

MULTIPLE MODALS CONSTRUCTION

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Abstract

Modal items of different semantic types can only be combined in a specific order. Epistemic items, for instance, cannot be embedded under deontic ones. I'll argue that this fact cannot be explained by the current semantic theories of modality. A solution to this problem will be developed in an update semantics framework. On the semantic side, a distinction will be drawn between circumstantial information about the world and information about duties, whereas I'll use Nuyts' notion of m-performativity to account for certain use of the modal items.

1 Introduction

The aim of this paper is to get a better grip on certain properties of modal items. The problem I will focus on concerns the modal combination of different semantic types.

Even though there is no general agreement on a precise definition and categorization of modality, a certain number of types have been identified and emerged as typical instances, like epistemic and deontic modality. I will concentrate on those two types and try to extend the analysis to a simple instance of evidentiality.

Both epistemic and deontic modality have generally been studied in isolation. Modal items (figure ??) have been categorized as belonging to one or more types, as epistemic or deontic, with a certain force, on a scale from mere possible to necessary. However not much work has been devoted to the study of combinations of modal items. This contribution will try to highlight some problems inherent to these cases.

	possibility	necessity	evidential
modal verbs	may, might	must, have to	
adverbs	maybe	certainly, obligatorily	reportedly
adjectival phrases	it is possible that	it is necessary that	
verbs	to be allowed to	to be required to	
PP			according to John

Figure 1: Some modal items of English

1.1 Some data

To see what is special about these combinations, we can look at the following examples:

- (1) a. Adverbs & modal verbs: $[[epistemic]] > [[deontic]]$
Maybe John must go to Berlin.
- b. 2× adverbs: $[[evidential]] > [[deontic]]$
Reportedly, this rule doesn't obligatorily apply to students.
- c. 2× modal verbs: $[[epistemic]] > [[deontic]]$
John may have to go to Berlin.

- d. Modal verbs & verbs: $[[epistemic]] > [[deontic]]$
 John might be obliged to quit the country.
- e. Adjectival phrase & verb: $[[epistemic]] > [[deontic]]$
 It is possible that John is allowed to leave.
- f. PP & modal verb: $[[evidential]] > [[epistemic]]$
 According to John, the company might fire 1.000 employees.

The inequalities indicate the relative (semantic) scope of the modal items. In (1-a) for instance, $[[epistemic]] > [[deontic]]$ means that the epistemic item is interpreted as having scope over the deontic item. Abstracting from the particular examples it seems that the following hypothesis can be formed:

Hypothesis 1 *If two modal items of different types are present in a grammatical sentence, they will be interpreted as having the following scope*

$$[[evidential]] > [[epistemic]] > [[deontic]]$$

We can try to test this hypothesis by trying to produce a counterexample:

- (2) a. #John must possibly go to Berlin.¹
 b. #John is allowed to certainly go to Berlin.
 c. #The company might reportedly fire 1.000 employees.²

Those examples seem to confirm the hypothesis. However, more than a correct description of the phenomenon (given the 9 sentences...), we would like to have an explanation. The obvious and traditional way to go is to check whether it is a syntactic, semantic or pragmatic problem.

The paper will be organized as follows. In section 2, I will argue that it cannot be a purely syntactic problem; in section 3, I will review the traditional semantic analysis of modality and argue that it cannot explain adequately this phenomenon either. I will then introduce Nuyts' analysis in section 4 and show how it can be used to sketch a framework where the problems at stake are made more explicit (section 5). I will finally conclude on a cross-linguistic note.

2 Not a syntactic problem

The order of interpretation proposed in hypothesis ?? will probably look familiar to the reader. Namely, it looks like a highly simplified version of Cinque's hierarchy of adverbs and functional heads in Cinque (1999):

$$\dots > \text{ModP}_{\text{evidential}} > \text{ModP}_{\text{epistemic}} > \dots > \text{ModP}_{\text{alethic}} > \dots > \text{ModP}_{\text{volition}} > \dots > \\ \text{ModP}_{\text{obligation}} > \text{ModP}_{\text{ability}} > \dots > \text{ModP}_{\text{permission}} > \dots > V$$

One could maybe argue that the semantic ordering is derivative of this universal syntactic hierarchy. However I don't think any argument for an explanation along this line, that the hard-wiring in the syntax implies the semantic scope restrictions, sounds convincing. To understand why, here is a quote from Cinque:³

¹I just claim here that the reading where *possibly* is interpreted under deontic *must* is not grammatical. The sentence seems correct with this surface syntactic structure if the epistemic adverb is "semantically moved" to have scope over the deontic modal.

