Treating modals and negation in 2nd Order Lambek Calculus

Martin Emms,
Centrum für Informations- und Sprachverarbeitung,
Universität München, Wagmüllerstr. 23, München 80538
emms@cis.uni-muenchen.de

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We will investigate how various phenomena associated with auxiliaries can be handled in a polymorphic categorial grammar, that is a grammar which takes the rules in Figure 1 as defining the derivable sequents[1].

$$x \Rightarrow x$$

$$\frac{U, y, V \Rightarrow w \qquad T \Rightarrow x}{U, y/x, T, V \Rightarrow w}/\,\mathrm{L} \qquad\qquad \frac{T, x \Rightarrow y}{T \Rightarrow y/x}/\mathrm{R}$$

$$\frac{T \Rightarrow x \qquad U, y, V \Rightarrow w}{U, T, x\backslash y, V \Rightarrow w}\backslash \mathrm{L} \qquad\qquad \frac{x, T \Rightarrow y}{T \Rightarrow x\backslash y}\backslash \mathrm{R}$$

$$\frac{U, x, y, V \Rightarrow w}{U, x\bullet y, V \Rightarrow w}\bullet\,\mathrm{L} \qquad\qquad \frac{T_1 \Rightarrow x \qquad T_2 \Rightarrow y}{T_1, T_2 \Rightarrow x\bullet y}\bullet\,\mathrm{R}$$

$$\frac{U, x[y/Z], V \Rightarrow w}{U, \forall Z.x, V \Rightarrow w}\forall\mathrm{L} \qquad\qquad \frac{T \Rightarrow x}{T \Rightarrow \forall X.x[X/Z]}\forall\mathrm{R},\ Z!$$

Figure 1: Polymorphic Lambek Calculus

For us, the following count as auxiliaries, and are grouped into the four subclasses *modal*, *perfect*, *progressive* and *passive*:

modal auxiliaries:	can, could, may, will, must, do
perfect auxiliary:	forms of have
progressive auxiliary:	forms of be
passive auxiliary:	forms of be

We will consider an ordering principle for auxiliaries and how this may be obtained as a theorem of a categorial grammar, thereby obviating the need to check such an extra-logical principle. We

[1] We assume familiarity with such a sequent-calculus based notion of a grammar. In the $\forall$R rule, $Z!$ indicates that Z is not a free variable below the line.

will also reflect on the subcategorisation of auxiliaries – should they subcategorise for a verb or a verb phrase – and see in what light a polymorphic categorial grammar places this question. We finally make some observations on how scope phenomena arising in association with auxiliaries can be treated.

1 Word order and verb-form dependencies

Auxiliary/verb-form dependency

The auxiliaries are all verbs which must be followed by another verb together with some of that verbs arguments. They all place particular requirements on the form of this following verb: the modals require a following *base* form verb (1i), the perfect and passive auxiliaries require a following *past participle* (1ii,iv), and the progressive auxiliary require a *+ing* form verb (1iii) [2]:

(1)	i.	*modal*	John could die
	ii.	*perf*	John has died
	iii.	*prog*	John is dying
	iv.	*pass*	the book was read

For the first three cases, involving an intransitive verb, we could assume that three lexical entries are concerned, one for die, with category $\mathrm{vp}_{[+base]}$, one for died, with category $\mathrm{vp}_{[+en]}$, and one for dying, with category $\mathrm{vp}_{[+ing]}$. The categories $\mathrm{vp}_{[+base]}$, $\mathrm{vp}_{[+en]}$, $\mathrm{vp}_{[+ing]}$ can be regarded simply as distinct atomic categories, for which we use mnemonic names.[3]

The form dependencies associated with the first three auxiliaries could then be captured by categorising a modal could, for example, as $\mathrm{np}\backslash\mathrm{s}/\mathrm{vp}_{[+base]}$, the perfect auxiliary, has, as $\mathrm{np}\backslash\mathrm{s}/\mathrm{vp}_{[+en]}$, and the progressive auxiliary, is, as $\mathrm{np}\backslash\mathrm{s}/\mathrm{vp}_{[+ing]}$.

A question we look at in later sections is whether other categorisations of these auxiliaries is required when the following verb is not intransitive, as in for example:

John could read the book
John has read the book
John is reading the book

One possibility — the one which we shall argue for later on — is that the already mentioned subcategorisation is assumed here also, in which case out of the material following the auxiliary, the categories $\mathrm{vp}_{[+base]}$, $\mathrm{vp}_{[+en]}$, $\mathrm{vp}_{[+ing]}$ must be derived. The other possibility is that either lexically or by some inference, the auxiliaries have a subcategorisation directly for the following verb. Although this latter possibility corresponds more directly to the observation that there is a dependency between auxiliary and the following *verb*, it is not the case that to capture the facts which witness this dependency it is necessary for the auxiliaries to directly subcategorise for a following verb.

Auxiliary ordering

[2] We abbreviate the 'perfect auxiliary' to '*perf*', and so on

[3] The reason for the choice of the not so mnemonic $+en$ will become clear later. The use of such mnemonic names does not here mean that in addition to the categorial grammar machinery defined in Figure 1, some kind of feature handling devices are intended to be used. This is not so say that such combinations of the basic categorial machinery with feature handling devices are impossible. They can be fairly simply defined, and have been studied in other DYANA related work. We refrain from the use of such a combination, because for the present application our use of the feature handling devices would be so superficial.

