The semantic roots of positive polarity: epistemic modal verbs and adverbs in Greek and Italian

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1 Modal adverbs: positive polarity, modal spread

What makes universal epistemic modal adverbs and verbs positive polarity items (PPIs)? We argue, based on an investigation of epistemic modals and adverbs in Greek and Italian, that one class of PPIs shows their limited distribution due to their particular presuppositions. We offer a semantic account of epistemic modal adverbs that captures their distribution in patterns typically known as modal concord (see Huitink 2012, 2014), but which we will call *modal spread*. Modal spread is not usually discussed in the context of positive polarity, but we argue that it is instrumental in revealing an additional argument of modality, namely a function that reflects the speaker's perspective. We show that the perspective is always *positive*, which is crucial to understanding the novel observation that negative modal adverbs do not exist. We show that by analyzing modal verbs as having a presupposition of positive bias which survives negation, we can capture the fact that both the modal and the adverb scope above negation.

The positive polarity property of English modal adverbs is discussed in Ernst 2009 (see also Nilsen 2004, challenged in Ernst *ibid.*). Ernst discusses modal adverbs in the context of *speaker-oriented adverbs* (SOAs), which includes the purely evaluative class. The observation is that SOAs always outscope a local negation:

(1) a. Unfortunately, John disappeared.
b. #John didn't unfortunately disappear.

(2) a. John probably left the country.
b. #John didn't probably leave the country.

Ernst observes further that as PPIs, SOAs resist being in the direct scope of other nonveridical operators (e.g., the operators in *if*-clauses and questions), as illustrated here (Ernst gives similar examples with *luckily, happily, surprisingly*).

(3) a. *Has he unfortunately disappeared?
b. *If he has unfortunately disappeared...

(4) a. *Has he probably disappeared?
b. *If he has probably disappeared...

If SOAs appear peripherally, either on the left or the right edge of the sentence, negation is not problematic.

(5) a. Unfortunately, John disappeared.
b. Unfortunately, John didn't disappear.
c. John didn't disappear, unfortunately.

(6) a. Probably, John disappeared.
b. John didn't disappear, probably.
c. Probably, John didn't disappear.

In the literature on polarity, PPI-hood is analyzed as the need to escape syntactically the offensive negation, and it typically translates into an anti-scope syntactic condition (Giannakidou 1998, Szabolcsi 2004; see also Progovac 1994). Recent works that study the interaction between modal verbs and negation observe likewise that modal verbs themselves can be PPIs or negative polarity items (NPIs) (see e.g. Iatridou and Zeijlstra (2013) who give a purely syntactic account). PPI behavior of evaluative adverbs has been observed also in French (Bonami and Godard 2008), and in Spanish (Mayol and Castroviejo-Miró 2014) where the high scoping is understood as contributive expressive meaning in the sense of Potts (2007).

As with every polarity item paradigm, one must ask the question of what makes it polarity sensitive (the *sensitivity question*, see Israel 1996, Giannakidou 2011 for an overview). Ernst offers an inspiring account that SOAs become PPIs because they are *subjective*.[1] Subjectivity is a pragmatic condition of the adverbs, namely that all worlds in the epistemic modal base are p worlds (p stands as standard for the prejacent proposition); this renders them odd in the scope of negation because negation conflicts with this condition. The important insight of this type of account is that the modal adverb lexically encodes a positivity that renders it incompatible with negation— and our analysis in the present paper will offer a more detailed framework within which to understand this positivity.

An additional important observation is that modal adverbs co-exist with modal verbs in what we call modal spread. Modal spread is not typically discussed in the context of positive polarity, but we will argue that it is, in fact, instrumental in revealing the additional structure in the modality. Consider the example below:

(7) John must probably/certainly be sleeping.

(8) He may possibly have forgotten.

Here we see the modal verbs *must, may* co-occurring with *probably/certainly, possibly*.[2] Lyons 1977 talks about 'harmony' in this case—and claims that there is a kind of concord running through the clause which results in the *double* realization of a *single* modality (Lyons, 1977: 808). This observation, namely that there is one modality in these cases, is stable in most of the analyses of the phenomenon (see Huitink 2012, 2014, Grosz 2010, *a contrario* Anand and Brasoveanu, 2010). The use appears to be harmonic because the verb and adverb in each sentence are of compatible force. But this is not always the case.

[1]Ernst in fact distinguishes three types of speaker oriented adverbs, of which are subjective and PPIs, and one which is not, see Ernst 2009: (61)): (a) Strong PPIs, subjective, blocked in all nonveridical contexts; (b) Weak PPIs, subjective or objective, blocked in antiveridical contexts, allowed sometimes in nonveridical non-negative context. Modal adverbs are placed in this class. The third class contains non-PPIs, which are objective in Ernst's terminology, and allowed in all nonveridical contexts. *Obviously* belongs to this class.

[2]The co-occurence may seem at first glance a bit awkward in English, but we find many such uses in corpora (see also early discussions in Haliday 1970 and Lyons 1977). In purely philosophical works we also find some discussion of modal verb and adverb combinations in English (e.g. Moss 2015), though the context and set of questions asked are distinct from the linguistic literature cited here as the background of our analysis. Yalcin (2007), finally, discusses construals with embedded modals under attitudes, but this also appears to be a phenomenon different form the positive polarity property of modal verbs and adverbs in Greek and Italian that we focus on here.

Modal verbs and adverbs with apparently opposing forces can also co-occur with a single modality reading; see below Italian *dovere* 'must' and *forse* 'maybe':

(9) Le luci sono accese. Gianni deve forse essere a casa. (non-harmonic)
The lights are switch-on. Gianni must maybe be at home.
'The lights are on. John must (#maybe) be at home.'

Below is an attested example. The context is the discussion of an archeological reconstruction of the town Castel Nuovo, near Naples.

(10) Il vaso, che costituisce uno dei premi guadagnati dagli atleti negli agoni panatenaici di Atene, **deve forse** fare parte del corredo di una sepoltura ubicata non lontano dall'area di Castel Nuovo.
'The jar, which constitutes one of the prizes earned by the athletes in the pan-athenians olympics of Athens, **must maybe** belong to the kid of a burila located not far from the area of Castel Nuovo.[3]'

Sentences like these are, to our knowledge, not discussed in the literature, and every theory of modal concord would claim that they do *not* have a single modality reading. We will argue here, however, that they do; and it is for this reason that we will be using the neutral term *modal spread* instead of *concord* or *harmony*. Huitink 2012 states that conditions on the adverbs "really can only be decided on a case to case basis" (Huitink 2012:30), but we show that there are some general principles that delimit the set of possible interactions.

Apparent harmonic uses seem to be pervasive in Greek and Italian:

(11) a. Prepi malon/opsdhipote na ine giatros.
Must probably/definitely subj be.3sg doctor
'He must probably/definitely be a doctor.'
b. Deve probabilmente/sicuramente essere un dottore.
Must.3sg.pres probably/certainly be a doctor.
'He must probably/definitely be a doctor.'

(12) a. Prepi malon/oposhipote na efije noris.
must probably/definitely subj left.3sg early.
b. Deve probabilmente/sicuramente essere partito presto.
Must.3sg.pres probably/certainly be left early.
'He must have probably/definitely left early.'

We see here the modal adverbs *malon/probabilmente* 'probably', *oposdhopote/certamente*, 'definitely', etc. co-occur with the necessity modals *prepei/dovere*/must. In Greek and Italian, modal spread is very common and unmarked. We offered combinations with present and past tenses, to illustrate that the phenomenon is tense independent. We find the co-occurence also with the future, see (13) (Giannakidou 2012, Giannakidou and Mari 2012, 2013):

(13) a. Arriverà certamente/probabilmente alle 4.
Arrive.FUT.3sg certainly/probably at 4.
'John will definitely/probably arrive at 4.'
b. O Janis tha erthi sigoura/malon stis 4.
the John FUT come.3sg certainly/probably at 4 pm.

[3]Source: `http://www.comune.napoli.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/1425/UT/systemPrint`

'John will definitely/probably arrive at 4.'

