\ \forall x(Cx \rightarrow Ax) \\ \hline \forall x(Cx \rightarrow \sim Bx) \end{array}$	Darapti XXX $\begin{array}{l} \forall x(Cx \rightarrow Ax) \\ \forall x(Cx \rightarrow Bx) \\ \hline \exists x(Bx \& Ax) \end{array}$
Celarent XXX $\begin{array}{l} \forall x(Bx \rightarrow \sim Ax) \\ \forall x(Cx \rightarrow Bx) \\ \hline \forall x(Cx \rightarrow \sim Ax) \end{array}$	Camestres XXX $\begin{array}{l} \forall x(Bx \rightarrow Ax) \\ \forall x(Cx \rightarrow \sim Ax) \\ \hline \forall x(Cx \rightarrow \sim Bx) \end{array}$	Felapton XXX $\begin{array}{l} \forall x(Cx \rightarrow \sim Ax) \\ \forall x(Cx \rightarrow Bx) \\ \hline \exists x(Bx \& \sim Ax) \end{array}$
Darii XXX $\begin{array}{l} \forall x(Bx \rightarrow Ax) \\ \exists x(Cx \& Bx) \\ \hline \exists x(Cx \& Ax) \end{array}$	Festino XXX $\begin{array}{l} \forall x(Bx \rightarrow \sim Ax) \\ \exists x(Cx \& Ax) \\ \hline \exists x(Cx \& \sim Bx) \end{array}$	Datisi XXX $\begin{array}{l} \forall x(Cx \rightarrow Ax) \\ \exists x(Cx \& Bx) \\ \hline \exists x(Bx \& Ax) \end{array}$
Ferio XXX $\begin{array}{l} \forall x(Bx \rightarrow \sim Ax) \\ \exists x(Cx \& Bx) \\ \hline \exists x(Cx \& \sim Ax) \end{array}$	Baroco XXX $\begin{array}{l} \forall x(Bx \rightarrow Ax) \\ \exists x(Cx \& \sim Ax) \\ \hline \exists x(Cx \& \sim Bx) \end{array}$	Disamis XXX $\begin{array}{l} \exists x(Cx \& Ax) \\ \forall x(Cx \rightarrow Bx) \\ \hline \exists x(Bx \& Ax) \end{array}$
		Bocardo XXX $\begin{array}{l} \exists x(Cx \& \sim Ax) \\ \forall x(Cx \rightarrow Bx) \\ \hline \exists x(Bx \& \sim Ax) \end{array}$
		Ferison XXX $\begin{array}{l} \forall x(Cx \rightarrow \sim Ax) \\ \exists x(Cx \& Bx) \\ \hline \exists x(Bx \& \sim Ax) \end{array}$

Conversions

XA-conv	::	if all B are A, then some A are B	::	$\forall x(Bx \rightarrow Ax) \rightarrow \exists x(Ax \& Bx)$[4]
XI-conv	::	if some B is A, then some A is B	::	$\exists x(Bx \& Ax) \rightarrow \exists x(Ax \& Bx)$
XE-conv	::	if all B are not A, then all A are not B	::	$\forall x(Bx \rightarrow \sim Ax) \rightarrow \forall x(Ax \rightarrow \sim Bx)$

An example shows how conversion works. Take the premises in Darapti. By converting the second premise Darapti becomes the first figure Darii.

Darapti XXX

(1)	$\forall x(Cx \rightarrow Ax)$	Given
(2)	$\forall x(Cx \rightarrow Bx)$	Given
(3)	$\exists x(Bx \& Cx)$	XA-conv, 2
(4)	$\exists x(Bx \& Ax)$	Darii, 1, 3 (First Figure)

In Chapter A8 of the *Prior Analytics*, Aristotle explains that for every nonmodal syllogism (syllogisms about mere 'belonging') there is a corresponding modal syllogism about necessity (about belonging or not belonging of necessity):

> In the case of necessary premises, then, the situation is almost the same as with premises of belonging: that is, there either will or will not be a deduction with the terms put in the same way, both in the case of belonging and in the case of belonging or not belonging of necessity, except that they will differ in the addition of 'belonging (or not belonging) of necessity' to the terms. (A8, 29b36–30a2)

So by adding 'belonging of necessity' or 'not belonging of necessity' to a nonmodal syllogism, we get a corresponding syllogism about necessity. Many scholars point to this passage as a clear suggestion that a *de re* analysis is right, since these modal expressions are added 'to the terms'. So let us try the following translations:

(LA)	::	'*A* belongs to every *B* of necessity'	::	$\forall x(Bx \rightarrow LAx)$
(LI)	::	'*A* belongs to some *B* of necessity'	::	$\exists x(Bx \& LAx)$
(LE)	::	'*A* does not belong to every *B* of necessity' (that is, '*A* is impossible for all *B*')	::	$\forall x(Bx \rightarrow L \sim Ax)$
(LO)	::	'*A* does not belong to some *B* of necessity'	::	$\exists x(Bx \& L \sim Ax)$.