We confined ourselves intentionally above to rather simple examples involving just a single auxiliary. Sentences can, however, contain several auxiliaries in a sequence:

(2)	he could follow John	$\langle modal \rangle$
	he could have followed John	$\langle$ *modal*, *perf* $\rangle$
	he could have been following John	$\langle$ *modal*, *perf*, *prog* $\rangle$
	John could have been being followed	$\langle$ *modal*, *perf*,*prog*,*pass* $\rangle$
	he could have been followed	$\langle$ *modal*, *perf*, *pass* $\rangle$
	he could be being followed	$\langle$ *modal*, *prog*, *pass* $\rangle$
	he has been swimming	$\langle$ *perf*, *prog* $\rangle$
	he was been following *	$\langle$ *pass*, *prog* $\rangle$
	he was been followed *	$\langle$ *pass*, *pass* $\rangle$
	John is having eaten *	$\langle$ *prog*, *perf* $\rangle$
	I was being swimming *	$\langle$ *prog*, *prog* $\rangle$
	he has done swim *	$\langle perf, mdl \rangle$

As witnessed by the unstarred examples above, there are many possibilities for such an auxiliary sequence – and clearly only a selection of the possibilities is given. On the other hand, equally clearly not everything is possible, as witnessed by the starred examples. In searching for a pattern amongst the possibilities, one hits upon the following ordering constraint (AOC):

Definition 1 (Auxiliary Ordering Constraint) *In any grammatical sentence, if a sequence of word-forms in that sentence realises the auxiliary-class sequence $\langle A_i \rangle_{1 \leq i \leq n}$, then this auxiliary sequence must conform to the following order (that is, A_i appears earlier than A_{i+1} in this order):*

modal< perf< prog< pass

This gives a necessary condition on correct auxiliary sequences.[4]

The fact that the distribution of auxiliaries conforms to the AOC might suggest that the grammar formalism allow for the stipulation of such ordering constraints. This, however, clearly is not necessary. What *is* necessary, is that if the grammar does not permit such explicit ordering constraints, then such a constraint must certainly be an entailment of the grammar's other specifications.[5] In other words the AOC must arise as a theorem. Now a categorial grammar does not allow explicit ordering constraints, and so we must consider whether the AOC can be obtained as a theorem.

It does not take long to see that certain aspects of the AOC can be readily entailed by a combination of the auxiliary/verb-form dependencies and paradigm realisation. In particular, if the grammar manages to enforce the auxiliary/verb-form dependencies, it is clear that the modals (could, must, and so on) will not be able to appear following a *modal*, *perf*, *prog*, or *pass* auxiliaries: the modals realise none of the forms required. If we have just one possible categorisation for modals, namely $np\backslash s/vp_{[+base]}$, then the combination of a modal with a following $vp_{[+base]}$, does not yield $vp_{[+base]}$, $vp_{[+ing]}$, or $vp_{[+en]}$. Hence the following will be underivable:

he must could die
he has could die
he is could die

[4]As a matter of fact being a sequence of auxiliary categories that conforms to the above order seems also to be a sufficient condition for there to be a realisation as a grammatical sentence.

[5]There remains the question of whether for parsing purposes it is still not more efficient to assume that such constraints can be directly specified

This gives the general outline of the argument which can be used to show that the AOC can be obtained as a theorem. We examine below what further must be assumed in order to obtain this.

a) We use two participle entries. eaten for example appears in one lexical entry as $vp_{[+en]}/np$, and is involved in combinations with the perfect auxiliary. eaten also appears in another lexical entry as $vp_{[+p.part]}/np[+by]$, and this is involved in combinations with the passive auxiliary.

Not all past participle word forms will appear in two lexical entries. hiccupped for example will have only the $vp_{[+en]}$ entry, as reflected by:

John has hiccupped
John was hiccupped *

The same goes for other intransitive verbs. We will make a similar assumption concerning the progressive and passive auxiliaries – see below.

b) We assume that the subcategorisation of modal auxiliaries is for $vp_{[+base]}$, of the perfect auxiliary is $vp_{[+en]}$, of the progressive $vp_{[+ing]}$, and of the passive is $vp_{[+p.part]}$.[6]

c) Finally, the following table shows for the various auxiliaries whether we assume they have forms whose value part $vp_{[+base]}$, $vp_{[+en]}$, $vp_{[+ing]}$ or $vp_{[+p.part]}$ occur:

(3)

	+base	*+en*	*+ing*	*+p.part*
modal	-	-	-	-
perf	have	-	having	-
prog	be	been	-	-
pass	be	been	being	-

We make some remarks on the above table. As alluded to above, the modals are assumed to have no forms whose value part is $vp_{[+x]}$, for $x \in \{base, en, ing, p.part\}$. Note that we distinguish an *auxiliary* do, from a main verb do, which subcategorises for an np, and has forms whose value part is $vp_{[+x]}$, for $x \in \{base, en, ing, p.part\}$. This gives the contrast:

(4)	he can do that	he can do swim *
	he has done that	he has done swim *
	he is doing that	he is doing swimming *

Various forms of the perfect auxiliary have are also distinguished from various forms of the main verb have, the latter having forms whose value part is $vp[+x]$, for all $x \in \{base, en, ing, p.part\}$. This gives the contrast:

(5)	I have had a good time	I have had slept *
	a good time was had	the book was had read *

The progressive auxiliary and passive auxiliary are regarded as having forms (namely been), whose value part is $vp_{[+en]}$, but not as having forms whose value part is $vp_{[+p.part]}$. In particular been is not such a form (this is the reason for the $+en$ notation). This gives the contrasts:

(6)	he has been reading	the book was been reading *
	the book has been read	the book was been read *

[6] As mentioned above the decision whether or not one has just a vp based subcategorisation for auxiliaries, we do not want at this point to assume is settled. As far as showing that the AOC is eliminable, it would be possible to give a categorial lexicon which does not make this assumption.