Crucially, in Greek, just like in English, these strong universal-like adverbs cannot co-occur with possibility ones *bori/may/might*. In Italian, on the other hand, weak modals can co-occur with strong adverbs, just as strong modals can co-occur with weak adverbs.

(14) a. #Bori malon/opsdhipote na efije noris.
May probably/definitely subj left.3sg early.
b. Può probabilmente/sicuramente essere partito presto.
Can.3sg.pres probably/certainly be left early.
'#He may have probably/definitely left early.'

(15) a. #Bori malon na ine giatros.
May probably subj be.3sg doctor.
b. Può probabilmente/sicuramente essere un dottore.
May.3sg.pres probably/certainly be a doctor.
'#He may probably be a doctor.'

Here is an attested example in Italian.

(16) La bassa partecipazione al lavoro delle più giovani **può probabilmente** essere spiegata facendo riferimento alla maggiore probabilità per le stesse di avere figli . . .
'The low participation to the job market of the youngest ones may probably be explained by making references to the highest probability for these women to have children . . .".[4]

The possibility adverb is grammatical with possibility modals in all three languages.

(17) a. Bori isos na efije noris.
may maybe subj left.3sg early
b. Può forse essere partito presto.
Can.3sg.pres maybe be left early.
He may have possibly left early.

(18) a. Bori isos na ine giatros.
may maybe subj be.3sg doctor
b. Può forse essere un dottore.
Can.3sg.pres maybe be a doctor.
He may possibly be a doctor.

We can summarize the facts above in the following two generalizations: (a) modal matching appears to be the general case, attested in all three languages (Greek, Italian, English), as well as Dutch (Geurts and Huitink 2006, Huitink 2012, 2014), and German (Grosz 2012); (b) languages are subject to variation wrt to whether they allow non-matching, which seems to be generally a more restricted option (Italian). In addition, we note that the modal adverbs are positive, meaning *probably, definitely, maybe*. There appear to be no negative versions of modal adverbs (e.g *un-probably, un-maybe, un-definitely*. In English, the adverb *unlikely* exists but, crucially, it is excluded from modal spread:

[4]Source: https://books.google.com/books?id=AS531W43O8cC&pg=PA147&lpg=PA147&dq=\%22puo+probabilmente+essere\%22&source=bl&ots=Hzf4lNcYk1&sig=Ku4QFMrZyjAOJ6EkvCHvc5l9CkE&hl=en&sa=X&ved=0ahUKEwjWoP-19tbKAhXpxIMKHcO-Dk0Q6AEIRDAI

(19) #He must/may unlikely be a doctor.

The impossibility of negative modal adverbs, to our knowledge unnoticed in the literature, must be taken as part of the puzzle of positive polarity of modal adverbs, and we address it in section 4. In addition, it must be noted the PPI-hood of adverbs still holds in modal spread. Observe:[5]

(20) a. #Den prepei profanos/malon na ine giatros.
Not must obviously/probably subj be.3sg doctor
b. #Non deve probabilmente/sicuramente essere un dottore.
#Not must.3sg.pres probably/certainly/forse be a doctor.
'He must not obviously/probably/maybe be a doctor.'

In an nutshell, our analysis will be the following. We will argue that the adverb reveals the speaker's perspective on the modality. The the speaker's perspective is an integral part of the modal structure: a presupposition of *positive bias*. This presupposition, as expected, survives negation, and forces the adverb and modal verb to scope above negation. Positive bias also helps us understand why there are no lexicalizations of negative modal adverbs cross linguistically. Our analysis derives *positive bias* for universal modals and adverbs; existential modals are not characterized by positive bias and do not appear to be PPIs as has been demonstrated in the literature (Iatridou and Zeijlstra 2013, Homer 2015).

We proceed first by offering some background on the ingredients of modality that we will be using. In section 3, we offer our analysis of modal adverbs and modal verbs, including a brief comparison with Huitink (2012) and Mayol and Castroviejo-Miró (2014). Our analysis will be shown to bear similarities with Matthewson's et al. (2007) treatment of modality in Salish. In section 4 we address in more detail the interaction with negation and the implications of positive bias, concluding with typological predictions.

2 The ingredients of modality

We assume a Kratzerian semantics for modals, where modals take modal bases and ordering sources, and add two ingredients, following Giannakidou 1998, 2012, 2013 and Giannakidou and Mari 2013, 2016: the first one is the *Nonveridicality Axiom* that all modal bases are non-veridical (see also Beaver and Frazee 2011 for nonveridicality as a defining property of the category modality). The second addition is the idea that necessity modals are positively biased. Biased modality is responsible for the appearance of strength with universal modals.

2.1 Nonveridicality Axiom, support and bias

Montague 1969 uses 'veridicality' to characterize sentences with direct perception verbs such as *see*; Giannakidou and Zwarts define veridicality in terms of truth entailment:[6]

(21) Veridicality. (based on Zwarts 1995, Giannakidou 1997, 1998, 1999). Let F be a unary sentential operator. The following statements hold:
(i) F is veridical iff F$p \rightarrow p$ is logically valid; otherwise F is nonveridical.
(ii) A nonveridical F is antiveridical, iff F$p \rightarrow \neg p$.

[5] We cannot consider questions or *if* clauses, because epistemic modals are ruled out there anyway: *#Prepei (profanos/malon) na ine giatros?, # Must it (probably, obviously) be the case that he is a doctor*? For a recent description of English see Hacquard and Wellwood 2014. The Greek and Italian facts don't appear to be different.

[6] See Giannakidou 2013 for a formal connection between truth and existence.

Functions that have veridicality and nonveridicality are propositional functions[7]. F is veridical iff Fp entails p, i.e. if whenever Fp is true, p is true too. F is nonveridical if Fp does not entail p, i.e. if when Fp is true, p may or may not be true. The contrast is illustrated below with the English adverbs *yesterday* and *allegedly*:

(22) Yesterday, John flew to Paris.

(23) Allegedly, John flew to Paris.

Yesterday and its cross linguistic counterparts are veridical because *yesterday (John flew to Paris)* entails that John flew to Paris. But *allegedly* is nonveridical because *allegedly (John flew to Paris)* doesn't. Modal adverbs, as a class, appear to be nonveridical. We illustrate below with the English words; the generalizations hold also for Greek and Italian adverbs:

(24) *Probably, Possibly, Maybe, Perhaps*, John flew to Paris.

In (21) veridicality is defined as truth entailment, and nonveridicality is the absence of truth entailment. Veridicality is thus identical to factivity (or actuality).

Consider now the modal verbs:

(25) Nicholas might/must bring dessert.

(26) Nicholas might/must have brought dessert.

Like modal adverbs, modal verbs are also nonveridical. Since MIGHT $p \rightarrow p$ is not logically valid, *might* is nonveridical. *Must* is also nonveridical, since MUST $p \rightarrow p$ is also not logically valid. (In other words, the principle T of modal logic is not validated; see Zwarts 1995, Giannakidou 1998, 1999). Modals function, then, as a class (possibility as well as necessity modals, modal adverbs) are nonveridical in that they do not entail the truth of the prejacent proposition.

In addition to being a property of linguistic expressions, veridicality and nonveridicality can also be understood as properties of modal spaces. In this case, nonveridicality characterizes a non-homogenous modal space:

(27) *Veridical, nonveridical modal spaces (sets of worlds) and homogeneity*

a. A modal space M is *veridical* with respect to a proposition p iff $\forall w'(w' \in \text{M} \rightarrow p(w'))$ (Homogeneity)

b. A modal space M is *non veridical* with respect to a proposition p iff $\exists w', w'' \in \text{M}(w' \neq w'' \wedge (p(w') \wedge \neg p(w''))$ (Non-homogeneity)

c. A modal space M is *antiveridical* with respect to a proposition p iff $M \cap p = \emptyset$. (Homogeneity)

Veridical and anti-veridical spaces are homogenous whereas non veridical spaces are non-homogenous (or, as Condoravdi 2002 puts it, 'diverse'; also Werner 2006). Modal bases are nonveridical spaces (and we use M for modal bases from now on). It is hardly necessary to establish the nonveridicality of the modal base of the possibility modal; MIGHT/POSSIBLY p is true if $M \setminus p \neq \emptyset$, i.e. the modal base M intersects with p, and it contains $\neg p$ worlds.