No syllogism about necessity will be valid that is not an instance of an XXX syllogism. So whenever we add *L*s to premises, we know that at the very least an X-conclusion will always follow. So for every valid XXX syllogism there are only LLL, LXL, and XLL combinations to consider. Further, Aristotle clearly believes that what is necessarily so is so. So, if there is either an LXL or an XLL syllogism, there will also be a corresponding LLL syllogism. I will discuss later two cases where Aristotle claims there is an LLL syllogism where there is neither an LXL nor an XLL. Consider the first figure LXL syllogisms:

Table 2: *The First Figure Valid LX*s

Barbara LXL (30a17–23)

$$\frac{\forall x(Bx \rightarrow LAx) \quad \forall x(Cx \rightarrow Bx)}{\forall x(Cx \rightarrow LAx)}$$

Celarent LXL (30a17–23)

$$\frac{\forall x(Bx \rightarrow L \sim Ax) \quad \forall x(Cx \rightarrow Bx)}{\forall x(Cx \rightarrow L \sim Ax)}$$

Darii LXL (30a37–b2)

$$\frac{\forall x(Bx \rightarrow LAx) \quad \exists x(Cx \& Bx)}{\exists x(Cx \& LAx)}$$

Ferio LXL (30a37–b2)

$$\frac{\forall x(Bx \rightarrow L \sim Ax) \quad \exists x(Cx \& Bx)}{\exists x(Cx \& L \sim Ax)}$$

All we need here is Uniform Substitution of LA for A and $L{\sim}A$ for ${\sim}A$. ($L{\sim}A$ for ${\sim}A$ is still Uniform Substitution: US of ${\sim}L\ {\sim}A$ for A gets ${\sim}{\sim}\ L{\sim}A$ for ${\sim}A$; that is, $L{\sim}A$ for ${\sim}A$.) So we can regard each of the syllogisms in Table 2 as an instance of a nonmodal first figure syllogism. Certainly, the first figure LXLs are formally correct. But none are valid *de dicto*. (To see this, look at a *de dicto* version of Barbara LXL, and let $A =$ unmarried, $B =$ bachelor, $C =$ Wellingtonian and assume that all Wellingtonians are in fact bachelors.) Since Aristotle proves the validity of syllogisms in other figures by reduction to the first figure, if *de dicto* does not work here, it will not work anywhere.

Next, look at the invalid first figure XLLs.[5] Aristotle rejects an L-conclusion for Barbara XLL; here only an X-conclusion follows:

> It is, moreover, also evident from terms that the conclusion can fail to be necessary, as for instance, if A were motion, B animal, and C stood for man. For a man is of necessity an animal, but an animal does not move of necessity, nor does a man. It would also be similar if AB were privative (for the demonstration is the same). (30a28–33)

So, with terms in place:

	Barbara XLL	
T	$\forall x(Bx \rightarrow Ax)$	All animals are moving
T	$\underline{\forall x(Cx \rightarrow LBx)}$	<u>All men are necessary animals</u>
F	$\forall x(Cx \rightarrow LAx)$	All men are necessarily moving

Since moving is only accidental to man it is false to say a man moves of necessity. So an L-conclusion does not follow. Of course, an X-conclusion does follow. That is, Barbara XLX is valid, but not Barbara XLL. Aristotle also extends the point to the privative: Celarent XLL is invalid. The same terms show why.

	Celarent XLL	(30a28-33)
T	$\forall x(Bx \rightarrow\sim Ax)$	All animals are not moving
T	$\underline{\forall x(Cx \rightarrow LBx)}$	<u>All men are necessary animals</u>
F	$\forall x(Cx \rightarrow L \sim Ax)$	All men are necessarily not moving

Again, an X-conclusion is fine: if the premises are true, then it follows that all men are not moving, $\forall x(Cx \rightarrow\sim Ax)$. In accounting for the invalidity of Darii and Ferio LXL, Aristotle again introduces terms:

> if the particular premise is necessary, the conclusion will not be necessary (for nothing impossible results[6]), just as it was not in the case of universal deductions; and similarly also in the case of privatives. Terms are motion, animal, white. (30b2–6)

	Darii XLL	
T	$\forall x(Bx \rightarrow Ax)$	All animals are moving
T	$\underline{\exists x(Cx \& LBx)}$	<u>Some white thing is a necessary animal</u>
F	$\exists x(Cx \& LAx)$	Some white thing is necessarily moving

Ferio XLL

T	$\forall x(Bx \rightarrow \sim Ax)$	No animals are moving
T	$\underline{\exists x(Cx \& LBx)}$	<u>Some white thing is a necessary animal</u>
F	$\exists x(Cx \& L \sim Ax)$	Some white thing is necessarily not moving

Aristotle explains why Darii and Ferio XLL are invalid by setting out terms of which two are accidents—'white' and 'moving'. Only one accident appears in any premise, but both feature in the conclusions. In Barbara LXL and Celarent LXL, the L-conclusions are rejected apparently because no thing moves or does not move of necessity. This same reason makes the L-conclusions of Darii and Ferio XLL unacceptable, too. The use of accidental terms to pick out subjects can be avoided in these cases by taking different terms. For example, let A be moving, B be animal, and C be man. Nevertheless, the fact that here Aristotle does use accidents in subject position of a true L-premise is important because it seems that such accidental subjects cause worries. These problems come up most specifically with the second figure.

Table 3: *Second Figure Mixed Valids*[7]

Cesare LXL (30b9–13)

$$\forall x(Bx \rightarrow L \sim Ax)$$
$$\underline{\forall x(Cx \rightarrow Ax)}$$
$$\forall x(Cx \rightarrow L \sim Bx)$$

Camestres XLL (30b14–18)

$$\forall x(Bx \rightarrow Ax)$$
$$\underline{\forall x(Cx \rightarrow L \sim Ax)}$$
$$\forall x(Cx \rightarrow L \sim Bx)$$

Festino LXL (31a5–10)

$$\forall x(Bx \rightarrow L \sim Ax)$$
$$\underline{\exists x(Cx \& Ax)}$$
$$\exists x(Cx \& L \sim Bx)$$

Table 4: *Second Figure LLL*s

Cesare LLL

$$\forall x(Bx \rightarrow L \sim Ax)$$
$$\underline{\forall x(Cx \rightarrow LAx)}$$
$$\forall x(Cx \rightarrow L \sim Bx)$$