²The reading with the evidential having scope over the epistemic modal is available and grammatical.

³This is however quite a selective cut of the original text! The first dots actually corresponding to "Although"...

“...many (perhaps most) of the relative orders among functional elements may ultimately reduce to scope relations among what we can take to be different semantic operators...” Cinque (1999, p.134-135)

Although Cinque ultimately considers his hierarchy to be hard-wired in the syntax, he concedes that a great part of the explanation for the hierarchy lies in the nature of the “semantic operators” and their relative scope. Hence the hierarchy still needs to be explained in non-syntactic terms. Moreover, syntacticians with concurrent theories about the syntax of modal items, like Cormack and Smith (2002), still agree on this point as well.

It has to be stressed however that the syntactic properties of particular modal items usually do influence their combinatorial properties with other modal elements. The point I want to make here however is that the fact that epistemic modals are “never” interpreted under deontic ones cannot be explained by syntactic considerations alone. As there seems to be an agreement among syntacticians on the fact that hypothesis ?? is not a strictly syntactic phenomenon, I will gladly take over this conclusion and continue the investigation by looking at the semantics of modal expressions.

3 Truth-conditional semantics

3.1 Kratzer’s possible worlds semantics

(Kratzer 1981, Kratzer 1991) offers a unified analysis of natural language modality within the framework of possible worlds semantics. The main tenet of her analysis is that modal items are not polysemous but context-sensitive. To be more precise, the modal items (like modal auxiliaries) that can be interpreted in different ways (deontically and epistemically, for instance) are context-sensitive.

Modality is a semantic domain that has to do with possibility and necessity. The quantificational force of a modal is therefore not context-sensitive, for instance *must* has universal force (necessity) whereas *may* has existential force (possibility).⁴

The context then fixes the interpretation to be given to a modal element through conversational backgrounds (the “In view of...” part of examples in (3)). Obviously (3-a) is interpreted epistemically and (3-b) deontically.

- (3) a. (In view of what is known) John may go to his office.
b. (In view of what the law provides) John may go to his office.

In order to avoid some problems of simple modal logic, modals are made doubly context-dependent. They depend on two different conversational backgrounds (functions from worlds to sets of propositions): one determining the accessible worlds from the world of evaluation (modal base), the other ordering those accessible worlds (ordering source). For instance, epistemic modals depend on an epistemic modal base and a stereotypical ordering source (characterizing a ‘normal’ course of events) and deontic modals depend on a circumstantial modal base (characterizing the relevant facts) and a deontic ordering source.

⁴It has recently been argued in Matthewson, Rullmann and Davis (2005) that this is actually not a cross-linguistically valid generalization. Lillooet’s modal enclitics would seem to have a context-dependent quantificational force.

3.2 Formalization

I will first introduce von Fintel and Iatridou's version of Kratzer's system (as formulated in von Fintel and Iatridou (2004)).

Definition 2 *Let W be a set of possible worlds.*

- i) A **proposition** p is a set of worlds, $p \in \mathfrak{P}(W)$.
- ii) A **conversational background** is a function from worlds to sets of propositions, $f : W \rightarrow \mathfrak{P}(\mathfrak{P}(W))$.
- iii) If a conversational background f is a **modal base**, it determines a set of accessible worlds from w by $\cap f(w)$.
- iv) A set of propositions P determines a **strict partial order** $<_P$ as follows:

$$\forall w', w'' : (w' <_P w'' \text{ iff } \forall p \in P (w'' \in p \rightarrow w' \in p) \text{ and } \exists p \in P (w' \in p \wedge w'' \notin p))$$

- v) A strict partial order $<_P$ determines a **selection function** max_P from set of worlds as follows:⁵

$$\forall V \subseteq W : max_P(V) = \{w \in V : \neg \exists w' \in V : w' <_P w\}$$

Intuitively, the ordering source will be used to order the worlds and the selection function will select the 'best' worlds according to it. We are now ready to give the definition of a possibility and a necessity modal:

Definition 3 (Necessity and possibility modal) *In a world w , a proposition p is a **necessity** (respectively **possibility**) with respect to a modal base f and an ordering source g , i.e. $\llbracket must\ p \rrbracket^{w,f,g} = 1$ ($\llbracket may\ p \rrbracket^{w,f,g} = 1$) iff*

$$\begin{aligned} &\forall w' \in max_{g(w)}(\cap f(w)) : w' \in p \\ &(\exists w' \in max_{g(w)}(\cap f(w)) : w' \in p) \end{aligned}$$

To summarize, all modal items are analyzed as quantifiers over possible worlds. Which worlds are to be quantified over is contextually determined: only the closest accessible worlds according to an 'ideal' are considered.