We propose that nonveridicality be a precondition on modalities. We encode this in the *Nonveridicality Axiom* below:

(28) *Nonveridicality/Non-Homogeneity Axiom of modals*
MODAL (M) (p) can be defined only if the modal base M is nonveridical, i.e. only if

[7] See Bernardi 2002 for type-flexible definitions.

M is non-homogenous containing p and non-p worlds.

The nonveridicality axiom guarantees that the modal base M of every modal will be partitioned into a set of worlds where p is true (the positive set) and its complement where p is not true (the negative set). This partition is crucial: MODAL p will not entail p since there are $\neg p$ worlds in M, and the actual world may be a non-p world. All modals (possibility and necessity) in all flavors (epistemic, deontic, bouletic, etc) obey this principle, and therefore come with partitioned modal bases; consequently, they do not entail p.

Necessity modals, in addition, are known to feature ordering sources. Portner (2009) defines Best worlds. The Best worlds are the ideal worlds, the ones best conforming to knowledge, rules, or goals (depending on the nature of modality).

(29) *Ordering of worlds* - Portner, 2009, p.65.
For any set of propositions X and any worlds $w, v : w \leqslant_X v$ iff for all $p \in X$, if $v \in p$, then $w \in p$.

(30) For any set of propositions X, Best worlds as per X.
Best$_X$: $\{w' : \forall q \in X(w' \in q)\}$

Given an epistemic modal base M(i), we can rewrite Best as a function over M(i), still in the spirit of Portner (*ibid.*).

(31) Best$_{\mathcal{S}}$M(i) = $\{w' \in$M$(i) : \forall q \in X(w' \in q)\}$.

Here we will disentangle the notion of Best worlds it into two basic parts: *support* and *positive bias*. The advantage of this is that we can refer to the positive set of the modal base, without having to say that these worlds are 'ideal', or 'preferred' by the speaker. This becomes necessary if we want to have a unified framework for necessity and possibility modals which generally lack such orderings.

Support is defined as in (32). The Support function takes the modal base as its argument and returns a subset of it. The set of worlds returned is such that the propositions in the ordering source $\mathcal{S}$ are true. In this set p is also true. We call the set returned by the function Support, the 'Support set.'

(32) Support function.
Support$_{\mathcal{S}}$(M(i)) = X s.t. $X \subset$ M(i) & $\forall w' \in X : p(w')$.

The support function delivers the positive set of the nonveridical modal base— and the adverbs, we will argue later, operate further on the size of that set.

We now define bias. Crucially, modal bias cannot be negative: there are no modal verbs in language such as NEG-MUST, and this is an important generalization that correlates, we will argue, with their positive polarity. We use a measure function μ, which takes sets as arguments and returns their sizes. $>$ stands for 'greater than'.

(33) A modal is positively biased iff :
μ(Support$_{\mathcal{S}}$(M(i))) > μ(M(i) $\setminus$ Support$_{\mathcal{S}}$(M(i)))

This states that the modal is biased if and only if the set of p worlds is larger than the set of $\neg p$ worlds. This delivers *positive* bias. If the set of p worlds is larger, then the speaker sees it as more likely that the actual world will be a p worlds rather than a $\neg p$ world, and this captures the intuition that universal modals are "stronger" than possibility modals. As in Kratzer (1981) and Portner (2009), the ordering source is a set of propositions. Such a set does not necessarily lead

to a configuration in which the set of p worlds is larger than the set of $\neg p$ worlds.

Crucially, existential modals do not have bias (we offer a precise analysis of epistemic existential modality in section 3.2). Rather, their modal base is partitioned into p and $\neg p$ sets of equal size. Following Giannakidou (2013), we call this situation *nonveridical equilibrium*. For Giannakidou (*ibid.*), the existence/absence of a bias correlates with the existence/absence of an ordering source, but since we broke here that correlation, the definition is now in terms of the size of the subsets of the modal base. Equilibrium can be obtained with both ordering sources and absence of ordering sources. An ordering source is a set of propositions, but the existence of such set does not always suffice to change the balance between the sets in the modal base.

(34) Nonveridical equilibrium (with ordering sources)
A modal base M(i) is a non-veridical equilibrium iff
$\mu(\text{Support}_{\mathcal{S}}(\text{M}(i))) \approx \mu(\text{M}(i) \setminus \text{Support}_{\mathcal{S}}(\text{M}(i)))$

Equilibrium is the state of fifty-fifty, i.e. p and $\neg p$ being equal options, none of the sets (the p set or the $\neg p$ set) is larger than the other. Nonveridical equilibrium characterizes possibility modals (and questions; Giannakidou 2013). In our system, as it will become clearer in 3.2. the difference between necessity and possibility modals boils down to precisely this contrast between positively biased modality and nonveridical equilibrium.

We can generalize the definition in (34) in such a way that the state of nonveridical equilibrium is not contingent on the existence of an ordering source $\mathcal{S}$:

(35) Nonveridical equilibrium (general).
Let X s.t. $X \subset$ M(i).
A modal base M(i) is a non-veridical equilibrium iff $\mu(X) \approx \mu(\text{M}(i) \setminus X)$

Let us focus now on epistemic MUST.

2.2 Epistemic MUST

Italian *dovere* and Greek *prepi*, just like *must* in English, are universal epistemic modals. For epistemic modals, the modal base M(i) is anchored to the speaker (i) and it contains the set of propositions known by i. w_0 is the actual world. The nonveridicality of universal epistemic modals is revealed by the fact that they cannot be used if the speaker knows p.

(36) Seeing the rain:
#It must be raining.
Prepei na vrexi.
#Italian.

The universal modal, therefore, cannot be used if p is entailed in M(i).

(37) M(i) = $\lambda w'.w'$ is compatible with what is known by the speaker i in w_0.[8]

Because the speaker sees the rain, she knows that it is raining. But this conflicts with the nonveridicality axiom of modality that requires the modal base to contain both p and $\neg p$ worlds, hence the oddity. The oddity is assumed sometimes to be due to evidentiality (Karttunen 1972, von Fintel and Gillies 2010, Lassiter 2013), but as cane seen in this core case, the intended evidentiality is a consequence of the non-veridicality which tolerates only partial knowledge

[8]Our notation M$_i$ is a shorthand for the Kratzerian notation using set intersection $\cap f_{epistemic}(w_0, i)$, where this returns the set of worlds compatible with what it is known in w_0 by the individual anchor i.

(Giannakidou and Mari 2016). If the speaker knows p, p has to be true in all worlds in M(i); but the modality requires that p be true only in a subset of M(i) (on the 'weakness' of 'must', see Lassiter, *ibid.*).

With epistemic modals, typically a normative ordering source $\mathcal{S}$ is used. Normality conditions have most notably been discussed in relation with genericity (see Asher and Morreau 1995) and progressives (Dowty 1979; Landman 1992; Portner 1998). Normality conditions are known under the term normality (Asher and Morreau, *ibid.*), inertia (Dowty, *ibid.*) stereotypicality (Portner, 2009) reasonability (Landman *ibid.*, Portner 1998; Mari 2014). The ordering source $\mathcal{S}$ determines a support set, and this is the set of worlds in which *strange things do not happen*, and is stereotypical (Portner 2009).

Consider (38). If I have red cheeks and sneezing nose, then, under stereotypical circumstances, I have the flu. However, circumstances may also be non-sterotypical, in which case such symptoms are indeed not indicative of flu but of a potentially worse disease. When we reason with modal verbs such non-steteotypical worlds are not within the set returned by the function Support$_{\mathcal{S}}$, though they are not excluded from the modal base:

(38) Devo avere l'influenza.
Must.1sg have the-flu.
'I must have the flu.'