Camestres LLL

$$\forall x(Bx \rightarrow LAx)$$
$$\underline{\forall x(Cx \rightarrow L \sim Ax)}$$
$$\forall x(Cx \rightarrow L \sim Bx)$$

Festino LLL

$$\forall x(Bx \rightarrow L \sim Ax)$$
$$\underline{\exists x(Cx \& LAx)}$$
$$\exists x(Cx \& L \sim Bx)$$

Baroco LLL

$$\forall x(Bx \rightarrow LAx)$$
$$\underline{\exists x(Cx \& L \sim Ax)}$$
$$\exists x(Cx \& L \sim Bx)$$

With all of the syllogisms in Table 3, there are valid LLL syllogisms—that is, Cesare LLL, Camestres LLL, and Festino LLL are all valid. Aristotle also says Baroco LLL is valid (A8, 30a6–14). The second figure LLLs are listed in Table 4.

Baroco LLL is an interesting case and I will say more about it later. But all of the syllogisms in Tables 3 and 4 are troubling. First, do notice that *none* of these syllogisms are substitution instances of valid XXXs, and in fact they will fail if we place no restrictions on terms. In each case if the B term is allowed to be an accident then we would be able to construct simple counterexamples to all these purportedly valid second figure syllogisms. Look at Cesare LXL for an example of this: Aristotle says it is valid but here is what would appear to be a counterexample. Let A be biped, B be white, and C be man: then we get

	Cesare LXL
T	All white things are necessarily not bipeds
T	All men are bipeds
F	All men are necessarily not white

If all white things are stones, then all white things are necessarily not bipeds. So the first premise is true. The second premise is certainly true for Aristotle. But the conclusion is false: no man is by necessity not white. Similarly, no man is by necessity white. Being white or being not white is only accidental to any man. So it looks like we have true premises and a false conclusion, *so it looks* like we have an invalid case instead of a valid one as Aristotle claims. It is even worse: given that all men are necessarily bipeds, these terms would also appear to invalidate Cesare LLL. The same terms would also invalidate *de re* LE-conversion: $\forall x(Bx \rightarrow L \sim Ax) \rightarrow \forall x(Ax \rightarrow L \sim Bx)$. That would be, 'if all white things are necessarily not bipeds, then all bipeds are necessarily not white'.[8]

Some of what Aristotle says in the *Posterior Analytics* suggests that he might not accept this kind of counterexample because he might not allow 'all white things are necessarily not bipeds' as a true premise. In *Posterior Analytics* A22, Aristotle describes what he calls "genuine (*haplos*) predication." His point there is that 'the white thing is a log' is not an example of genuine predication. The reason is that 'white' identifies a subject indirectly, or accidentally. Genuine predication does not allow picking out a subject in this way. The only way to genuinely predicate is to predicate something of a subject which is identified by a substance term. So maybe Aristotle is thinking like this when he is talking about Cesare LXL and the other second figure modal syllogisms and modal conversion.

Let us suppose that the restriction on modal premises is right—that Aristotle now means to restrict modal premises to genuine premises with substance subjects. Call this restriction the *genuineness requirement*. The genuineness requirement would validate Cesare LXL and Festino LXL. And restricting modal premises to genuine premises gets *all* of the second figure LLLs to come out valid. So restricting modal premises to genuine premises looks pretty good.

Unfortunately, there are three reasons this will not work. First, Aristotle does give examples, in the first figure, that have accidents as subjects of necessary propositions. In constructing counterexamples to Darii XLL and Ferio XLL, Aristotle offers 'some white thing is a necessary animal' as a true apodeictic premise. This is not genuine predication because white is an accident.[9] Second, the genuineness requirement will not validate Camestres XLL which Aristotle claims is valid (30b14–18). In LPC, Camestres XLL is the following,

$$\frac{\begin{array}{l}\forall x(Bx \rightarrow Ax) \\ \forall x(Cx \rightarrow L \sim Ax)\end{array}}{\forall x(Cx \rightarrow L \sim Bx)}$$

where B occurs as subject only in a nonmodal premise. Finally, the third reason the genuineness requirement will not work: it validates Camestres LXL and Baroco LXL, both of which Aristotle claims are invalid.[10] Table 5 lists Aristotle's second figure mixed invalids. All the examples are Aristotle's own. I mark rejected conclusions with an asterisk.

Table 5: *Invalid Second Figure $L + X$ Forms*

	Camestres LXL	$(30b20-40)$
	$\forall x(Bx \to LAx)$	All men are necessary animals
	$\forall x(Cx \to\sim Ax)$	All white things are not animals
*	$\forall x(Cx \to L \sim Bx)$	All white things are necessarily not men
	Festino XLL	
	$\forall x(Bx \to\sim Ax)$	
	$\exists x(Cx \& LAx)$	(no terms given, no specific discussion)
*	$\exists x(Cx \& L \sim Bx)$	
	Baroco LXL	('the same terms will serve', 31a10–15)
	$\forall x(Bx \to LAx)$	All men are necessary animals
	$\exists x(Cx \& \sim Ax)$	Some white thing is not an animal
*	$\exists x(Cx \& L \sim Bx)$	Some white thing is necessarily not a man
	Baroco XLL	('through the same terms', 31a15–17)
	$\forall x(Bx \to Ax)$	All men are animals
	$\exists x(Cx \& L \sim Ax)$	Some white thing is necessarily not an animal
*	$\exists x(Cx \& L \sim Bx)$	Some white thing is necessarily not a man
	Cesare XLL	
	$\forall x(Bx \to\sim Ax)$	
	$\forall x(Cx \to LAx)$	(no terms given, no specific discussion)
*	$\forall x(Cx \to L \sim Bx)$	