Finally the passive auxiliary is assumed to have being as a form with $\mathrm{vp}_{[+ing]}$ value, whilst the progressive auxiliary is assumed to have no form with $\mathrm{vp}_{[+ing]}$ value. In particular being is not such a form. This gives the following contrast:

(7) the book was being read he was being reading the book *

These assumptions will give almost all of the consequences of the AOC. [7] Of the 16 possible two element sequences $\langle A, B\rangle$, where $A, B \in \{modal, perf, prg, pas\}$, 10 are such that A does not occur earlier than B in the order specified by the AOC:

$$\begin{array}{llll}
\langle modal, modal\rangle & \langle perf, modal\rangle & \langle prog, modal\rangle & \langle pass, modal\rangle \\
 & \langle perf, perf\rangle & \boxed{\langle prog, perf\rangle} & \langle pass, perf\rangle \\
 & & \langle prog, prog\rangle & \langle pass, prog\rangle \\
 & & & \langle pass, pass\rangle
\end{array}$$

9 out of 10 of these AOC violations will be ruled on the above assumptions because in these cases there is no way that a sequence of categories beginning with a B auxiliary category can ever reduce to $\mathrm{vp}_{[+x]}$, where $\mathrm{vp}_{[+x]}$ is the subcategorisation of the preceding A auxiliary.

There remains the highlighted $\langle prog, perf\rangle$ case, which is an AOC violation, but is not ruled out by our assumptions so far. There can be a sequence of categories commencing with a perfect auxiliary category, namely $\mathrm{vp}_{[+ing]}/\mathrm{vp}_{[+en]}, \mathrm{vp}_{[+en]}$, such that this reduces to the subcategorisation of a preceding progressive auxiliary, namely $\mathrm{vp}_{[+ing]}$. We have then no way to rule out the following example of an AOC violation:

John is having hiccupped

Now we cannot simply revise the lexicon so that having is not regarded as a form of the perfect auxiliary, with a $\mathrm{vp}_{[+ing]}$ value. This is because of grammatical examples such as:

having hiccupped, he left

Must we then at least have a reduced form of the AOC, containing just the prohibition that *prog* cannot precede *perf*? We suggest below a way that this can be avoided.

The strategy to be applied comes from work on the Vendler verb classification. Vendler made the proposal, subsequently much discussed, that verbs be classified according to whether they describe *states*, *activities*, *achievements* or *accomplishments*. Possession and non-possession of these features was proposed to be useful in explaining various syntactic phenomena, such as the distribution of in, at, for temporal adverbials, occurrence in commands, and so on. One of these phenomena is felicitous occurrence with the progressive auxiliary, for which *non-stativity* was proposed to be crucial. This can be used to explain why the following is ungrammatical:

he is knowing the answer *
he is seeming to be unaware of the danger *

[7] At least assuming there are no pathological categorisations of other non-verbal items. The notion 'pathological' needs further investigation in this context, for it ought to be possible to specify exactly the minimal assumptions concerning other lexical items so that the AOC follows from the above assumptions. For example, there must be no lexical items $\mathrm{vp}_{[+x]}\backslash\mathrm{vp}_{[+y]}$, where $+x$ and $+y$ are different.

As with is having hiccupped, these cannot be explained away by a gap in the paradigm argument, because the *+ing* forms themselves can occur in the absence of the progressive auxiliary:

knowing the answer, he boldly raised his hand
seeming to be unaware of the danger, he entered the room

The Vendlerian account would be that knowing the answer (or perhaps just knowing) and seeming to be unaware (or perhaps just seeming) are *+stative*, and therefore incompatible with the progressive auxiliary. In a similar way, we might classify having hiccupped (or perhaps just having) as *stative*.

This suggests a way in which the final $\langle prg, prf \rangle$ AOC exception can also be obtained as a consequence of other aspects of the grammar.

Having established at least the plausibility of the claim that a categorial grammar may be formulated which entails the AOC, the question arises as to whether this was costly. Would a hybrid categorial grammar which made use of an explicit ordering constraint be noticeably simpler than that outlined above ? Arguably not. In order to derive the AOC we have needed at several points to have more than one lexical entry associated with a single string: distinguishing auxiliary do from main verb do, auxiliary have from main verb have, distinguishing between eaten as 'past' past-participle, and eaten as 'passive' past-participle. Although one should avoid multiplying lexical entries beyond necessity, these distinctions can be independently motivated.

2 V or VP subcategorisation of Auxiliaries

One finds in various grammatical frameworks a discussion of the appropriate subcategorisaton for auxiliaries. There are two main views. One is that they subcategorise for a *verb phrase* (VP). The other is that they subcategorise for a *verb* (V). In the case of the latter option, there is also the question whether the V subcategorisation includes the auxiliaries themselves as possible complements. Brackettings suggested by these different views of subcategorisation are given below:

John is [being [given presents]]	VP complements
John [is [being given]] presents	V complements
John [[is being] given] presents	V complements (including auxiliaries)

Only in the third option do we have complex auxiliaries. The notion that there might be complex auxiliaries is one at which a traditional linguist would baulk: such objects do not have one of the distributional properties by which one might traditionally define the auxiliaries, namely participation in Subj-Aux inversion:

is being John given presents *

However, we are not practising traditional linguistics here, nor proposing sets of distributional properties that are intended to individuate a particular class. This does not mean that we can simply ignore the above datum, and a categorial account which generates complex auxiliaries must deal with the above fact. Doing this may, though, be rather easy, precisely because a categorial grammar does not deal directly in terms of notions like Subj-Aux inversion. The possibility of such verb-initial word orders will be provided for by giving to the verbs which can so appear an appropriate categorisation. The possibility that complex auxiliaries can be formed will create no problem for an account of Subj-Aux inversion along these lines.

We have already noted in the preceding section, that the dependency that exists between verb-form and preceding auxiliary, does not entail that the auxiliaries should subcategorise for a following *verb*. This dependency does not speak directly for or against the VP subcategorisation. We now wish to see whether there are any considerations which decide the issue.