Since the modal is non-veridical, the modal base is partitioned into the positive support set for p, on the one hand, and the negative $\neg p$ set, on the other. However, with universal epistemic modals, the speaker is positively biased towards p worlds. The truth conditions, after combination with the lower tense (which will be PRES or PAST; Giannakidou 2009, Giannakidou and Mari 2016) will come out as follows:

(39) *Prepei/dovere/must* (first pass)
At the utterance time t_u, $[\![$prepei/dovere/must(PRES(p))$]\!]^{M,i,\mathcal{S}}$ will be defined if only if:
(i) the modal base M(i) is nonveridical and
(ii) there is a set X, $X =$ Support$_{\mathcal{S}}$(M(i)) and $\mu(X) > \mu$(M(i) $\setminus X$) (*positive bias*);
if defined, $[\![$prepei/dovere/must (PRES(p))$]\!]^{M,i,\mathcal{S}}$ = 1 iff $\forall w' \in$ Support$_{\mathcal{S}}$(M$_i$) $p(w', t_u)$

(39) reflects the ingredients of support and bias that we just established in the earlier section. It states that an epistemic modal has two presuppositions: (i) that the modal base be non veridical and (ii) that there is a Support set in the modal base that is larger than the negative set. In the truth conditions, MUST quantifies universally over the p worlds. We take it that MUST equivalents cross linguistically have this basic lexical entry. Importantly, the support function and bias are lexically triggered by the adverbs, as we argue in 3.1. where we finalize the syntax-semantics.[9]

Finally, a comment on the temporal complement of *prepei/dovere/must*. We see that PRES provides the utterance time t_u, which we standardly understand as an interval referring to the

[9]Greek and Italian are languages that have a single possibility and a single necessity modal. English, on the other hand, has a plethora such as *should, would, will, could, have to, can, may, might, need, might*, etc. The MUST modal that we single out here is the epistemic necessity modal, corresponding to *must, will, should*. Notice that any other lexicalization of necessity (*have to, need*) leans towards deontic readings, which are not the object of study of this paper. Our notion of bias should extend to cover deontic or more generally dynamic modals, but given that in this case we are dealing with different modality, it is expected that the transfer will not be straightforward. And indeed, in the domain of universal deontic modals, one find also NPIs: *You don't have to go, you don't need to go*, recently discussed in Iatridou and Zeijlstra 2013, Homer 2015). Our claim is that universal epistemic modals are the class characterized by positive bias.

utterance *now*. Some authors use n (Abusch 2004, Giannakidou 2009), but we will stick to t_u. Epistemic modals have been known to different temporal orientations determined by the tense they combine with (see, among others, Condoravdi, 2002; Matthewson 2012; Mari, 2015a, Giannakidou and Mari 2012, 2016). Across languages, they have noted to be present (40-a), past (40-b), or future oriented (40-c). The temporal orientation is the relation between the time of evaluation of the modal and the time of evaluation of the prejacent.

(40) a. You must be eating right now
b. You must have seen this movie
c. After his long transatlantic flight, John must/will be really stiff when we gets out of the plane!

Here, we innovate over previous proposals (e.g. Giannakidou, 2009), in that we have explicitly coded present orientation (provided by statives, imperfectives and gerunds) as a PRES (for motivating discussion of this innovation, see Giannakidou and Mari 2016).

Note, moreover, that, when combined with PAST (in English: present perfect), *prepei/dovere/must* take high scope, and we do not obtain a future in the past but an epistemic interpretation:

(41) Giacomo avrà avuto l'influenza.
Giacomo have.3sg.FUT have.past.aprt the-flu.
'Giacomo must have had the flu.'

The truth conditions for PAST sentences, will thus be at follows.

(42) *prepei/dovere/must* with PAST (to be revised).
At the utterance time t_u,
$[\![\text{prepei/dovere/must(PAST}(p))]\!]^{M,i,\mathcal{S}}$ will be defined if only if
(i) the modal base $\text{M}(i)$ is nonveridical and
(ii) there is a set X, $X = \text{Support}_{\mathcal{S}}(\text{M}(i))$ and $\mu(X) > \mu(\text{M}(i) \setminus X)$ (*positive bias*);
$[\![\text{prepei/dovere/must (PAST}(p))]\!]^{M,i,\mathcal{S}}$ = 1 iff $\forall w' \in \text{Support}_{\mathcal{S}}(\text{M}_i) : \exists t' \prec t_u \wedge p(w't')$

The definition is parallel to that with PRES. In sum, we have added to the universal modal the nonveridicality presupposition (which holds for all modals), and the presupposition of positive bias that requires that the positive set be larger than the negative set in the modal base. With this background, let us proceed now to address the role of the adverbs.

3 Modal adverbs as arguments of the verb

The role of the adverbs, we propose, is to supply the overt realization of the bias function. To make this precise, consider first that there are three nuances of strength for the adverbs. We do not claim that these are exhaustive, but they are faithful of the range of possibilities observed in the three languages we are considering.

(43) a. *Definitely* (It. *assolutamente*; Gk. *oposdhipote*): Strongly positive force.
b. *Probably* (It. *probabilmente*; Gk. *mallon*): positive force.
c. *Maybe* (It. *forse*; Gk. *isos*): neutral force, its use with *dovere* indicates hesitation, its appears to weaken the universal modal.

While the semantics of the adverbs can be characterized in an absolute way as above, when they combine with modal verb they appear to *strengthen, weaken* or *preserve* the default positive

bias presupposition of the universal modal, see Table 1.

	definitely	*maybe*	*probably*
must	strengthening	weakening	default
may	strengthening	default	strengthening

Table 1: Modal spread with universal and existential modals

Not all the analytical possibilities are realized in each language, and while default and strenghtening are allowed in all, Italian differs from Greek and English. Our Italian data show that weakening is realized for necessity epistemic modals and strengthening for possibility ones. These two analytical possibilities are not realized in Greek or English. Recall the key examples from section 1:

(44) a. #Bori malon/opsdhipote na efije noris.
May probably/definitely subj left.3sg early
b. Può probabilmente/sicuramente essere partito presto.
Can.3sg.pres probably/certainly be left early.
'#He may have probably/definitely left early.'

(45) a. Le luci sono accese. Gianni deve forse essere a casa.
The lights are switch-on. Gianni must maybe be at home.
b. Ta fora one anamena. O Janis prepei #isos na ine spiti.
The lights are on. The John must (#maybe) be at home.
'The lights are on. John must (#maybe) be at home.'

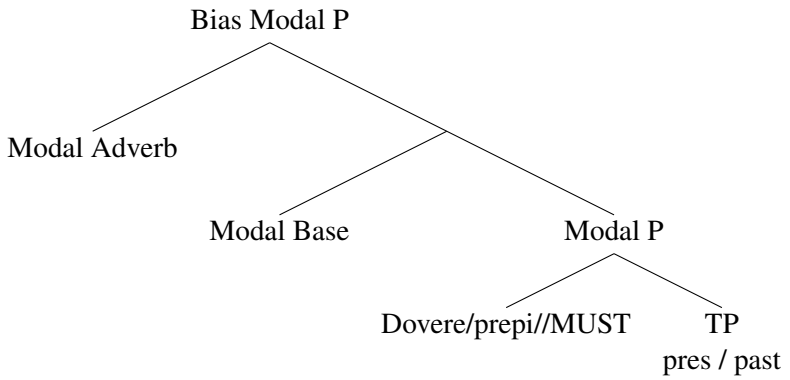
Our idea is the following. The adverb, as a modal element itself, contributes its own presupposition of bias. For uniformity, with no overt adverb, we assume that there is a silent adverb akin to 'probably' contributing this presupposition. With existential modals, the modal itself does not supply Support and bias; by combining the existential modal with an adverb, this function is added (section 3.2).

In the discussion that follows, we use MUST, MAY and *definitely*, *probably*, and *maybe* (with or without italics) as expressions of the metalanguage standing for the universal modals, existential modals and the corresponding adverbs in Greek, English, and Italian.

3.1 Necessity modality and the effect of adverbs

The starting structure plus the adverb is follows:

(46)



This is the structure of 'modal spread', and contains a place where the adverb appears. If no adverb appears, and recalling our earlier definition of *prepei/dovere/must*, we can say that there is a silent adverb, which is represented as $\emptyset$ in (47). This silent adverb hosts the presupposition of positive bias in the default case:

(47) Default specification of bare MUST across Italian, Greek, English.
At the utterance time t_u, $[\![\emptyset$ MUST(PRES $(p))]\!]^{M,i,\mathcal{S}}$ will be defined if only if
(i) the modal base M(i) is nonveridical and
(ii) there is a set X, $X =$ Support$_{\mathcal{S}}$(M(i)) and $\mu(X) > \mu$(M$(i) \setminus X$); if defined,
$[\![\emptyset$ MUST(PRES $(p))]\!]^{M,i,\mathcal{S}}$ = 1 iff $\forall w' \in$ Support$_{\mathcal{S}}$(M$_i$) $p(w', t_u)$

The default configuration is in Figure 1.