Consider the restriction to genuine apodeictic premises. The first two objections to the restriction can be dealt with by looking at how Aristotle proves validity. Aristotle uses LE-conversion to validate Camestres XLL. He first describes LE-conversion at A3, 25a29–30: "if it is necessary for A to belong to no B, then it is necessary for B to belong to no A": $\forall x(Bx \to L \sim Ax) \to \forall x(Ax \to L \sim Bx)$. When we translate Aristotle's proof of Camestres XLL into LPC with *de re* necessity, we get:

Camestres XLL (30b14–18)

(1)	$\forall x(Bx \to Ax)$	Given
(2)	$\forall x(Cx \to L \sim Ax)$	Given
(3)	$\forall x(Ax \to L \sim Cx)$	LE-conv, 2
(4)	$\forall x(Bx \to L \sim Cx)$	1, 3
(5)	$\forall x(Cx \to L \sim Bx)$	LE-conv, 4

Assuming that all necessary premises are genuine premises, then the C term in (2) is a substance term. The B term starts out without any restrictions because it is in an assertoric premise. That leaves open the possibility of having an accidental B term. But an accidental B term would result in an invalid conversion. To see this let B be awake and C be man. So it seems we have a problem because the move from (4) to (5) is suspect. So perhaps the restriction to substance terms is not to be decided on the basis of the premises but on the basis of input into valid conversion. There is, in fact, some evidence that Aristotle thinks conversion must be restricted by appropriate selection of terms.

> So one must select the premises about each subject in this way, assuming first the subject itself, and both definitions and whatever is peculiar to the subject; next after this, whatever follows the subject; next, whatever the subject follows; and then, whatever cannot belong (*me endechetai . . . huparchein*) to it. (Those to which it is not possible (*me endechetai*) for the subject to belong need not [or, perhaps, must not[11]] be selected, because the privative converts).

For Aristotle, what does 'not possibly belong' also 'necessarily does not belong', so his warning here appears to be a warning about choosing accidental terms because they make a mess of conversions. It is not absolutely clear exactly what his point is, but at least it shows that Aristotle is very worried about what happens to modal conversion when you have accidental terms. Suppose, then, that instead of putting restrictions on the premises, we put the following restriction on LE-conversion: in applying LE-conversion to a proposition the proposition must be genuine. This would guarantee that the B term in Aristotle's proof of Camestres XLL is a substance. So the conversion from (4) to (5) would be valid because only substance terms would be involved.

In fact, *de re* L-conversions generally (LA, LI, and LE-conversions) can be justified by the genuineness requirement. This because of the validity of the following.

(C1) $[\forall x(Bx \to L \sim Ax) \& \forall x(\sim Bx \to L \sim Bx)] \to \forall x(Ax \to L \sim Bx)$

(C2) $[\exists x(Bx \& LAx) \& \forall x(Bx \to LBx)] \to \exists x(Ax \& LBx)$

Of course, we cannot tell just by looking at a syllogism's premises whether terms will be restricted because we cannot tell in advance whether conversion will be needed. This also helps account for my first objection to taking all apodeictic premises as genuine: first figure proofs do not involve any conversion, so L-premises there may or may not be genuine. So in the first figure there is no problem about the truth of 'some white thing is a necessary animal'.

The genuineness restriction on conversion gets all of Table 3 and all of Table 4, except Baroco LLL. Of course, validity in these cases means validity for appropriately restricted terms. For example, the restricted validity of Cesare LXL follows from

$$[\forall x(Bx \to L \sim Ax) \& \forall x(\sim Bx \to L \sim Bx) \& \forall x(Cx \to Ax)] \to \forall x(Cx \to L \sim Bx).$$

Baroco LLL cannot be proved by straightforward conversion, a fact Aristotle notes in A8, 30a6–14. In this same passage he claims that Baroco LLL can be proven by a method he calls "setting out (*ekthesis*)" but he does not carry out the proof for this case. Patterson [6] and Thom [12] give accounts of how ekthesis does the job. What is especially interesting about their accounts is that they involve a B subject in an LE-conversion.[12]

All this still leaves problems with Camestres LXL and Baroco LXL. Aristotle discusses Camestres LXL in detail and gives two separate explanations about why we only get Camestres LXX, and not LXL. First, he gives a formal explanation at 30b22–23:

Camestres LXX	
$\forall x(Bx \rightarrow LAx)$	A belongs to every B of necessity
$\forall x(Cx \rightarrow \sim Ax)$	but merely belongs to no C
$\forall x(Ax \rightarrow \sim Cx)$	then, when the privative is converted
$\forall x(Bx \rightarrow \sim Cx)$	it becomes the first figure (i.e., Celarent XLX)

Here, Aristotle reminds us that the conclusion of the first figure Celarent XLX will not be necessary. His point seems to be that since the first figure Celarent XLX provides the basis for the proof of the second figure mood Camestres LXX, then in this second figure mood, as in the first, the conclusion will not be necessary. But there are some troubles here. Aristotle stops too soon when he stops at the conclusion ‘all *B*s are non-*C*s’. The general form of the second figure has C as subject and B as predicate. When Aristotle gives a counterexample through terms, this seems to lead to serious difficulties. In his counterexample, Aristotle gives terms ‘animal’, ‘man’, ‘white’ for A, B, and C.