3.3 Examples

- (4) (In view of what his boss ordered him) John must go to Berlin.

$$\begin{aligned} \llbracket must\ (\text{John goes to Berlin}) \rrbracket^{w,f,g} = 1 & \quad \text{iff} \\ \forall w' \in max_{g(w)}(\cap f(w)) : w' \in (\text{John goes to Berlin}) \end{aligned}$$

Sentence (4) is interpreted deontically. In the present framework, that means that the context provides a circumstantial modal base f and a deontic ordering source g . The sentence is true if and only if in all the worlds that share the same circumstances as the base world w and where most of his duties are fulfilled, John goes to Berlin. We can now turn to an example of combination of modals.

⁵This selection function determines the closest worlds according to the 'ideal' P . As usual, this move is only harmless as long as we assume the Limit Assumption of Lewis (1973, p.19).

(5) Pedro may have to leave the country.

$$\begin{aligned} & \llbracket \text{may must (Pedro leaves the country)} \rrbracket^{w, f_1, g_1, f_2, g_2} = 1 \text{ iff} \\ & \exists w' \in \max_{g_1(w)}(\cap f_1(w)) : \forall w'' \in \max_{g_2(w')}(\cap f_2(w')) : \\ & w'' \in (\text{Pedro leaves the country}) \end{aligned}$$

- a. (In view of what is known) It is possible that (in view of what the law provides) it is necessary that Pedro leaves the country.
- b. #(In view of what the law provides) It is possible that (in view of what is known) it is necessary that Pedro leaves the country.

The problem is to determine which conversational background is attributed to which modal. The standard reading is the one where *may* is epistemic and *have to* deontic, paraphrased as **??**. But the framework doesn't prohibit reading **??**.⁶ There is no reason why we could not combine the conversational backgrounds in this way. The only straightforward solution is to stipulate that deontic modals scope under epistemic ones. This problem will, I think, be cropping up for any "modal" theory of deontic modality that treats deontic modality on a par with epistemic modality, i.e. as an accessibility relation on worlds.

3.4 Brennan's version: Back to the 70's

Another solution to the problem would be to differentiate between epistemic and deontic modals at the semantic level. This path has been explored in Brennan (1993).⁷ She developed a revision of Kratzer's framework where deontic modals have their own special modal base. The starting point for this move can be found in the following quote from Kratzer (1991, p.650):

"... the distinction between modals with circumstantial and modals with epistemic modal bases which is at the heart of our proposal may correlate with a difference in argument structure."⁸

Remember that circumstantial modal bases are "used" with deontic modals. Hence, if modal bases for deontic and epistemic modals also differ structurally, maybe we will be able to explain their combinatorial properties by this fact. The difference in argument structure referred to by Kratzer (1991) corresponds very roughly to the difference between raising and control verbs. Jackendoff (1972), for instance, develops an analysis of modal auxiliaries where epistemic and deontic modals correspond to raising verbs (or speaker-oriented adverbs) and control verbs (subject-oriented adverbs) respectively. However both types of modals are considered to

⁶It is interesting to remember that such an example was originally used in Kratzer (1978, p.144-147) to argue for an attributive conversational background (against a referential one). But notice however that making **??**'s deontic conversational background explicit in **??** doesn't even force a *deontic > epistemic* reading. The *epistemic > deontic* reading is still the only natural reading and the deontic ordering source is interpreted as g_2 (not g_1):

- (i) In view of what the law provides, Pedro may have to leave the country.

Furthermore this explicit deontic conversational background outside of the epistemic scope seems to force a referential reading of the ordering source, i.e. $g_2(w') = g_2(w)$ (though not of its circumstantial modal base). On the contrary, the typical reading of **??** seems to involve a referential reading of the modal base, i.e. $f_2(w') = f_2(w) \approx f_1(w)$. This must certainly be studied in more detail. In particular this could undermine the stance of definition 2, leaving an anaphoric view à la Frank (1997) as only possibility.

⁷Brennan (1993) actually concentrates on the analysis of root modals (deontic, ability...), and is not meant to solve the problems caused by modal combinations.

⁸See Brennan (1993, p.5): "...she [Kratzer] leaves open the possibility that there are also structural differences (in argument structure, for example) between them."

belong to the same syntactic class of (modal) auxiliaries, the difference being in their respective interpretation rules.