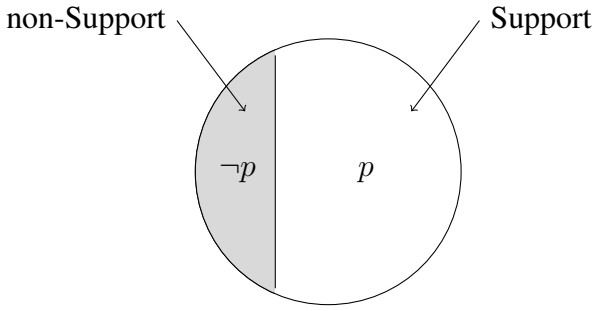


Figure 1: universal epistemic modality (default positive bias)

So, in the bare case, the silent adverb is the host of positive bias, and the epistemic space is partitioned in such a way that the positive set of p worlds is larger than the negative set ($\neg p$ worlds). In our Figures, the Support worlds are white. The canonical syntactic structure of the modal is thus modal spread, and there is a syntactic host for the positive bias presupposition. [10] In other words, the modal MUST has positive bias because its structure contains an adverb that contributes that presupposition.

When an overt adverb is used, it contributes its own presupposition:

(48) $[\![$Probably/mallon/probabilmente $q]\!]^{M,i,\mathcal{S}-adv}$ is defined iff
$\mu\big((\text{M}(i))\big) > \mu\big(\text{M}(i) \setminus (\text{M}(i))\big)$
The Support set in the modal base (p worlds) is larger than the set of non-Support worlds ($\neg p$ worlds).

(49) $[\![$Definitely/oposdhipote/sicuramente $q]\!]^{M,i,\mathcal{S}-adv}$ is defined iff
$\mu\big((\text{M}(i))\big) >> \mu\big(\text{M}(i) \setminus (\text{M}(i))\big)$
The Support set in the modal base (p worlds) is *much* larger ($>>$) than the set of non-Support worlds ($\neg p$ worlds).

(50) $[\![$Maybe/forse/isos $q]\!]^{M,i,\mathcal{S}-adv}$ is defined iff
$\mu\big((\text{M}(i))\big) \approx \mu\big(\text{M}(i) \setminus (\text{M}(i))\big)$
The Support set the modal base (p worlds), is approximately of the same size as the set of non-support worlds ($\neg p$ worlds).

When the universal epistemic modal combines with any of these adverbs, the adverb determines the bias. The adverbs *probably/mallon/probabilmente* are equivalent to the default

[10] Note also that the set of propositions in $\mathcal{S}$ and $\mathcal{S} - adv$ need not be the same (see also Huitink, 2012).

islet adverb, so positive bias is maintained. When the adverb has a stronger bias such *definitely/oposdhipote/sicuramente*, the modal structure has stronger bias. We can view this as the meta-constraint below:

(51) *Modal-Adverb determines the bias*
In a syntactic configuration [Modal-Adverd MODAL q] the bias presupposition is determined by the Modal-Adverb.

We provide below the full combinations pictorially.

(52) At the utterance time t_u,
$[\![$Probably MUST(PRES(p))$]\!]^{M,i,\mathcal{S}-adv}$ will be defined if only if
(i) the modal base M(i) is nonveridical and
(ii) there is a set X, $X =$ Support$_{\mathcal{S}-adv}$(M(i)) and
$\mu(X) > \mu$(M(i) $\setminus X$);
if defined, $[\![$Probably MUST(PRES(p))$]\!]^{M,i,\mathcal{S}-adv}$ = 1 iff
$\forall w' \in$ Support$_{\mathcal{S}-adv}$(M$_i$) : $p(w', t_u)$

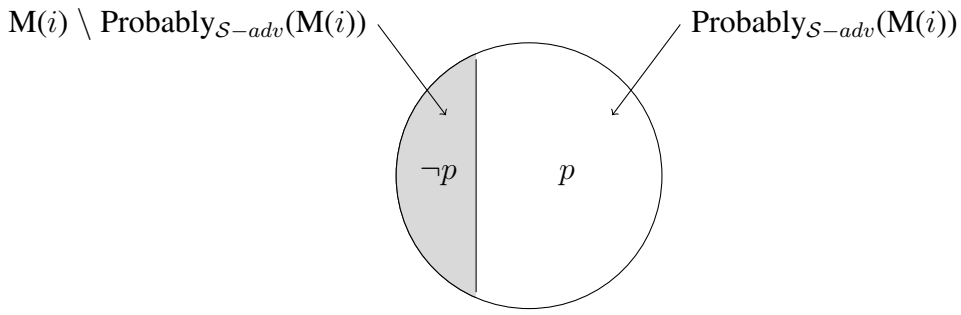


Figure 2: Default *MUST + probably*

When a stronger adverb is used— *definitely, absolutely*— the positive set becomes bigger:

(53) At the utterance time t_u,
$[\![$Definitely MUST(PRES(p))$]\!]^{M,i,\mathcal{S}-adv}$ will be defined if only if
(i) the modal base M(i) is nonveridical and
(ii) there is a set X, $X =$ Support$_{\mathcal{S}-adv}$(M(i)) and
$\mu(X) >> \mu$(M(i) $\setminus X$);
if defined, $[\![$Definitely MUST(PRES(p))$]\!]^{M,i,\mathcal{S}-adv}$ = 1 iff $\forall w' \in$ Support$_{\mathcal{S}-adv}$(M$_i$) : $p(w', t_u)$

We call this, as indicated, *Strengthening the default*. Now consider the combination with a possibility modal. Italian allows the combination of *dovere* with a possibility adverb like *forse*. In this case, the possibility adverb appears to 'cancel' the bias and contributes equilibrium. The modal structure becomes therefore weaker in force:

(54) At the utterance time t_u,
$[\![$Maybe MUST(PRES(p))$]\!]^{M,i,\mathcal{S}-adv}$ will be defined if only if
(i) the modal base M(i) is nonveridical and
(ii) there is a set X, $X =$ Support$_{\mathcal{S}-adv}$(M(i)) and

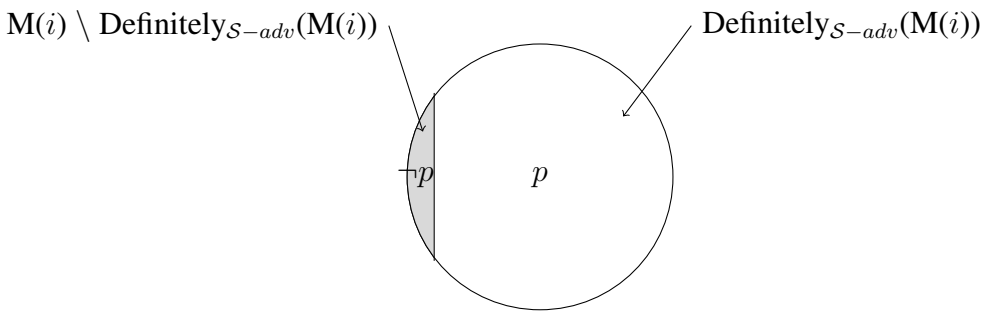


Figure 3: Strengthening the default: *MUST* + *definitely*

$\mu(X) \approx \mu(\text{M}(i) \setminus X)$;
if defined, $[\![\text{maybe MUST(PRES}(p))]\!]^{M,i,\mathcal{S}-adv} = 1$ iff $\forall w' \in \text{Support}_{\mathcal{S}-adv}(\text{M}_i) : p(w', t_u)$

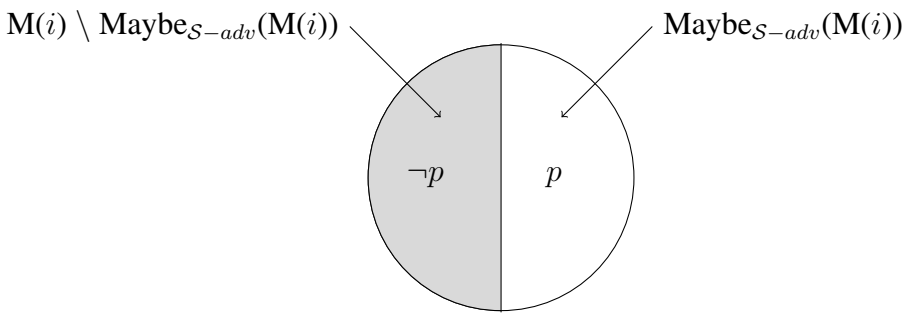


Figure 4: Bias overrule: nonveridical equilibrium *MUST* + *maybe*

We call this *Bias overrule*, and it must be recognized as an option since it exists in Italian. However, it appears to relies on conflict with the default, which expects a positively biased adverb. Bias overrule therefore it is a more marked option, and we expect it to be more constrained as is indeed the case.