	Camestres LXL	(30b20–40)
T	$\forall x(Bx \rightarrow LAx)$	All men are necessary animals
T	$\underline{\forall x(Cx \rightarrow \sim Ax)}$	<u>All white things are not animals</u>
F	$\forall x(Cx \rightarrow L \sim Bx)$	All white things are necessarily not men

In his formal explanation, when Aristotle says that by conversion Camestres “becomes the first figure” he shows us that with terms in place we get a (valid first figure) syllogism in which we *can* conclude

(1) ‘All men are not white.’ T

That is certainly what we get with conversion to Celarent XLX. And since an L-conclusion does not follow, then we *cannot* conclude

(2) ‘All men are necessarily not white.’ F

The difficulty with both the “proofs” of invalidity (i.e., the formal explanation and the counterexample) is that in fact they only establish that

$$\begin{array}{l} \forall x(Bx \rightarrow LAx) \\ \underline{\forall x(Cx \rightarrow \sim Ax)} \\ \forall x(Bx \rightarrow L \sim Cx) \end{array}$$

is invalid. Why should Aristotle think this invalidates Camestres LXL? Presumably because he thinks that the conclusion of Camestres can be obtained by LE-conversion from the conclusion of this syllogism. Since the conclusion of this syllogism—that is, (2)—is a genuine predication, it would seem that LE-conversion does apply. But here is where he has made a mistake. Aristotle thinks that the falsity of

(2) ‘All men are necessarily not white.’ F

shows you cannot get

(3) 'All white things are necessarily not men.' F

It seems that he holds that (2) is *equivalent* to (3)—by LE-conversion. But taking LE-conversion as an equivalence will only work if both terms are substances. They are not in this counterexample. If Aristotle were to use LE-conversion as he does here, then he would be able to use it to establish the falsity of 'all white things are necessarily not men'. And this could be used to invalidate Cesare LXL. [Let the terms be 'horse', 'man', and 'white' in Cesare LXL.]

This raises a very subtle point of logic, more subtle than mistaking an implication for an equivalence. Although we can, of course, state LE-conversion as an equivalence, $\forall x(Bx \rightarrow L \sim Ax) \equiv \forall x(Ax \rightarrow L \sim Bx)$, it is better from Aristotle's point of view to think of it as a rule which can be used in both directions. In that case we need not require that *both* terms be substances, but we must remember that when it is used in one direction, it is the A term that must be a substance; in the other direction it is the B term that must be a substance. In arguing from falsity to falsity, Aristotle is in fact using a contraposed form of the rule. And he is mistaken about which term must be the substance term. In going from the falsity of 'all men are necessarily not white' to the falsity of 'all white things are necessarily not men' we are in fact using a rule which would take us from the truth of 'all white things are necessarily not men' to the truth of 'all men are necessarily not white'. This demands that white be the substance term and it clearly is not. Perhaps Aristotle is confused here because in using conversion in a proof of validity, as we have seen in the case of the *valid* second figure moods, he is going from the truth of antecedent to the truth of consequent.

If this is his mistake, although indeed it is a mistake, and although it does indeed create an inconsistency in his system, it is not surprising that it is a mistake which has gone unnoticed for so long. To give it a name, I will call it the *Subtle Mistake*. It would appear to affect some other invalid syllogisms too.[13] In the second figure the subtle mistake affects Aristotle's account of Baroco LXL and Baroco XLL. When Aristotle discusses these, he claims that the same terms he uses to establish the invalidity of Camestres LXL can be used to invalidate Baroco LXL and XLL. Since in Camestres LXL, he interprets 'all white things are necessarily not men' as false, when he comes to the two Barocos he rejects 'some white things are necessarily not men' for the same reason.

What would Aristotle have said about all these if he had seen his mistake? Who can say? Maybe he would not accept Camestres LXL because it cannot be validated by conversion (as Thomason's modeling shows [13]). On the other hand, if Aristotle interprets the conclusion of Camestres LXL the wrong way, then the terms he gives do indeed produce a counterexample. The same holds for the two Barocos in Table 5. But consider the extent of the confusion that comes of the subtle mistake. First, there is some evidence that Aristotle really wants to say Baroco XLL is valid. In A10 he sets out a general rule about second figure mixed syllogisms: "in the case of the second figure, if the privative premise is necessary, then the conclusion will also be necessary; but if the positive premise is, the conclusion will not be necessary" (30b7–9). This would make Baroco XLL valid because the privative premise is necessary. That would mean that the counterexample in Table 5 is not really a counterexample.

This leads to a second reason to think Aristotle is badly confused: his counterexample to Baroco XLL is just plain fishy since in it 'some white thing is necessarily not an animal' is supposed to be true, but 'some white thing is necessarily not a man' is supposed to be false. If Aristotle really means to allow that, then he is right to reject Baroco XLL. But he does not notice that the counterexample he constructs against Baroco XLL also invalidates Baroco LLL, which Aristotle says is valid. So who can say what Aristotle's response to the subtle mistake would be?[14]

A catalogue of mistakes in itself is not really insightful. But it is important to notice here that only a few of Aristotle's examples are implicated—Festino XLL and Cesare XLL are not implicated. Aristotle offers no discussion of Festino XLL and Cesare XLL, but these are not affected by his mistake. They reduce by straightforward nonmodal conversion to first figure syllogisms with X- but not L-conclusions, so Festino XLX and Cesare XLX are valid, but not Festino and Cesare XLL.