Brennan implements this analysis within Kratzer's framework which has the consequence of changing the notion of modal base for some deontic modals, namely for those that function as control verbs. Epistemic modals and all the ordering sources remain the same and the new modal bases for deontic modals are functions of an individual and a world and yield a set of properties.⁹ My interest lies not so much in the precise formalization than in the fact that an essential distinction is made between epistemic and deontic modals, therefore I will simply sketch a consequence of this framework with an example of combination of modals.

The proposed interpretation of example (5) is blocked because the sentence is semantically not well-formed. This is due to the fact that the deontic modal takes as argument the (denotation of the) intransitive verb phrase under it; however this IV is constituted of an epistemic modal and a verb phrase but, as epistemic modals are propositional operators, the sentence is uninterpretable.

- (6) # Pedro may have to leave the country. (deontic > epistemic)
 $\llbracket may_d('must_{ep} \lambda x. \ulcorner x \text{ leaves the country} \urcorner')(Pedro) \rrbracket^{w,f_x,g} = \#$

This failure of interpretation can thus be attributed to the epistemic modal: because some of its basic properties would not be respected, epistemic modals cannot be embedded under deontic ones. The main problem with Brennan's analysis is that it only partially solves the problem of combinations of modals, i.e. only in those cases where the deontic modal is a "VP-modal" as in example (6-a). The other deontic modals, as example (6-b), are still analyzed as propositional operators along the same lines as epistemic modals. Hence, Brennan's analysis could solve the problem if sentence (6-b) could embed an epistemic modal. However, sentence (7) does sound ungrammatical and the problem doesn't seem to disappear for those deontic modals.

- (7) a. Pedro must leave.
 $(must_d^1[\ulcorner \lambda x. x \text{ leaves} \urcorner])(Pedro)$
 b. Tax forms have to be filled out in ink.
 $must_d^2[\ulcorner Tax \text{ forms are filled out in ink} \urcorner]$

- (8) # Tax forms have to maybe be filled out in ink. (deontic > epistemic)

The second problem with Brennan (1993) comes to light in example (6), namely, she has to abandon the aim of a fully unified theory of modality. Even though the general idea of context-dependence is kept, Brennan has to introduce different interpretive rules for the non context-dependent parts of deontic and epistemic modals (the $must_d^1$ and $must_d^2 = must_{epistemic}$ of example (6)). This goes obviously against one of the starting points and main motivation of the original framework (see Kratzer (1978, p.103)). However this distinction between deontic and epistemic modals seems to be descriptively more adequate: the two systems don't appear to be on a par. I can have uncertainties about whether someone has some obligations but I don't really know what it would amount to to have epistemic obligations. Hence I will follow Brennan in making a distinction between epistemic and deontic but I will try to give an analysis general enough to encompass the two types of deontic modals as example (7) makes it clear that those deontic forms have the same distributional properties.

⁹See Brennan (1993, p.65-68).

4 Linguistic interlude

Before turning to the formal analysis, I will briefly expose some views held by Palmer (2001) and Nuyts (2004) concerning modality. First, epistemic modality is about knowledge: but not anybody's knowledge. As Palmer (2001) puts it "...with epistemic modality speakers express their judgments about the factual status of the proposition". Therefore questions of truth could be a step too far and we should maybe opt instead for a framework that takes as a central issue the information exchange between a speaker and a hearer.

Simplifying somehow, we could say that within the standard account an epistemic possibility sentence is true if, given a set of propositions representing what is known, the sentence is compatible with this information. It can well be in some cases that the set of propositions represents the speaker's knowledge, but it would seem to be more general than Palmer's view. Nevertheless as soon as we take into account some pragmatic considerations it becomes obvious that under reasonable assumptions the two positions amount to the same. In particular, if we assume that the speaker knows the meaning of *might* and asserts truthfully "John might be home," the relevant set of propositions must be a part of the speaker's knowledge.¹⁰ Palmer only states that "speakers express their judgments" whereas the truth-conditional account tells us under which conditions the sentence is true. However one can understand the meaning of an epistemic sentence without knowing which *f* and *g* of definition 2 are the relevant ones, i.e. without knowing its truth value. To capture this core meaning of "expressing the speaker's judgment" it seems that we should better use a framework that is able to represent the information exchange and not only the truth conditions.

To formalize the idea that the speaker expresses in an assertion his judgment about the status the embedded proposition, I will use Nuyts notion of m-performative¹¹ and descriptive use of modals from (Nuyts 2001, Nuyts 2004). A modal is used m-performatively if it expresses the current commitment (i.e. at utterance time) of the speaker towards the proposition expressed, and it is used descriptively if no such commitment is made (at utterance time) by the speaker about the evaluation of the embedded proposition.