Semantic consideration 1

There is one semantic consideration that might favour a V subcategorisation in the case of the passive auxiliary. If one did not distinguish between two past-participles, then a VP subcategorisation seems untenable. Consider an example such as:

John was given the dog

If there is no distinguished *passive* past-participle, and we have a VP complement analysis of the passive auxiliary, it is hard to see how we can expect the correct meaning to be associated with given the dog. the dog has to be understood as associated with the direct object role in this case. However, if we have the same sequence occurring after the perfect auxiliary, as in he has given the dog a bone, the dog has to be understood as associated with the indirect object role. So, if we have no distinguished passive past-participle, then for semantic reasons we would have to have a V-complement analysis of the passive auxiliary: it would due to the passive auxiliary, that in combining was given with the dog, that the dog comes to be associated with the direct object role.

However, for other reasons, it seems necessary to have the distinction made in the previous section between two kinds of past participle. In particular the existence of participial phrases argues strongly for this, in which the participle verb form occurs without any accompanying auxiliary. The associated noun-phrases are understood as filling the same roles as they are in the corresponding sentences in which the passive auxiliary occurs.

For example, out of verb-forms with $\mathrm{vp}_{[+p.part]}$ value, prenominal participial phrases can be built, as illustrated by (8i):

(8) i. a [written] answer
ii. a [carefully written] answer
iii. a [by me written] answer *
iv. a [given] book *
v. an [ordered] man *
vi. a [given a book] student *
vii. a [ordered to undress] man *

The possibilities are fairly restricted though. A transitive verb with $\mathrm{vp}_{[+p.part]}$ value can appear (8i), possibly modified by an adverb (8ii). Larger phrases that arguably also have a $\mathrm{vp}_{[+p.part]}$ value are not possible. Modification with a by-phrase is not possible (8iii). Ditransitive verbs do not make participial phrases on their own (8iv,v), nor in combination with their complements (8vi,vii). The restrictedness of the possibilities might suggest these are to be dealt with by particular additional lexical entries, rather than by assuming the same lexical item is involved as that which appears in combination with the passive auxiliary. However, in German, the corresponding formation of prenominal phrases based on participles is not so restricted, and in English there are also possibilities for less restricted participial phrases to occur when not used prenominally, but as sentence adjuncts for example:

[watched by my wife], I left
[informed by my superiors of the risks involved], I entered the room

Although not all $\mathrm{vp}_{[+p.part]}$ phrases are possible here, it seems clear that the formation of such participial phrases is a sufficiently general process that we must suppose that the same lexical entry of the verbs is involved here as is involved in constructions involving the passive auxiliaries.

So, given that the participial phrases exist, and mean what they do, we have to assume a lexical entry with $vp_{[+p.part]}$ value which is semantically distinct for the the lexical entry with $vp_{[+en]}$ value. There is then no longer any semantic necessity then for a V complement analysis of the passive auxiliary.

Semantic consideration 2

If the V complement analysis takes the form of a series of separate categorisations of the auxiliary, one for each kind of verb that may immediately follow the auxiliary, we will call it *multi-monomorphic*. There seem to be arguments that this will not be semantically adequate.

Consider sentences of the form 'x *modal tv* Q', where *tv* is a transitive verb, and Q is a quantified noun-phrase:

$$\text{we} \begin{Bmatrix} \text{could} \\ \text{might} \\ \text{must} \end{Bmatrix} \text{kill one of the first years}$$

The most natural reading of these is not that there is a particular first year that we could/might/must kill, but rather that the state of affairs that a first year is killed is a either a possibility (could/might) or a necessity (must).

The VP-complement analysis will yield straightforwardly the most natural reading. The V-complement analysis will, at least in its simplest incarnation, yield only the less natural reading, deriving from the individual level relation kill, the new individual level relations could kill, might kill, must kill. If indeed these combinations of auxiliary and verb could *only* be associated with individual level relations, then the most natural reading of the sentences above would be unobtainable. To obtain the other readings, one would have to allow for argument-raising type-shifts to take place, unreflected in the syntactic composition of the phrase.

Examples of the following kind would present a further challenge to the V-complement analysis:

$$\text{he} \begin{Bmatrix} \text{could} \\ \text{might} \\ \text{must} \end{Bmatrix} \text{read the book in less than 10 minutes}$$

Here within the scope of a modality we need some reference to a speed of reading. This will straightforwardly be obtained on a VP-complement analysis. However, on the V-complement analysis, the adverbial which indicates that the speed of reading is at issue is encountered *after* the modal and the verb have been combined into a meaningful unit. A multi-monomorphic V-complement analysis could be made to work here also, albeit by an extension of the usual semantic type-shifting techniques, in order that the aux-verb combination appropriately anticipates the later adverbial.

Finally consider:

$$\text{he} \begin{Bmatrix} \text{could} \\ \text{might} \\ \text{must} \end{Bmatrix} \text{read the book faster than anyone else has}$$

On many accounts of ellipsis, the ellipsis is resolved semantically by accessing the content of some preceding syntactic unit. In the example, the obvious candidate is read the book, but on the V-complement analysis, this is not a syntactic unit.

While none of these examples rule out a multi-monomorphic V-complement analysis, it is striking that these are not problematic *at all* for the VP-complement analysis. Therefore, other things being equal, it seem one should adopt the VP-complement analysis.

There is another possibility, however, and that is a *polymorphic* V-complement analysis, which we will now consider.