Table 6: *Third Figure Valid Mixed Modals*

Darapti LXL (31a24–30)

$$\frac{\forall x(Cx \to LAx) \qquad \forall x(Cx \to Bx)}{\exists x(Bx \& LAx)}$$

(Darapti XLL) (31a31–33)

$$\frac{\forall x(Cx \to Ax) \qquad \forall x(Cx \to LBx)}{\exists x(Bx \& LAx)}$$

Felapton LXL (31a33–37)

$$\frac{\forall x(Cx \to L \sim Ax) \qquad \forall x(Cx \to Bx)}{\exists x(Bx \& L \sim Ax)}$$

Datisi LXL (31b19–20)

$$\frac{\forall x(Cx \to LAx) \qquad \exists x(Cx \& Bx)}{\exists x(Bx \& LAx)}$$

(Disamis XLL) (31b12–19)

$$\frac{\exists x(Cx \& Ax) \qquad \forall x(Cx \to LBx)}{\exists x(Bx \& LAx)}$$

Ferison LXL (31b35–37)

$$\frac{\forall x(Cx \to L \sim Ax) \qquad \exists x(Cx \& Bx)}{\exists x(Bx \& L \sim Ax)}$$

I have put parentheses around the names of two of these: Darapti XLL and Disamis XLL. The remaining syllogisms are easy. They are valid because all they depend on is Uniform Substitution together with ordinary nonmodal conversion.[15] The corresponding third figure LLLs follow from these. Further Bocardo LLL is also valid by Uniform Substitution (LB for B and $L \sim A$ for A) together with the T-principle:

Bocardo LLL

$$\begin{array}{l} \exists x(Cx \& L \sim Ax) \\ \underline{\forall x(Cx \rightarrow LBx)} \\ \exists x(Bx \& L \sim Ax) \end{array}$$

But now look at the cases I have bracketed in Table 6. Take Darapti XLL. This involves getting a modal operator (L) to shift from scope over the B term to scope over the A term. But what is interesting is that when we look at Aristotle's text, we do not find him trying to validate this syllogism. Aristotle discusses a syllogism with the same premises as in Darapti XLL, but a different conclusion. His proof is as follows (31a31–33):

(1)	$\forall x(Cx \rightarrow Ax)$	Given
(2)	$\forall x(Cx \rightarrow LBx)$	Given
(3)	$\exists x(Ax \& Cx)$	XA-conv, 1
(4)	$\exists x(Ax \& LBx)$	Transitivity 3, 2

And this seems to fit what Aristotle does describe: from premises

$\forall x(Cx \rightarrow Ax)$	'*A* belongs to every *C* but not of necessity'
$\forall x(Cx \rightarrow LBx)$	'*B* belongs to every *C* of necessity'

convert CA to

$\exists x(Ax \& Cx)$	'*C* converts to some *A*.'

"Consequently, if *B* belongs to every *C* of necessity, then it will also belong to some *A* of necessity," (31a33); that is,

$\exists x(Ax \& LBx)$	'*B* will belong of necessity to some *A*.'

And Aristotle stops there. (1) – (4), however, is not Darapti XLL. It would become Darapti XLL if Aristotle were to convert (4), but in the text he does not convert it. As Aristotle gives the first premise, *A* belongs to every *C* *"but not of necessity,"* so (1) is about mere belonging. If *A* merely belongs to every *C*, then *A* need not belong of necessity to any *C*.[16] So Aristotle clearly leaves open the case for an accidental *A* predicate in (1). If *A* is an accident, the genuineness requirement on conversion is not satisfied in (4), so Aristotle is not entitled to convert, and he does not. This means that we do not get a proof from Aristotle that Darapti XLL in Table 6 is valid.

With Disamis XLL we find a different but related problem. The syllogism called Disamis in Table 6 is not a syllogism Aristotle claims is valid. At A11, 31b12–19, Aristotle discusses a syllogism that is similar but not exactly the same. The difference is in the *AC* premise:

$\forall x(Cx \rightarrow LBx)$	if it is necessary for *B* to belong to every *C*
$\underline{\exists x(Ax \& Cx)}$	and *A* is below *C*,[17]
$\exists x(Ax \& LBx)$	then it is necessary for *B* to belong to some *A*

This much is valid but it is not in the third figure; it is in first figure. But Aristotle has more to say about this proof. He claims the conclusion itself converts. As he puts it: "if it is necessary for B to belong to some A, then it is also necessary for A to belong to some B (for it converts)" (31b18–19). So, $\exists x(Ax\&LBx)$ converts to $\exists x(Bx\&LAx)$. We know that conversion requires genuineness. In the syllogism Aristotle discusses, the A term is the subject term in a premise, so if it is a substance term, the conversion is legitimate. However, in Disamis XLL in Table 6, the A term is the predicate in a nonmodal premise. So there the A term might be an accident, and that means conversion cannot be guaranteed. Although we do get a proof from Aristotle, it is not a proof that Disamis XLL is valid.

I list Aristotle's third figure invalids in Table 7.

Table 7: *Invalid Third Figure L+X Forms*

	Felapton XLL	(31a37 – b10)
	$\forall x(Cx \rightarrow \sim Ax)$	All horses are not awake
	$\forall x(Cx \rightarrow LBx)$	All horses are necessarily animals
*	$\exists x(Bx\&L\sim Ax)$	Some animals are necessarily not awake
	Datisi XLL	(31b20 – 31)
	$\forall x(Cx \rightarrow Ax)$	All animals are wakeful
	$\exists x(Cx\&LBx)$	Some animal is necessarily a biped
*	$\exists x(Bx\&LAx)$	Some biped is necessarily wakeful
??	Disamis LXL	(31b31 – 33)
	$\exists x(Cx\&LAx)$	Some animal is necessarily a biped
	$\forall x(Cx \rightarrow Bx)$	All animals are wakeful
*	$\exists x(Bx\&LAx)$	Something wakeful is a necessary biped
	Bocardo XLL	(31b40 – 32a1)
	$\exists x(Cx\&\sim Ax)$	Some man is not wakeful
	$\forall x(Cx \rightarrow LBx)$	All men are necessarily animals
*	$\exists x(Bx\&L\sim Ax)$	Some animal is necessarily not wakeful
	Ferison XLL	(32a1 – 4)
	$\forall x(Cx \rightarrow \sim Ax)$	All animals are not wakeful
	$\exists x(Cx\&LBx)$	Some animal is necessarily white
*	$\exists x(Bx\&L\sim Ax)$	Some white thing is necessarily not wakeful
??	Bocardo LXL	(32a4 – 5)
	$\exists x(Cx\&L\sim Ax)$	Some animal is necessarily not a biped
	$\forall x(Cx \rightarrow Bx)$	All animals are moving
*	$\exists x(Bx\&L\sim Ax)$	Some moving thing is necessarily not a biped