- (9) a. It's possible that it was raining that night.
 b. It was possible that it was raining that night.
 c. According to John, it's possible that it was raining that night.

In example (8-a), the speaker evaluates as possible a certain past raining-event and commits himself to this evaluation. It would be pragmatically odd for the speaker to continue by saying "but it wasn't." Sentence (8-b) doesn't involve the same commitment on the part of the speaker, that is, he doesn't have to believe at the moment of utterance that it is possible that it was raining in order to utter (8-b) truthfully (he could even know that it wasn't raining). Finally, in example (8-c) the speaker reports John's opinion and obviously doesn't have to commit himself to it.

In simple declarative clauses, modal items are usually used m-performatively, i.e. they standardly convey a commitment of the speaker. However, in a past tense declarative as (8-b) this commitment is not conveyed; this is the case too in knowledge "reports" as (8-c) but also in the antecedent of conditionals or under attitude verbs. The main point is then that some modal items can be used m-performatively and descriptively, as *possible* in (8), but that some other modal items can almost exclusively be used m-performatively.¹² Furthermore m-performative items

¹⁰Notice that the knowledge of the hearer cannot be taken as already containing this information, otherwise any *might*-sentence would be automatically true and as such pragmatically odd.

¹¹It is actually called performative by Nuyts but was so renamed by Faller (2002) in order to avoid confusion with the speech-act notion of performativity.

¹²Epistemic modal adverbs, like *maybe*, are usually m-performative. This could well be a consequence of their

can only be used in illocutionary force bearing environments (Faller 2002, p.213). They cannot occur under negation, in the antecedent of a conditional or, for instance, under a m-performative modal item. This means that, in a sentence combining two modal items with scope $m_1 > m_2$, m_1 would be m-performative and m_2 would be descriptive.

4.1 Proposal

I want to make use of some of those ingredients in order to account for the combinational properties of modal items. The basic intuition is that it makes sense to be uncertain about some obligations whereas to have possibilities as obligations seems odd.

I will follow Brennan in making a distinction between epistemic and deontic items in the semantics (although S and VP deontic modals will be treated uniformly). This simply means that I will not treat factual information about the world and deontic information at the same level. Epistemic items will be formalized as tests on an agent's information state and deontic ones as update of the agent's to-do-list. I will then formalize Nuyts' notion of m-performativity indirectly. M-performativity will be the default interpretation of the 'highest' modal in an assertion. Hence modal items that are inherently m-performative will be anchored to the speech event and represent the speaker's commitment.

M-performative epistemic modals as *maybe* will thus have to be interpreted on a whole information state, but as deontic operators force further interpretation on the deontic domain, the combination m-performative epistemic under deontic item will result in the failure of interpretation.

5 Formal framework

I will first introduce the standard setup of update semantics (US from now on) and from that construct in a stepwise way an US system with obligations. I will finally try to render Nuyts' ideas within this framework and use it on examples of combinations of modal items.

5.1 Update semantics

Definition 4 *An US system is made of three components: a language, a set of information states, a set of update operations.*

1. The **basic language** \mathcal{L}_0 is constructed as usual from a set of atomic sentences \mathcal{P} and combination thereof with the connectives \neg and \wedge , i.e. $\mathcal{P} \subseteq \mathcal{L}_0$, if $\varphi \in \mathcal{L}_0$ then $\neg\varphi \in \mathcal{L}_0$ and if φ and $\psi \in \mathcal{L}_0$ then $\varphi \wedge \psi \in \mathcal{L}_0$.

The **possibility language** \mathcal{L}_1 is defined as follows, $\mathcal{L}_0 \subseteq \mathcal{L}_1$ and if $\varphi \in \mathcal{L}_0$ then $\text{poss}(\varphi) \in \mathcal{L}_1$.

2. A world/possible world/possibility is a function with domain \mathcal{P} and range $\{0, 1\}$, and W is the set of possible worlds. An **information state** σ is a subset of W , and let Σ be the set of information states.

3. The update operations are then defined as follows,

$$\begin{aligned}
\sigma[p] &= \{w \in \sigma \mid w(p) = 1\}, \\
\sigma[\neg\varphi] &= \sigma - \sigma[\varphi], \\
\sigma[\varphi \wedge \psi] &= \sigma[\varphi] \cap \sigma[\psi], \\
\sigma[\text{poss}(\varphi)] &= \sigma, \text{ if } \sigma[\varphi] \neq \emptyset \text{ (}\emptyset \text{ otherwise)}.
\end{aligned}$$

Obviously this very simple system is not conceived to talk about obligations but about knowledge. Learning that φ is the case consists in updating your information state with φ . Learning that $\neg\varphi$ is the case means removing those possibilities (i.e. possible worlds) where φ is the case from your information state. Learning that $\varphi \wedge \psi$ is learning that φ and that ψ , and finally φ is possible, $\text{poss}(\varphi)$, if learning that φ doesn't leave you with no information, i.e. some world in your information state is a φ -world.