VP vs. polymorphic V

If one adopts a V complement analysis, then means must be provided for each auxiliary to combine with a large range of verb types: intransitive, transitive, ditransitive, to name but three. It would surely be wrong to do this by giving one categorisation to each auxiliary for each different kind of verb that it should modify, i.e. to adopt the multi-monomorphic approach. Besides the above mentioned semantic drawbacks, this would miss the generalisation that in all cases, the compound verb has to be seen as inheritting the subcategorisation requirements of the verb modified: if an auxiliary is to be combined with a transitive verb, then the resulting verb subcategorises for a direct object, if it combines with a ditransitive verb, then the resulting compound verb has to subcategorise for a direct and an indirect object, and so on. If there were as many different lexical entries for the auxiliaries as there are different types of verbs that may immediately follow an auxiliary, then this would leave open the possibility that for verbs of one particular kind, the compound verb did not inherit the subcategorisation requirements of the modified verb. It would also leave open the possibility that a given auxiliary is uncombinable with verbs of one particular kind.

To capture these generalisations on a V complement analysis one needs *polymorphic* categorisations of the auxiliaries. Just such polymorphic categories are proposed in several HPSG analyses, and in one of the columns in Table1, it is indicated how this can be be achieved in 2nd Order Lambek Calculus.

		poly. V-comp categories	mono. VP-comp categories
modal	could	$\forall X.(\mathrm{np}\backslash \mathrm{s}/X)/(\mathrm{vp}_{[+base]}/X)$	$(\mathrm{np}\backslash \mathrm{s})/\mathrm{vp}_{[+base]}$
perf	has	$\forall X.(\mathrm{np}\backslash \mathrm{s}/X)/(\mathrm{vp}_{[+en]}/X)$	$(\mathrm{np}\backslash \mathrm{s})/\mathrm{vp}_{[+en]}$
	have	$\forall X.(\mathrm{vp}_{[+base]}/X)/(\mathrm{vp}_{[+en]}/X)$	$\mathrm{vp}_{[+base]}/\mathrm{vp}_{[+en]}$
	having	$\forall X.(\mathrm{vp}_{[+ing]}/X)/(\mathrm{vp}_{[+en]}/X)$	$\mathrm{vp}_{[+ing]}/\mathrm{vp}_{[+en]}$
prog	is	$\forall X.(\mathrm{np}\backslash \mathrm{s}/X)/(\mathrm{vp}_{[+ing]}/X)$	$(\mathrm{np}\backslash \mathrm{s})/\mathrm{vp}_{[+ing]}$
	be	$\forall X.(\mathrm{vp}_{[+base]}/X)/(\mathrm{vp}_{[+ing]}/X)$	$\mathrm{vp}_{[+base]}/\mathrm{vp}_{[+ing]}$
	been	$\forall X.(\mathrm{vp}_{[+en]}/X)/(\mathrm{vp}_{[+ing]}/X)$	$\mathrm{vp}_{[+en]}/\mathrm{vp}_{[+ing]}$
pass	was	$\forall X.(\mathrm{np}\backslash \mathrm{s}/X)/(\mathrm{vp}_{[+p.part]}/X)$	$(\mathrm{np}\backslash \mathrm{s})/\mathrm{vp}_{[+p.part]}$
	be	$\forall X.(\mathrm{vp}_{[+base]}/X)/(\mathrm{vp}_{[+p.part]}/X)$	$\mathrm{vp}_{[+base]}/\mathrm{vp}_{[+p.part]}$
	been	$\forall X.(\mathrm{vp}_{[+en]}/X)/(\mathrm{vp}_{[+p.part]}/X)$	$\mathrm{vp}_{[+en]}/\mathrm{vp}_{[+p.part]}$
	being	$\forall X.(\mathrm{vp}_{[+ing]}/X)/(\mathrm{vp}_{[+p.part]}/X)$	$\mathrm{vp}_{[+ing]}/\mathrm{vp}_{[+p.part]}$

Table 1: Polymorphic V- and Monomorphic V-complement Auxiliary Categorisations

The generalisation that many different kinds of verb can appear immediately following an auxiliary is also captured by the VP complement analysis, simply because several different kinds of verb can form the basis of a VP. The simpler, monomorphic categorisations of the auxiliaries using the VP complement assumptions are also given in Table 1.

The VP-complement categories are clearly simpler, and all things being equal should then be preferred. Are all things equal though ? One might think that the more complex, polymorphic, V-complement categories would allow one to capture phenomena that the VP-complement categorisation would not. We show now that this *impossible*. For each of the entries in the table one can show that the polymorphic, V-complement categorisation is derivable from the VP-complement categorisation. The transition required is always an instance of the sequent $a/b \Rightarrow \forall X.(a/X)/(b/X)$, which is $\mathrm{L}^{(/,\backslash,\forall)}$ derivable:

$$\dfrac{\dfrac{\dfrac{\vdots}{a/b, b/X, X \Rightarrow a}}{a/b \Rightarrow (a/X)/(b/X)}/\mathrm{R},/\mathrm{R}}{a/b \Rightarrow \forall X.(a/X)/(b/X)}\forall\mathrm{R}$$

This means that where $aux[V]$ is any V-complement auxiliary category, and $aux[VP]$ is the corresponding VP-complement category:

$$\begin{array}{lrl} & \mathrm{L}^{(/,\backslash,\forall)} \vdash & U_1, aux[V], U_2 \Rightarrow x, \\ \text{implies} & \mathrm{L}^{(/,\backslash,\forall)} + Cut \vdash & U_1, aux[VP], U_2 \Rightarrow x \text{ (by Cut elimination for } \mathrm{L}^{(/,\backslash,\forall)}) \\ \text{implies} & \mathrm{L}^{(/,\backslash,\forall)} \vdash & U_1, aux[VP], U_2 \Rightarrow x \end{array}$$

Therefore,

> *in the context of an* $\mathrm{L}^{(/,\backslash,\forall)}$ *grammar, there can be no argument from a deficit in coverage, to prefer the V-complement analysis over the VP-complement analysis.*