To sum up: in our analysis, modal spread emerges not as a redundant or anomalous phenomenon, but as the underlying argument structure of modal verbs. The adverbs are thus an integral component of modality, i.e. specifically the hosts of the bias or equilibrium. When adverbs are used without modals (*Ariadne probably left*), the null hypothesis is that the structure is still the same, i.e. with an implicit modal. Importantly, no rules of concord were needed in our discussion above.

We close the discussion of MUST with two syntactic observations. First, the adverbs cannot be separated from the verb:

(55) a. #Gianni deve non sicuramente essere qui.
Gianni must not certainly be here.

The adverb and the modal verb cannot be separated because our syntactic structure renders the adverb an argument of the verb.[11] On the other hand, adverbs appear in embedded clauses under higher attitude verbs:

[11] One could try to rescue the above by *non sicuramente*, but this would create a contradiction.

(56) Credo che Maria è certamente/forse a casa.
believe.1SG.PRES that Maria is maybe/certainly at home.
I believe that Maria maybe/certainly is at home.

(57) Pistevo oti i Maria isos/sigoura ine sto spiti.
believe.1SG.PRES that the Maria maybe/certainly is at home.
I believe that Maria maybe/certainly is at home.

Importantly, they can't move above the attitude verb:

(58) #Forse/Certamente, credo che Maria e a casa.
Maybe/certainly believe that Maria is at home.
Maybe, certainly, I believe that Maria is at home.

(59) #Isos/sigoura, pistevo oti i Maria ine sto spiti.
Maybe/certainly, believe.1SG.PRES that Maria is at home.
Maybe, certainly, I believe that the Maria is at home.

This suggests that in the embedded position the adverbs are interpreted as local modal structures, i.e. as embedded MUST or MIGHT (see Anand and Hacquard 2013 for a recent discussion). Embedded occurrences challenge the potential of an analysis of modal adverbs as contributing at the non at-issue level (e.g., in the spirit of Mayol and Castroviejo-Miró 2013).

Let us move on now to show how our analysis captures the possibility modals. Recall that these are not NPIs, and can scope below negation (*Ariadne might not be a doctor, Ariadne cannot be doctor*).

3.2 Possibility modality

The truth conditions for possibility modals in the system we outlined above are as follows.

(60) At the utterance time t_u,
$[\![$*bori/potere/might(PRES* $(p))]\!]^{M,i}$ will be defined if only if
(i) the modal base M(i) is nonveridical;
(ii) $\exists X \subset$ M(i) s.t. $\mu(X) \approx \mu$(M(i) $\setminus X$) (nonveridical equilibrium)
if defined, $[\![$MIGHT(PRES $(p))]\!]^{M,i}$ = 1 iff $\forall w' \in X s.t.\ X \subset$ M(i) $p(w', t_u)$

The modal base is partitioned between p and $\neg p$ worlds, with no ordering (note the absence of a white area, see Figure 5). Existential modals carry a presupposition of nonveridical equilibrium.

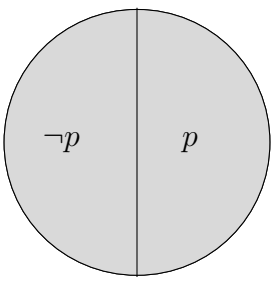


Figure 5: Bare existential modal: nonveridical equilibrium

The possibility modal contains a positive set of worlds $X \subset$ M(i), where p is true. Unlike with the universal modal, however, the set X is not the output of a selection function, and there is no ordering (or, null ordering source, as is sometimes assumed). Importantly, the relation between the positive and the negative set is now $\approx$ which gives nonveridical equilibrium. In this semantics, the lexical difference between a universal modal and an existential one becomes a difference not in quantificational force, but in presupposition— which establishes the nature of the relation between the positive and the negative set. When the relation is $\approx$, it produces equilibrium and we have existential modals, but when it is >, the modal has positive bias presupposition, and this spells out as necessity. In other words, the presupposition of $\approx$ and > distinguishes between universal and existential modals respectively.

Our analysis is reminiscent of Klinedinst 2005, and Matthweson et al. 2007, who give the lexical entry below. Matthewson et al. (*ibid.*) use this entry and posit a choice function to account for the force shift (universal or existential) of what appears to be a single lexical modal verb in Salish.

(61) Modal(p) is true with respect to a modal base B and a possible world w iff:
$\exists W[W \subseteq B(w) \wedge W \neq \emptyset \wedge \forall w'[w' \in W \rightarrow p(w')]$

In English, Greek, and Italian, unlike in Salish, there is a lexical difference between a possibility and a necessity modal, but the similarity in terms of idea is clear. For one thing, if the difference between an existential and a universal modal is in the presupposition, as we are arguing, then Salish emerges, in our system, as a language that possesses a modal with no presupposition. Implicit adverbs can subsequently be seen as realizations of the choice function by manipulating the size of the support set– but the manipulation is expected to be free in a language like Salish.

We assume, as with the universal modal, that a silent adverb hosts the (now equilibrium) presupposition of *bori/potere/might*. Now, recall the presuppositions of the adverbs from our earlier discussion:

(62) $[\![\text{Probably } q]\!]^{M,i,\mathcal{S}-adv}$ is defined iff
$\mu\big((\text{M}(i))\big) > \mu\big(\text{M}(i) \setminus (\text{M}(i))\big)$
The Support set in the modal base (p worlds) is larger than the set of non-Support worlds ($\neg p$ worlds).

(63) $[\![\text{Definitely } q]\!]^{M,i,\mathcal{S}-adv}$ is defined iff
$\mu\big((\text{M}(i))\big) >> \mu\big(\text{M}(i) \setminus (\text{M}(i))\big)$
The Support set in the modal base (p worlds) is *much* larger ($>>$) than the set of non-Support worlds ($\neg p$ worlds).

(64) $[\![\text{Force/Maybe } q]\!]^{M,i,\mathcal{S}-adv}$ is defined iff
$\mu\big((\text{M}(i))\big) \approx \mu\big(\text{M}(i) \setminus (\text{M}(i))\big)$
The Support set the modal base (p worlds), is approximately of the same size as the set of non-support worlds ($\neg p$ worlds).

With the addition of *maybe*, we obtain (65). We use MIGHT as the label for *bori/potere/might*. The combination maintains the default, which now is non-veridical equilibrium. With possibility modals, *maybe* has no effect on the equilibrium, since it returns a modal base equally partitioned between p worlds and $\neg p$ worlds. The only effect of the adverb is to contribute (possibly) a different set of propositions $\mathcal{S}$ than those already used to determine the modal base. Such a set, however, does not affect the equilibrium. Given the definedness conditions for *forse/maybe*, we obtain the configuration depicted in Figure 6.