In all these cases except Disamis LXL and Bocardo LXL, Aristotle is able to give counterexamples in which the premises are genuine, in the sense that they have substance subjects.[18] So Aristotle will clearly reject cases in which he can produce a "genuine" counterexample. It is worth noting here that genuine counterexamples could also be given for Darapti XLL and Disamis XLL listed in Table 6. But as we have seen, Aristotle's text does not support the claim that he accepts Darapti XLL and Disamis XLL. There is only one way Aristotle puts an L on a term, and that is by modal conversion. But modal conversion is always restricted to genuine conversion. A term that begins life as the predicate of an assertoric premise is for Aristotle a term of "mere belonging." Mere belonging must be able to cover accidental predicate terms; it cannot be restricted to essential terms. In the third figure invalids in which the A term begins life as the predicate of an assertoric premise, the A term clearly cannot be guaranteed to be a substance term and, therefore, cannot be guaranteed to satisfy the restriction on conversion.

But look closely at Disamis LXL and Bocardo LXL. Aristotle rejects as false 'something wakeful is a necessary biped' and 'some moving thing is necessarily not a biped'. The problem with these cannot be that nothing is a necessary biped, or nothing is necessarily not a biped, because the premises in these syllogisms say some animals are. Given what we have seen so far, these conclusions would appear to be true and Disamis LXL and Bocardo LXL valid. So, what is Aristotle doing? In his counterexample to Datisi XLL, Aristotle gives 'wakeful','biped', and 'animal' for A, B, and C. At 31b31–33, he explains that Disamis LXL can be shown to be invalid "through the same terms."[19] Notice that when we put terms in place, the premises in Disamis LXL are exactly the premises in Datisi XLL. Aristotle has already established in Datisi XLL that 'some biped is necessarily wakeful' is false. Two lines later, when he comes to Disamis LXL, he wants to have 'something wakeful is necessarily a biped' false. This looks like he is making the subtle mistake again: he wants to establish invalidity by arguing from falsehood to falsehood, this time through LI-conversion.

Bocardo LXL falls with Disamis LXL. This is so because Bocardo is simply Disamis with $L \sim A$ in place of LA, and Aristotle has already rejected Disamis LXL. Aristotle accepts Bocardo LLL, but rejects both Bocardo XLL and LXL. The same problems arise here as with the second figure Barocos, with the added point that Bocardo LLL does not require genuineness.

What does all this really mean? Clearly, in a sense there is a modal syllogistic. But also there is an important sense in which there appears not to be. First, the valid apodeictic principles are *all* instances of valid assertorics with restrictions on subject terms when subject to modal conversion. There is also a rather different sense in which we can say there is no modal syllogistic: because of Aristotle's subtle mistake there are a number of syllogisms whose validity we cannot legitimately pronounce upon. For instance, does Aristotle accept the real Camestres LXL? We do not have the evidence to decide. On the one hand, Camestres LXL cannot be proven with the aid of conversion; on the other hand, as I have shown, Aristotle's argument *against* Camestres LXL involves the subtle mistake. Although logicians can and have produced formal models for what they take to be the apodeictic syllogistic, a close examination of the text would suggest that we just cannot be sure of what Aristotle would say in cases like Camestres LXL. But in all the cases we can be clear about, the apodeictic syllogisms turn out to be instances of nonmodals with the single restriction that only genuine propositions are subject to modal conversion. So perhaps it is even misleading to talk about XXXs, LLLs, and LXLs because all the evidence we do have suggests that for Aristotle there is only one logic.

This paper deals only with the apodeictic syllogistic. The conclusions drawn here are also true of the problematic syllogistic as I intend to show in another paper.

NOTES

1. The Kneales favor a *de dicto* analysis but do not develop an account of how a *de dicto* analysis might be supposed to work.
2. In Rini [8] I give textual evidence for thinking that McCall's system and Aristotle's are not completely isomorphic.
3. I use standard modal LPC-translations. Johnson and Thomason do not. They give direct set theoretic interpretations and rules, but their interpretations give precisely (1) and (2). Some authors prefer to analyze Aristotle's logic using set theory because it is purely extensional and not committed to possible worlds. In [5] McCall tries to avoid the *de dicto* /*de re* dispute with a neutral representation, but Johnson's and Thomason's semantics show that McCall's account ultimately requires *de re* modality.
4. Notice that XA-conversion requires nonempty terms.
5. I am going to take Aristotle's counterexamples seriously. Quite a few writers do not—for instance, van Rijen [14] who argues that the "striking carelessness of [Aristotle's use counterexamples] witnesses the relative unimportance of this part of the theory's systematics" ([14], p. 201).
6. Both Ross and Smith are bothered by the remark "for nothing impossible results (*ouden gar adunaton sumpiptei*)." Ross investigates the surrounding passage in considerable detail, looking for parallel arguments that might explain the language ([9], pp. 320–21). Finding none, he brackets "*ouden gar adunaton sumpiptei*." Smith takes this expression to mean "nothing impossible *would* result from supposing the conclusion not to be necessary" ([10], p. 122). I do not have anything to add to this discussion.
7. In these tables by 'valid' I mean syllogisms claimed by Aristotle to be valid.
8. For this reason it is sometimes supposed that modal conversion must be interpreted *de dicto* in which case it is trivially valid. However, as we have seen a *de dicto* reading will not validate the syllogisms. Becker [1] thinks this shows that Aristotle is confused. I will show that whatever is going on here, it is not a confusion between *de re* and *de dicto*.
9. Aristotle does sometimes say that swans are white by necessity, but his comments about white animals are infamously inconsistent. I am not going to assume that necessarily white swans are what he has in mind here. For an account of the inconsistencies involving these creatures see Striker [11].
10. Here is how the genuineness requirement on premises validates Camestres LXL. Assume that B is a substance term, then B is equivalent to LB, and $\sim B$ is equivalent to $L \sim B$. I will call this the Substance Principle. And I will call the principle that what is necessarily so is so the T-principle.