One can also ask the converse question: can there be an argument from a deficit in coverage, for preferring the VP-complement analysis over the V-complement analysis ? There certainly can, because in $\mathrm{L}^{(/,\backslash,\forall)}$ the sequent $\forall X.(a/X)/(b/X) \Rightarrow a/b$ is not derivable:

$$\dfrac{\dfrac{\dfrac{\dfrac{\text{FAIL}}{a/\overline{X} \Rightarrow a} \quad \dfrac{b, \overline{X} \Rightarrow b}{b \Rightarrow b/\overline{X}}/\mathrm{R}}{a/\overline{X}/(b/\overline{X}), b \Rightarrow a}/\mathrm{L}}{\forall X.(a/X)/(b/X), b \Rightarrow a}\forall\mathrm{L}}{\forall X.(a/X)/(b/X) \Rightarrow a/b}/\mathrm{R}$$

$\overline{X}$ represents some category which we choose to instantiate the quantified variable. The derivation fails because $\mathrm{L}^{(/,\backslash,\forall)} \not\vdash a/\overline{X} \Rightarrow a$, for *any* $\overline{X}$. In a version of the calculus which allows the left-hand side of a sequent to be empty, $\mathrm{L}_\epsilon^{(/,\backslash,\forall)}$, we do have $\mathrm{L}_\epsilon^{(/,\backslash,\forall)} \vdash a/\overline{X} \Rightarrow a$, if we choose $\overline{X} = \forall X.X\backslash X$, and for this value of $\overline{X}$, also the other subgoal of the proof is derivable. So in $\mathrm{L}_\epsilon^{(/,\backslash,\forall)}$ we do have the sequent $\forall X.(a/X)/(b/X) \Rightarrow a/b$, and so in this version of the calculus it is not possible for the V-complement analysis to fail to deliver some result that the substitution of the VP-complement analysis would deliver. Even though one could in this case adopt the V-complement analysis without fear of undergeneration, there is still the argument from simplicity to adopt the monomorphic VP-complement analysis.

So here we have not argued that a 2nd order polymorphic V-complement analysis is to be preferred. Rather we have shown that with the 2nd order Lambek calculus one can deal with the question of the subcategorisation of auxiliaries very directly, allowing one to prove that a certain monomorphic categorisation covers the same data as the proposed polymorphic categorisation, and that in a version of the calculus allowing empty antecedent the reverse also holds. In a grammar framework with instead a fixed finite number of combination schemes, such general statements are not possible, and if one finds empirical differences between the options in a particular grammar, one has to decide whether this is a reason for preferring one option over the other, or a reason for extending the combinatory options.

It is worth perhaps reflecting on the above statement in the context of arguments that have been made that the subcategorisation of an auxiliary must be ambiguous. In a GPSG setting, [Johnson, 1986] argues for example that auxiliaries must subcategorise for VP's, for V's, and for *partial* VP's, where these consist of a V combined with some but not all of its complements (= PVP). This is argued for on the basis of topicalisation data in German such as:

(9) a. [erzählen]$_V$ kann er seiner Tochter ein Märchen
b. [ein Märchen erzählen]$_{PVP}$ kann er seiner Tochter
c. [seiner Tochter ein Märchen erzählen]$_{VP}$ kann er
d. [erzählen konnen]$_V$ wird es ihr schon

The idea is that topicalisation structures involve a fronted constituent, followed by a particular scrambling of what would be a possible subordinate clause, but for the absence of the fronted constituent. The scrambling places the finite verb at the front of this 'subordinate-clause with topic gap' structure. The salient fact is that in the examples above, the bracketted string must be assigned some category x, and the following material analysed as having a slash feature with value x. To analyse this following material in this way, some substructure has to be analysed as missing the subcategorised-for x, and then this slash-feature inheritted upwards. Thus (9a) involves a missing subcategorised-for V, (9b) a missing subcategorised-for PVP, and (9c) a missing subcategorised-for VP, and (9d) again a missing subcategorised-for V. In the fourth case, also to generate the gap-filler, a V-subcategorisation is again argued to be necessary.

Now the ambiguous subcategorisation hypothesis can be equated with the assumption that the auxiliaries have a polymorphic V-complement analysis of the style described earlier. On the basis of our earlier statement, it must be the case that if the above data can be accounted for by a $\mathrm{L}^{(/,\backslash,\forall)}$ grammar using such a *polymorphic* V-complement analysis, then it can be accounted for using the *monomorphic* VP-complement analysis. We sketch how one VP-complement analysis could go.

	clause-final	*V2 version*
kann	$\mathrm{vp}_{[+base]}\backslash\mathrm{np}\backslash\mathrm{s}_{[+sub]}(=M)$	$\forall X.X\backslash\mathrm{s}_{[+fin]}/(\mathrm{s}_{[+sub]}/M/X)$
wird	*ditto*	*ditto*
können	$\mathrm{vp}_{[+base]}\backslash\mathrm{vp}_{[+base]}$	
erzählen	$\mathrm{np}\backslash\mathrm{np}\backslash\mathrm{vp}_{[+base]}$	

For the finite auxiliaries, two lexical entries are given, one locating them clause-finally, to yield a subordinate clause ($\mathrm{s}_{[+sub]}$), and the other a 'V2' entry, which leads to main clauses ($\mathrm{s}_{[+fin]}$) with the verb in second position. This 'V2' categorisation allows a variety of topicalisations from the subordinate clause word order. For (9a), with the topicalisation of erzählen, we need to be able to convert the category sequence corresponding to er seiner Tochter ein Märchen to $\mathrm{s}_{[+sub]}/M/\overline{X}$, where $\overline{X}$ is some categorisation of erzählen. So taking $\overline{X}$ as $\mathrm{np}\backslash\mathrm{np}\backslash\mathrm{vp}_{[+base]}$, we use the derivation

(10) $$\cfrac{\text{np} \Rightarrow \text{np} \quad \text{np} \Rightarrow \text{np} \quad \text{np}, \text{vp}_{[+base]}, \text{vp}_{[+base]}\backslash\text{np}\backslash\text{s}_{[+sub]} \Rightarrow \text{s}_{[+sub]}}{\cfrac{\text{np}, \text{np}, \text{np}, \overline{X}, M \Rightarrow \text{s}_{[+sub]}}{\text{np}, \text{np}, \text{np} \Rightarrow \text{s}_{[+sub]}/M/\overline{X}}/\text{R},/\text{R}}\backslash\text{L}$$

The same will suffice for (9d), if erzählen können can be given the same category as erzählen, $\text{np}\backslash\text{np}\backslash\text{vp}_{[+base]}$. It clearly can.