(65) At the utterance time t_u,
$[\![\text{Maybe MIGHT(PRES}(p))]\!]^{M,i,\mathcal{S}-adv}$ will be defined if and only if (i) the modal base M(i) is nonveridical;
(ii) there is a set X, $X = \text{Support}_{\mathcal{S}}(\text{M}(i))$ and $\mu(X) \approx \mu(\text{M}(i) \setminus X)$; if defined,
$[\![\text{Maybe MIGHT(PRES}(p))]\!]^{M,i,\mathcal{S}-adv}$ = 1 iff $\forall w' \in \text{Support}_{\mathcal{S}-adv}(\text{M}(i))$: $p(w', t_u)$

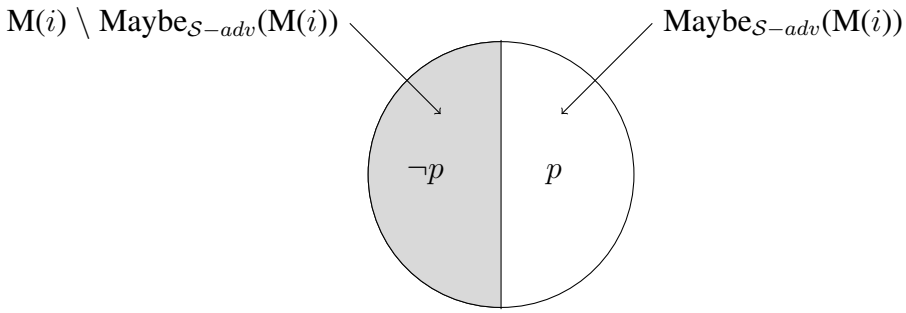


Figure 6: Maintaining the default: *MIGHT* + *maybe*

As mentioned earlier, possibility modals are only compatible with possibility adverbs in Greek, but Italian allows also stronger adverbs . Let us recall the essential data here.

(66) a. #Bori malon na ine giatros.
May probably subj be.3sg doctor
b. Può probabilmente/sicuramente essere un dottore.
May.3sg.pres probably/certainly be a doctor.
'He may probably be a doctor.'

In other words, Italian just as it allows for default weakening (Bias overrule) with the necessity modal, it also allows *default strengthening* of the possibility modal (66-b).

(67) At the utterance time t_u,
$[\![\text{Probably MIGHT(PRES}(p))]\!]^{M,i,\mathcal{S}-adv}$ will be defined if and only if
(i) the modal base Mi is nonveridical;
(ii) there is a set X, $X = \text{Support}_{\mathcal{S}}(\text{M}(i))$ and
$\mu(X) > \mu(\text{M}(i) \setminus X)$;
if defined,
$[\![\text{Probably MIGHT(PRES}(p))]\!]^{M,i,\mathcal{S}-adv}$ = 1 iff $\forall w' \in \text{Support}_{\mathcal{S}-adv}(\text{M}(i)) : p(w', t_u)$

The strong adverb here overrules the default equilibrium and creates positive bias, i.e. it returns a Support set larger than the negative set. Default strengthening is the dual of default overrule that we observed when a possibility adverb modified MUST in Italian.

Having made explicit all crucial details we go back now to the positive polarity property, and discuss our predictions about the interaction with negation and positive bias.

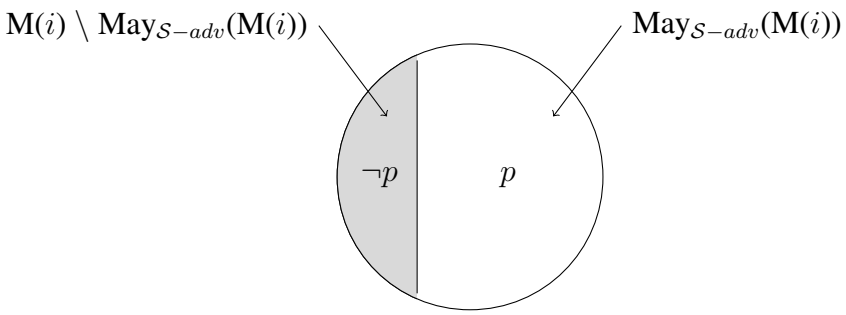


Figure 7: Default strengthening: *MIGHT* + *probably*

4 Back to the PPI property: why not negative bias with universal modals and adverbs?

A central aspect of our proposal is that epistemic universal modal verbs and adverbs have positive bias. This determines a default where the prejacent p-set is larger than the non-p set. In the general case the default can only be preserved or strengthened by the adverbs, and in the worst case, it reaches equilibrium. Crucially, the positive bias survives, as expected, by negation:

(68) Gianni non deve essere a casa.
Gianni not must be at home.
'Gianni must not be at home.'

The presupposition of this sentence still is that the size of the worlds where the prejacent is true is greater than the size of worlds where the prejacent is not true. This translates syntactically into having the modality scope above negation; therefore presupposition and scope are isomorphic, and this forces *must (John not be at home)* to be the only possible interpretation of the sentence. In this configuration, the speaker is positively biased towards the negative proposition since this is now the prejacent. The configuration obtained is thus the following.

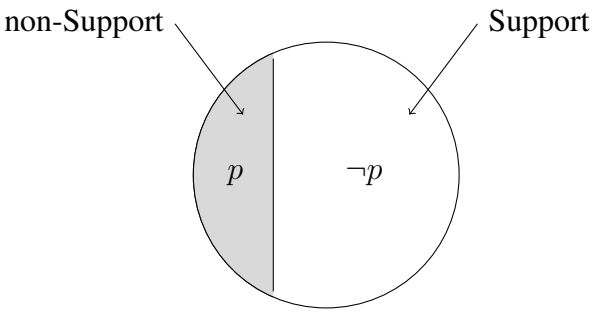


Figure 8: Positive bias with negation - Deriving PPI

So even with negation, the positive bias survives and is reflected in syntax as the wide scope above negation. But, here is a conceptual question: **Why isn't is possible to find an adverb capable of pushing the equilibrium line to the direction of enlarging the $\neg p$ worlds?** The analytical possibility is given in (69):

(69) $[\![\text{Negative bias Adv } p]\!]^{M,i,\mathcal{S}-adv}$ is defined iff
$\mu\big(\text{Negative bias-Adverb}_{\mathcal{S}-adv}(\text{M}(i))\big) < \mu\big(\text{M}(i) \setminus \text{Negative bias-Adverb}_{\mathcal{S}-adv}(\text{M}(i))\big)$
The set of Support worlds (p worlds) in the modal base is smaller than the set of non-Support worlds ($\neg p$ worlds), given the set of propositions $\mathcal{S}$.

The configuration that one would expect is depicted in Figure 9.

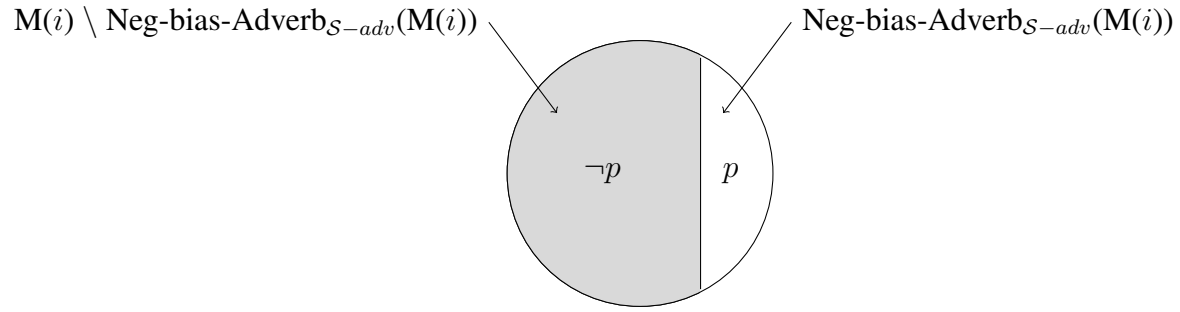


Figure 9: Hypothetical Negative Bias-Adverb

Why is this type of adverb ruled out? More broadly, why isn't there a negative version of a universal modal like UN-MUST? Recall, as we noted at the beginning, that there literally are no lexicalizations of adverbs or modal verbs with a meaning like this, i.e there are no Greek or Italian lexicalizations of *un-must, un-probably, un-definitely*.[12] Negative bias epistemic adverbs would be the duals of the positive manipulators of the Support set, and it is pretty clear at this point that such adverbs do not exist. One could argue that English *unlikely* might be one of these, but note three things. First, *unlikely* is not, strictly speaking an adverb; it both a predicate and an adverb. Second, we see that it is incompatible with *must*.[13]

(71) #John must unlikely be at home.