In order to account for obligations I will adopt a method introduced by Portner (2003) and used for imperatives by Mastop (2005) in a US-framework. The main idea is to use a to-do-list to represent obligations. What is a to-do-list? It is not much than what it says, a list of sentences that we take to stand for **obligations**, the main point being that this list is a separate entity from the circumstantial information about the world. I will not deal with permissions but argue that it doesn't affect the problem at stake.

Definition 5 (Worlds and obligations)

1. A to-do-list is a set $\pi = \{(p, DO), (q, DO), \dots\}$ with p, q atomic sentences, i.e. a subset of the product $\mathcal{P} \times \{DO\}$.
2. A possibility is a pair of a world and a to-do-list, i.e. (w, π) . A possibility is thus characterized by what is the case and what are the duties in it.

Obviously this is a very crude characterization of obligations. Moreover some choices have to be explained about the formalization and the notation. Just as possibilities are functions from atomic sentences to truth values, to-do-lists could be seen as partial functions from atomic sentences to $\{DO, DON'T\}$,¹³ i.e. duties and prohibitions.

- (10)
- a. #It is allowed that you *maybe* go.
 - b. You must not come to my talk.
 - c. #You must not *maybe* come to my talk.

Example (9-a) shows that permission sentences cannot embed epistemic items either. Example (9-b) which exemplifies a prohibition behaves in the same way as an obligation when it combines with an epistemic item, see (9-c). Therefore I'll concentrate on obligations and simplify the framework correspondingly, keeping the (p, DO) notation as a reminder of this more complex structure and leaving permission aside.

- (11)
- a. Thesis paper must be acid-free.
 - b. #Thesis paper must *maybe* be acid-free.
 - c. Junior must go to bed at 8.00.
 - d. #Junior must *maybe* go to bed at 8.00.

There are some other features of deontic constructions that don't seem to change the embedding properties. First, most frameworks link to-do-lists to individuals, this means the to-do-list has to be a list of atomic imperatives, as Mastop (2005), or properties, as Portner (2003). In the

¹³Mastop (2005) defines its to-do-lists using atomic imperatives, not atomic sentences.

same way as Brennan (1993), it would solve the problem for example (9-b) with an analysis of epistemic items as propositional operators. However this doesn't work for example ?? (and its ungrammatical version ??). There, the obligation is not restricted to a particular individual (neither syntactically or semantically) and the deontic seems to scope over the whole sentence in an ought-to-be reading.¹⁴ The combination in ?? is still odd, precisely because the concept of epistemic obligation is odd, whether it is linked to a particular individual or not.

Finally the question of the addressee (or the source/authority) of the obligation need not be a worry. Sentence ?? can be, depending on the context, used to convey that Junior₁ (age 9) has been ordered by his mother to go to bed at 8.00 or that the babysitter has been requested to see to it that Junior₂ (age 1:6) will be in bed at 8.00. Whatever interpretation is salient, its maybe-version ?? is still ungrammatical. Therefore I will only model obligations in the simplest way possible, abstracting away from who's the carrier of the obligation and who issued it.

We now have to extend our system to be able to talk about obligations. I will first extend the notion of information states, then add a new operator to the language and define its update operation.

Definition 6 (US with to-do-lists)

1. An **information state** σ is a set of possibilities, i.e. a subset of $W \times \mathfrak{P}(\mathcal{P} \times \{DO\})$. The **absurd state** is the empty set \emptyset and the **initial state** is the set of all possibilities consisting of a world and a to-do-list, $\mathbf{0} = W \times \mathfrak{P}(\mathcal{P} \times \{DO\})$
2. The **simple deontic language** \mathcal{L}_2 is defined as follows, $\mathcal{L}_1 \subseteq \mathcal{L}_2$, if $p \in \mathcal{P}$ then $!p$, $poss(!p)$ and $!poss(p) \in \mathcal{L}_2$.
3. The update operations are defined in the obvious way for the already given operators.

$$\begin{aligned}\sigma[!\varphi] &= \{i \in \sigma \mid i = (w, \pi) \text{ and } \pi[\varphi] = \pi\}, \\ \pi[\varphi] &= \pi \cup \{(\varphi, DO)\}\end{aligned}$$

The update operation for $!p$ could be simplified to the equivalent $\sigma[!p] = \{i \in \sigma \mid i = (w, \pi) \text{ and } (p, DO) \in \pi\}$, but what I want to illustrate here is that $!$ triggers an operation on to-do-lists. To learn that p is an obligation is to add p to your information state's to-do-list.¹⁵ Consider a sentence of the form $poss(!p)$, that could be used to model the logical form of sentence ??:

(12) John might have to give a talk.