For (9b) we need to be able to convert the sequence of categories corresponding to er seiner Tochter to $\text{s}_{[+sub]}/M/\overline{X}$, for some $\overline{X}$, where $\overline{X}$ is a categorisation of ein Märchen erzählen. So taking $\overline{X}$ as $\text{np}\backslash\text{vp}_{[+base]}$, we have the following variation on (10):

(11) $$\cfrac{\text{np} \Rightarrow \text{np} \quad \text{np}, \text{vp}_{[+base]}, \text{vp}_{[+base]}\backslash\text{np}\backslash\text{s}_{[+sub]} \Rightarrow \text{s}_{[+sub]}}{\cfrac{\text{np}, \text{np}, \overline{X}, M \Rightarrow \text{s}_{[+sub]}}{\text{np}, \text{np} \Rightarrow \text{s}_{[+sub]}/M/\overline{X}}/\text{R},/\text{R}}\backslash\text{L}$$

For (9c), we categorise er as $\text{s}_{[+sub]}/M/\overline{X}$, for $\overline{X} = \text{vp}_{[+base]}$:

(12) $$\cfrac{\text{np}, \overline{X}, M \Rightarrow \text{s}_{[+sub]}}{\text{np} \Rightarrow \text{s}_{[+sub]}/M/\overline{X}}/\text{R},/\text{R}$$

The difference that having a polymorphic categorisation of clause final auxiliaries would make is that in each of the derivations (10), (11), (12), where we have $\overline{X}$ occurring next to M in one of the subgoals, we would be able to carry on the derivation by combining an instance of the polymorphic M with $\overline{X}$ (recall $\overline{X}$ varies across the examples). But since nothing forces us to combine M directly with $\overline{X}$ in this way, there is no need for a polymorphic categorisation of clause final auxiliaries (though also nothing need be *lost* by such a categorisation).

The one place in a categorial grammar where there would seem to be a need for a polymorphic categorisation of an auxiliary in a subordinate clauses is the case of *auxiliary flip* in German, as illustrated by examples such as:

daß er das Examen hat bestehen können
daß ich Cecilia habe Hans die Nilpferde füttern helfen lassen
daß er die Lieder wird haben singen können

In the three examples hat, habe and wird haben do not appear subsequent to material that one can categorise as $\text{vp}_{[+base]}$, but instead appear apparently *inserted* into such material. The extension of the categorial logic to one including an *infixation* connective $\downarrow$ has been investigated by several authors (see [Moortgat, 1991]), associated with a ($\downarrow$L) rule that allows one to conclude from $U, a, V \Rightarrow c$ and $T_1, T_2 \Rightarrow b$ to $U, T_1, a \downarrow b, T_2, V \Rightarrow c$. Using this, one could obtain the first example by assigning hat the category $(\text{np}\backslash\text{s}_{[+sub]}) \downarrow \text{vp}_{[+base,+ersatz]}$ [8]. In [Emms, 1994a] it is shown how such $a \downarrow b$ categories can be represented in a polymorphic categorial grammar, as $\forall X.(X\backslash a)/(X\backslash b)$. The auxiliary-flip cases could then be obtained by the categorisations:

hat	$\forall X.(\text{np}\backslash X\backslash\text{s}_{[+sub]})/(X\backslash\text{vp}_{[+base,+ersatz]})$
wird	ditto
haben	$\forall X.(X\backslash\text{vp}_{[+base,ersatz]})/(X\backslash\text{vp}_{[+base,+ersatz]})$

[8] Where $\text{vp}_{[+base,ersatz]}$ is a category that results from the presence of the *ersatz* past-participle of the modal verb können.

As indicated above, the usual case of clause-final auxiliaries can be captured by the monomorphic categorisation $\mathrm{vp}_{[+base]}\backslash(\mathrm{np}\backslash \mathrm{s}_{[+sub]})$, or more complicatedly by the polymorphic categorisation $\forall X.(X\backslash \mathrm{vp}_{[+base]})\backslash(X\backslash \mathrm{np}\backslash \mathrm{s}_{[+sub]})$. Comparing this polymorphic categorisation with the above entries for flipped auxiliaries, it is perhaps of interest to note that they differ simply by flipping one slash. Hence, for the sake of homogeneity of the lexicon, one might still adopt the polymorphic categorisation of the clause-final auxiliaries, despite the sufficieny of the monomorphic categorisation.

3 Scope ambiguities

In this section we will touch briefly on some of the scope-ambiguity issues that arise associated with auxiliaries.