    (1) $\forall x(Bx \rightarrow LAx)$
    (2) $\forall x(Cx \rightarrow \sim Ax)$

(3)	$\forall x(\sim LAx \rightarrow \sim Bx)$	Contrapostion (1)
(4)	$\forall x(\sim Ax \rightarrow \sim LAx)$	T-principle
(5)	$\forall x(Cx \rightarrow \sim LAx)$	Transitivity (2, 4)
(6)	$\forall x(Cx \rightarrow \sim Bx)$	Transitivity (5, 3)
(7)	$\forall x(Cx \rightarrow L \sim Bx)$	Substance Principle (6)

11. Smith ([10], p. 151) notes the Greek is open to either reading.

12. Here is how Patterson and Thom explain ekthesis. Suppose $\exists x(Cx \& L \sim Ax)$. Then there is something that is both C and $L \sim A$. What this means is that we may choose a term, say D, to designate that part of the Cs which are $L \sim A$s. So by ekthesis we have $\forall x(Dx \rightarrow Cx)$ and $\forall x(Dx \rightarrow L \sim Ax)$. This is a powerful tool—it creates two universal propositions from a single existential.

    Patterson's proof ([6] p. 73) of Baroco LLL works like this:

(1)	$\forall x(Bx \rightarrow LAx)$	Given
(2)	$\exists x(Cx \& L \sim Ax)$	Given
(3)	$\forall x(Dx \rightarrow Cx)$	Ekthesis, 2
(4)	$\forall x(Dx \rightarrow L \sim Ax)$	Ekthesis, 2
(5)	$\forall x(Bx \rightarrow L \sim Dx)$	Cesare LLL, 4, 1
(6)	$\forall x(Dx \rightarrow L \sim Bx)$	LE-conv, 5
(7)	$\exists x(Cx \& Dx)$	XA-conv, 3
(8)	$\exists x(Cx \& L \sim Bx)$	Ferio LXL, 6, 7

    Patterson says about the LE-conversion that gets from (5) to (6) "whether or not that conversion is valid is obviously beside the present point." Be that as it may, it is certainly relevant to the point I am trying to make. L-conversion is valid under the genuineness requirement. So, the B term must be a substance term. So, Baroco LLL is valid. Thom's proof ([12], p. 50) uses ekthesis together with Camestres LLL which, of course, relies on L-conversion. In fact, the LE-proposition that converts in Thom's proof has B as the subject term. So, again, the genuineness requirement on modal conversion guarantees that B is a substance term, and so Baroco LLL is valid.

13. In the third figure it affects Bocardo LXL and Disamis LXL. When I discuss the third figure I will explain how these are affected.

14. Thom says the "rejection of Baroco XLL and Bocardo LXL must be put down to carelessness" ([12], p. 135). In Chapter 6, Thom offers a set theoretic account in the style of [2] and [13] that includes Baroco XLL and Bocardo LXL as valid.

15. Though in the case of Datisi LXL a slight textual problem arises. Datisi LXL is valid. But Aristotle actually discusses a syllogism with different premises. The passage in question is A11, 31b16–20. There the first premise is still "all Cs are necessary As"—that is the same as in Datisi. But Aristotle gives the second premise by saying "B is below (*hupo*) C." For Aristotle this sometimes means that *every* B is a C and sometimes that *some* B is a C. If it is a particular premise then it would have to be $\exists x(Bx \& Cx)$. So we really have a valid first figure syllogism, with an L-conclusion:

$$\begin{array}{l} \forall x(Cx \rightarrow LAx) \\ \underline{\exists x(Bx \& Cx)} \\ \exists x(Bx \& LAx) \end{array}$$

    And that means we do not really find in Aristotle's text any statement that he counts the third figure Datisi LXL as valid. But in fact, both versions are valid.

16. The point is made explicit in the discussion of the invalid Barbara XLL. If it is true that A belongs to every B but not of necessity, then "B may be such that it is possible for A to apply to no B" (30a27–28). That is, A might be an accidental term, something which possibly does not belong to B.

17. For a justification of taking the second premise to be $\exists x(Ax \& Cx)$ see note 15.

18. In Ferison XLL the conclusion has an accidental subject, but as in the case of the first figure invalids, a completely genuine counterexample could be given. Let $A =$ wakeful, $B =$ animal, $C =$ man.

19. He cannot mean that A is wakeful, B is biped, and C is animal, because those would make both premises in Disamis LXL false. So whereas the same terms will work in both Darapti XLL and Disamis LXL, Aristotle clearly does not mean that they should be taken in the same order.

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