$!p$ is possible in state σ , $\sigma[poss(!p)] = \sigma$, if and only if learning that p is an obligation doesn't leave you with no information, i.e. $\sigma[!p] \neq \emptyset$ which means p belongs to a possibility's to-do-list in σ . Now consider a sentence of the form $!poss(p)$:

$$\begin{aligned}\sigma[!poss(p)] &= \{i \in \sigma \mid i = (w, \pi) \text{ and } \pi[poss(p)] = \pi\} \\ &= \{i \in \sigma \mid i = (w, \pi) \text{ and } \pi \cup \{(poss(p), DO)\} = \pi\} = \emptyset\end{aligned}$$

The interpretation of this sentence results in the absurd state as there is no such thing in the to-do-lists as the obligation of a possibility.

It is time to add the last change on the information state. So far an information state is a set of possibilities consisting of a world and a to-do-list. It characterizes the information an agent

¹⁴Feldman (1986).

¹⁵However it is an eliminative system, hence the equivalence with the simpler definition.

may have. We will add information about what other agents know. To do that we need a set of agents \mathcal{A} , and a particular agent $a \in \mathcal{A}$; a 's information about the other agents is of the form $A_a = \{\sigma_b \mid b \in \mathcal{A} - \{a\}\}$ with $\sigma_b \subseteq W \times \mathfrak{P}(\mathcal{P} \times \{DO\})$, that is, an information state according to definition 5.¹⁶

Definition 7 (Information state of some agent a)

1. A possibility is a tuple of the form $i = (w, \pi, A_a)$. An information state is a set of possibilities.
2. The new language is defined as follows, $\mathcal{L}_2 \subseteq \mathcal{L}_3$ and if $\varphi \in \mathcal{L}_2$ then $\Box_b \varphi \in \mathcal{L}_3$ for $b \in \mathcal{A}$.
3. The update operation for \Box_b , $b \in \mathcal{A}$ is:

$$\sigma_a[\Box_b \varphi] = \{i \in \sigma_a \mid i = (w, \pi, A_a) \text{ with } \sigma_b \in A_a \text{ and } \sigma_b[\varphi] = \sigma_b\}$$

The goal of such an information state is simply to represent different kinds of information by different entities. This is however not enough to solve the ordering problem. As was already noticed, at this point the system is only able to represent the harmless combinations of epistemic over deontic modals.

5.2 Assertions and m-performativity

As already mentioned, m-performativity will be modeled as a default interpretation of assertions. The standard interpretation of a declarative sentence conveys that its content represents the speaker's belief or commitment.

Definition 8 (Assertion) *The update due to agent a's assertion of φ to agent b is modeled as follows,*

$$\sigma_b(\varphi)_a = \sigma_b[\varphi] \cap \sigma_b[\Box_a \varphi]$$

In this view, accepting a 's assertion consists in accepting the content of the utterance and learning that it is also part of a 's knowledge. The top level operator of a sentence $\varphi = Op[\psi]$ will thus also be bound to the speaker's information state through \Box_a , i.e. making the utterance m-performative.

Finally, we need to account for inherently m-performative modal items. Those items are only interpretable in illocutionary force bearing environments as assertions. A m-performative epistemic possibility modal is an operator, say *Poss*, similar to *poss* but restricted to assertions, i.e.,¹⁷

$$\sigma_b(Poss \varphi)_a = \sigma_b[\Box_a poss \varphi] \text{ if } \sigma_b[\varphi] \neq \emptyset, (\emptyset \text{ otherwise})^{18}$$

We can also define the m-performative deontic operator, say $!_m$, as the operator $!$ but restricted to assertions.

¹⁶A better, though more involved, way to represent this would be to allow the information state of the agent to contain other information states of the same kind. This leads to circularity but can be formalized in the framework of non-wellfounded sets.

¹⁷It is still unclear how to formalize this correctly, but I would prefer not to add this operator to the syntax of the language.

¹⁸ $\sigma_b(Poss \varphi)_a = \sigma_b[poss \varphi] \cap \sigma_b[\Box_a poss \varphi]$ and $\sigma_b[poss \varphi] = \sigma_b$ if $\sigma[\varphi] \neq \emptyset$ (\emptyset otherwise).