A first fact about modal auxiliaries is that there are possibilities for scope ambiguities to arise between a modal auxiliary and a subject quantifier:

$$\text{three people} \left\{ \begin{array}{l} \text{could} \\ \text{might} \\ \text{must} \end{array} \right\} \text{stay behind}$$

The $\mathrm{np}\backslash \mathrm{s}_{[+fin]}/\mathrm{vp}_{[+base]}$ categorisation of modals will not lead to the readings in which the quantifier takes narrow scope with respect to the modal. The simplest way in which to obtain the ambiguity is to change the value part of the auxiliary category to one subcategorising for a quantifier categorisation. There are several ways to categorise quantifiers in a polymorphic grammar. For the following we will suppose that quantifiers are categorised as $\forall X.X/(\mathrm{np}\backslash X)$ [9], which we will abbreviate as Q. The two readings will be associated with the derivations:

$$\dfrac{\dfrac{Q \Rightarrow Q \qquad \mathrm{s}_{[+fin]} \Rightarrow \mathrm{s}_{[+fin]}}{Q, Q\backslash \mathrm{s}_{[+fin]} \Rightarrow \mathrm{s}_{[+fin]}}\backslash L \qquad \mathrm{vp}_{[+base]} \Rightarrow \mathrm{vp}_{[+base]}}{Q, Q\backslash \mathrm{s}_{[+fin]}/\mathrm{vp}_{[+base]}, \mathrm{vp}_{[+base]} \Rightarrow \mathrm{s}_{[+fin]}}/L$$

$$\dfrac{\mathrm{s}_{[+fin]} \Rightarrow s_{[+fin]} \qquad \dfrac{\dfrac{\mathrm{np} \Rightarrow Q \qquad \mathrm{vp}_{[+base]} \Rightarrow \mathrm{vp}_{[+base]} \qquad \mathrm{s}_{[+fin]} \Rightarrow \mathrm{s}_{[+fin]}}{\mathrm{np}, Q\backslash \mathrm{s}_{[+fin]}/\mathrm{vp}_{[+base]}, \mathrm{vp}_{[+base]} \Rightarrow \mathrm{s}_{[+fin]}}\backslash L,/L}{Q\backslash \mathrm{s}_{[+fin]}/\mathrm{vp}_{[+base]}, \mathrm{vp}_{[+base]} \Rightarrow \mathrm{np}\backslash \mathrm{s}_{[+fin]}}\backslash R}{Q, Q\backslash \mathrm{s}_{[+fin]}/\mathrm{vp}_{[+base]}, \mathrm{vp}_{[+base]} \Rightarrow \mathrm{s}[+fin]}\forall L,/L$$

It is perhaps worth noting that the value part of the auxiliary should have as an argument a *polymorphic* categorisation of quantifiers, and not just some monomorphic instance of it such as $\mathrm{s}_{[+fin]}/(\mathrm{np}\backslash \mathrm{s}_{[+fin]})$. The latter is not only a derivable categorisation of quantifiers, but also of a phrase such as Mary thinks that John, and if this were the subcategorisation of the value part of the auxiliary, this would then allow the possibility that (13a) is interpretted as synonymous with (13b):

(13) a. Mary thinks that John should stay
b. it should be the case that Mary thinks that John stays

[9] Which is a categorisation which in the version of the calculus allowing empty antecedents will account for both pre- and post-verbal occurrences of quantifiers

We will finally consider how we might treat sentences featuring auxiliaries and negation, such as:

(14) a. John must not stay
b. John can not stay

By far the most likely reading of (14a) has not taking narrow scope wrt. the modal, and by the far the most likely reading of (14b) has not taking wide-scope wrt. the modal. While perhaps neither sentence is ambiguous, the sentence frame *NP MODAL NEGATION VP* is. Now one sometimes suggested categorisation of negation, namely $\forall X.X/X$, will render this sentence frame ambiguous, with the wide-scope for negation being obtained by the derivation:

$$\frac{\mathrm{np}, Q\backslash \mathrm{s}_{[+fin]}/\mathrm{vp}_{[+base]} \Rightarrow \mathrm{s}_{[+fin]}/\mathrm{vp}_{[+base]} \qquad \mathrm{vp}_{[+base]} \Rightarrow (\mathrm{s}_{[+fin]}/\mathrm{vp}_{[+base]})\backslash \mathrm{s}_{[+fin]}}{\mathrm{np}, Q\backslash \mathrm{s}_{[+fin]}/\mathrm{vp}_{[+base]}, \forall X.X/X, \mathrm{vp}_{[+base]}}\forall \mathrm{L}, /\mathrm{L}$$

However, categorising negation thus makes the means available for very general wide-scoping of negation, and would for example allow (15a) to be interpretted as (15b), and (15c) to be interpretted as (15d).

(15) a. Mary thinks that John must not stay
b. Mary does not think that John must stay
c. Mary must not stay and John can not go
d. Mary must stay and John can go

Therefore, if negation is categorised in this way, means must be found to curtail these semantic overgenerations. One approach to this (explored in [Emms, 1994a] is to use the modalisation strategy to boundedness, as described in for example [Morrill, 1993]. A more modest approach would be to treat these *modal* + *negation* sequences as individual lexical items, each with their own particular lexical meaning settling the relative scope of the negation and the modal. This latter possibility is given support by the fact that such *modal* + *negation* sequences can be *contracted* (mustn't, cannot etc), and the readings obtained when the contraction is used are the same as when the two items appear as separate words.

A complicating factor, however, in this is the distinction made for example in [Horn, 1989] between normal and *meta-linguistic* negation, the latter being associated with a distinctive intonation and negating not the truth of an utterance but rather its *assertability*:

three people must not stay — four people must

Such meta-linguistic negation is claimed to not trigger negative polarity items, and to be unavailable when contracted forms of a modal and a negation are used. Clearly we will get the wrong results if such a use of negation immediately following auxiliary is treated as if the auxiliary and the negation form a chunk. This meta-linguistic negation is perhaps a good candidate for being treated via the polymorphic image of the infixation category $\mathrm{s}_{[+meta]} \downarrow \mathrm{s}_{[+fin]}$, i.e. $\forall X.(X\backslash \mathrm{s}_{[+meta]})/(X\backslash \mathrm{s}_{[+fin]})$.

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