The sentence is rather odd. Third, Greek and Italian do not have lexical equivalents to *likely, unlikely*. The same holds for universal epistemic modals: there is simply no *un-must, un-should, un-ought* in English, and no such counterparts in Greek or English. So, indeed we can generalize that necessity epistemic verbs and adverbs, as a class, are characterized by positive bias. This is reflected in their lexicalization with a silent adverb contributing bias that we suggested; and it is because of positive bias that they are PPIs.

In two recent papers (Iatridou and Zeijlstra 2013, and Homer 2015), it has been claimed that deontic modals, in contrast to epistemic universals, scope above or below negation, and that existential modals can also scope below, regardless of flavor (epistemic or deontic):

(72) a. Ariadne may not be a doctor.

[12]Though we do find *improbable, unnecessary, indefinite* as adjectives. This is a very different construal, however, since it does not involve sentential modality. We will refrain from making any generalizations about the modal predicates; but see Nilsen 2004 for some initial observations that they differ from their adverbial counterparts.

[13]In Italian, there is the adverb *inverosimilmente*, which, at first glance appears to combine with *dovere*:

(70) Gianni deve inverosimilmente essere a casa.
John must unlikely be at home.
'#John must unlikely be at home.'

However, *inverosimilmente* is not an epistemic adverb, but metaphysical.

b. Ariadne may not talk to Dean.
c. Ariadne doesn't have to be a doctor (to apply for this job).
d. Ariadne does't need to have a lot of money.

These are all scopings inside negation. The former two, with the possibility modals, are epistemic, and the modal is inside the scope of negation. The latter two, with necessity modals, are *not* epistemic. Iatridou and Zeijlstra (*ibid.*) specifically make the claim that universal epistemic modals cannot be NPIs syntactically, and our idea of positive bias gives a semantic explanation for this syntactic behavior. Therefore, we conclude that the positive bias of necessity epistemic modals is a very basic property of this lexical category, and responsible both for their PPI status and for the fact that there are no modal adverbs with tis force that are negative.

Crucially, in the expected scoping above negation we have *positive bias towards the negative sentence*, since this is now the argument of epistemic MUST:

(73) Ariadne must probably not be a doctor (= MUST (Ariadne not be a doctor)).

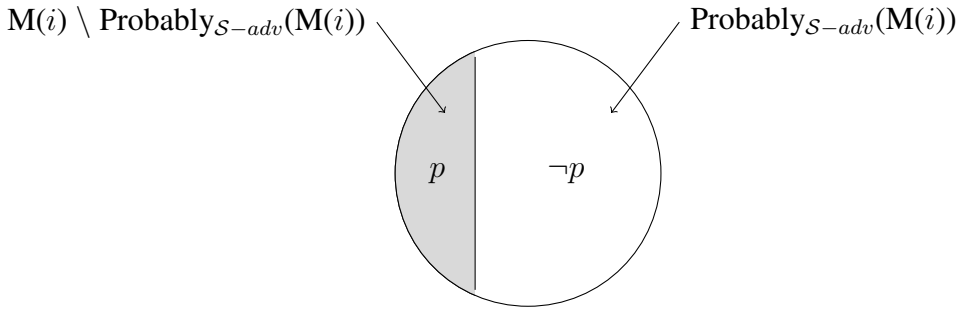


Figure 10: Modal concord *MUST + probably*

In sum, once the modal and adverb deliver a complete meaning at the level of the core modal structure, the bias can no longer be manipulated. Tolerance and some deviation from the default is negotiated internally to the modal meaning, but overwriting of the default is not allowed outside of the modal structure itself.

Our analysis thus derives necessity epistemics as always having positive bias, and predicts their correct scope behavior and PPI status wrt negation. Existential modals, on the other hand, are not characterized by bias but by nonveridical equilibrium. Equilibrium makes no prediction of PPI behavior, and this is consistent with the observations in the literature about the scope of possibility modals, namely that they can appear inside the scope of negation.

5 Comparison with previous approaches

In our analysis, modal spread doesn't have to do with concord or harmony. Nevertheless, our idea that the adverb is an argument of the modal verb brings us close in spirit to Huitink 2012, who has the insight that adverbs manipulate the ordering source. Huitink's proposal, without going into the formal details, can be summarized by the following trees (items (55) and (56) in Huitink, 2012).

According to Huitink, an adverb like *obligatorily* denotes a set of propositions that directly acts as the ordering source. There is no notion of strength in Huitink's analysis, which focuses instead on distinguishing "concord" from "disruption of concord". Our analysis allows us to

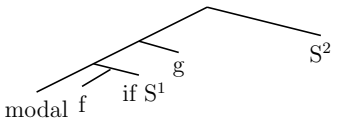


Figure 11: Modal skeleton - Huitink, 2012

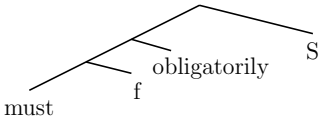


Figure 12: Adverbs provide the ordering source - Huitink, 2012

cover both cases by using the same mechanism. By employing Support functions, we can account for the flexibility of the combinations of modal verbs with a larger range of adverbs, with no extra machinery. In this respect, our analysis is also simpler than Grosz (2010). Grosz analyzes modal verbs operators over degrees, which map their prejacents into sets of degrees on a scale of necessity. In this setting, adverbs denote the endpoints of scales (see also discussion in Huitink, 2012). Our account does not use the extra device of degrees and is thus simpler.

In addition to the above accounts (including ours) which are semantic, there is also a pragmatic line of analysis, mostly coming from the literature on evaluative adverbs. This line of analysis goes back to Bonami and Godard (2008) for Romance languages and indirectly to Ernst (2009) for English. Mayol and Castroviejo-Miró (2013), following Bonami and Godard (*ibid.*), pursue the evaluative analysis in the sense of of conventional implicature (Potts 2005, 2007), and propose that evaluative adverbs contribute non-propositional content, and are in essence operators that modify the felicity conditions of the utterance (see also Wolf, 2013).

(74) Projective tier: force operator(ϕ) $\wedge$ $p \rightarrow$ unfortunate(p), where p is the proposition the speaker is biased toward. (Majol and Castroviejo-Miró, 2013, item (86))

Recall that modal adverbs occur in embedded clauses (59) (repeated in (75)).

(75) Credo che Maria deve forse/certamente essere a casa.
believe.1SG.PRES that Maria must maybe/certainly be at home.
I believe that Maria must maybe/certainly be at home.

If the modal adverbs were force operators, we would not expect them to be interpreted within the embedded clause. This leads us to reject the pragmatic analysis for modal adverbs– even if needed for the class of purely evaluative adverbs (*sadly, unfortunately, curiously*). It is, finally, important to note that purely evaluative adverbs range from positive to negative (unfortunately, sadly, etc)– and this is in sharp contrast to the epistemic modal adverbs which are lexically positive. This gives us one more reason to think that modal adverbs cannot be reduced to the purely evaluative ones.

6 Conclusions

In this paper, we started with the common observation that epistemic modal adverbs are PPIs. We decided to study their behavior by examining modal spread— a phenomenon which, like all spread or concord phenomena in language, appears to be redundant or even anomalous, since we have two apparent modal operators being interpreted as a single modality. We made the following claims. First, the nonveridical modal base of all modals includes a positive set of p-worlds, and all modals universally quantify over that set. Second, the modal base is either in equilibrium (existential, possibility modals) or in positive bias (universal, necessity modals). The adverbs are arguments of the verb whose function is to manipulate the size of the positive set. In this analysis, modal spread emerges not as a redundancy, but as explicitly realizing the additional argument of modals. Our analysis thus makes the adverbs an integral component of modality— and modal spread is the canonical structure of modality even if one piece (the adverb or the verb) is missing. At the same time, the positive polarity property is derived as a syntactic reflex of the semantic positive bias of universal modals. Crucially, possibility modals are in nonveridical equilibrium, and are not blocked in the scope of negation.

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