5.3 Examples

Now the system is in place, we can use it on the examples and see how the hearer interprets sentence ???

(13) S: “Maybe John must go to Berlin.”

Intuitively this sentence means that some state of affairs is an epistemic possibility, namely that John has the obligation to go to Berlin. Formally it will have the following logical form: $Poss !p$ with the relevant interpretation of p .

$$\sigma_H(Poss(!p))_S = \sigma_H[\Box_S poss(!p)] \text{ if } \sigma[!p] \neq \emptyset$$

Hence, if the information state of the hearer contains a possibility where John has such an obligation ($\sigma[!p] \neq \emptyset$), we obtain that the hearer updates his information state with the fact that the speaker is committed to $poss(!p)$.

$$\begin{aligned} \sigma_H(Poss(!p))_S &= \{i \in \sigma_H \mid i = (w, \pi, A_H) \text{ with } \sigma_S \in A_H \text{ and } \sigma_S[poss(!p)] = \sigma_S\} \\ &= \{i \in \sigma_H \mid i = (w, \pi, A_H) \text{ with } \sigma_S \in A_H \text{ and } \sigma_S[!p] \neq \emptyset\} \end{aligned}$$

Hence the combination m-performative epistemic over descriptive deontic works fine. We can now turn to the infelicitous combinations, deontic $>$ (m-performative) epistemic, of the form $!_m Poss(p)$.

(14) S: #“John must *possibly* go to Berlin.” (example (2-a))

$$\begin{aligned} \sigma_H(!_m Poss(p))_S &= \sigma_H[!Poss(p)] \cap \sigma_H[\Box_S !Poss(p)], \\ \text{however, } \sigma_H(!_m Poss(p)) &= \{i \in \sigma_H \mid i = (w, \pi, A_H) \text{ and } \pi[!Poss(p)] = \pi\} = \emptyset \end{aligned}$$

The failure of interpretation is now caused by the fact that $Poss$ cannot be interpreted outside an illocutionary force bearing environment. This must be contrasted with the explanation of the infelicity of example ???. Failure is there due to the structure obligation (to-do-lists) whereas it is now due to the m-performativity. It would seem that, if this result is not only caused by the epistemic nature of the element, we should obtain a similar result by trying to embed a m-performative deontic item, and indeed examples in ??? involving a m-performative deontic are infelicitous.

(15) a. #Maybe, you must go now!
b. #Maybe, go now!

(16) According to John, Pete might have to go to Berlin.

Lastly, I would like to suggest that sentences containing an evidential-like element as *according to John*¹⁹ can be integrated within this framework quite easily (using the \Box operator). A sentence like (11) will just have the following logical form, $\Box_J poss(!p)$. However it would require for instance the extension of this framework by using non-wellfounded sets.

¹⁹Whether “according to John” should be considered a real evidential (quotative or hearsay type) is problematic. If we do so, sentence ??? would suggest that hypothesis ??? should probably be revised too.

- (i) a. It might be so that, according to John it was scheduled at 18.00 but that, according to Pete it was scheduled at 19.00.
b. $[[evidential]] \geq [[epistemic]] > [[deontic]]$

6 Conclusion

In this paper, I argued that the existence of certain scope properties of modal categories should be accounted for within a semantic framework. I therefore introduced an update semantics system in which the ordering $[[epistemic]] > [[deontic]]$ follows from the semantics and pragmatics of the modal items. Two central points of this system allow it to account for the scope order.

First Brennan's distinction between deontic and epistemic items has been sharpened, following Portner (2003) and Mastop (2005), allowing us to differentiate between deontic and epistemic operators. The former operate on to-do-lists while the latter operate on circumstantial information. Second, I used Nuyts' notion of m-performativity to model Palmer's conception that with modality "...speakers express their judgments..." Some modal items can typically only be used m-performatively, that is, anchored to the speaker at the speech event, which explains why they cannot embed. These two factors were used to account for the possible and impossible combinations of deontic and epistemic items, used descriptively and m-performatively.

Of course, this framework is still quite crude and can be improved in several directions. It would seem natural, for instance, to have a more involved account of the deontic realm. The to-do-lists can only handle obligations but it should be extendable to a full (constructive) system with permission in the manner of Mastop (2005). The analysis of the relative scopes should be extended to other modalities, in particular to more typical instances of evidentiality than the one used in this paper. Finally, hypothesis ?? on the relative order of modalities must definitely be tested cross-linguistically: it would be surprising if it turned out to be a feature unique to the English language.

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