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# Quantifiers for a Modal Future

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**ABSTRACT**

Future auxiliaries present a challenge to the classical analysis of modal expressions as existential or universal quantifiers over a contextually provided set of possible worlds: these expressions come with a distinct modal flavor, but their interaction with negation and the fact that future judgments come in degrees of confidence is unexpected if the classical analysis were correct. I show how a uniform quantifier analysis of modal expressions can accommodate the distinct empirical phenomena surrounding future auxiliaries. The resulting analysis extends to address a set of related challenges that have been observed for a quantifier analysis of ability modals.

## 1 | The Plot

A popular exercise in the literature on philosophy of language is to identify modal expressions that seemingly resist a classical analysis as existential or universal quantifiers over a contextually provided set of possible worlds.[1] Take the English future auxiliaries *will*, *shall*, and *going to*: these expressions come, by (almost) all available accounts, with a distinct modal flavor,[2] and yet it is anything but transparent how they could be existential or universal quantifiers over possible worlds. For starters, *will* appears to be "scopeless" with respect to negation, in the sense that cases such as (1a) and (1b) ring equivalent[3]:

(1) a. The butler will not do it.
b. It is not the case that the butler will do it.

Ordinary modals, in contrast, do enter into nontrivial scope relations with negation. Take epistemic *must* and *might*:

(2) a. It must not be the butler who did it.
b. It is not the case that it must be the butler who did it.
c. It does not have to be the butler who did it.

(3) a. It might not be the butler who did it.
b. It is not the case that it might be the butler who did it.
c. It cannot be the butler who did it.

In both cases, we detect scope interactions between the modal and the negation operator. (2a), to wit, rules out the butler as the culprit; in contrast, (2b), paraphrased in (2c), merely suggests that we cannot be certain that it was the butler. Similarly, (3a) says that the butler might be innocent, while (3b), paraphrased in (3c), says that the butler must be innocent. And this is just how things should be, if the modals at play are universal or existential quantifiers.

Graded modal judgments pose another puzzle for any attempt to fit *will* into a standard modal mold (Cariani and Santorio 2018; Cariani 2021). Take a future contingent such as (4):

(4) The die will come up 1.

Assuming we are concerned with a fair six-sided die, it is natural to think that (4) has a nonzero probability of being true. That is hard to explain if we adopt the canonical view that *will* is a universal quantifier over a suitably restricted set of possible worlds, for example, the ways the future could unfold that are most likely (Kaufmann 2005) or maximally normal (Copley 2009).[4] On all of these views, it seems plain certain that the die does not come up 1 at *all* worlds in the modal domain, as there is simply no reason why worlds at which the die (say) comes up 2 should be less likely or normal than ones at which the die comes up 1. So how could *will* be a necessity modal and still have nontrivial probability?[5]

Data like these provide reason to ditch the classical approach to modals in favor of a SELECTION FUNCTION SEMANTICS for future auxiliaries (Cariani and Santorio 2018; Cariani 2021).[6] Indeed, similar data play a pivotal role in the debate between proponents of a selection function semantics for conditionals and those who prefer to think of conditionals as universal quantifiers over possible worlds.[7] According to the latter, conditionals are STRICT in the sense that "If *A*, *C*" is true just in case *C* is true at all the contextually relevant *A*-worlds. But that makes it a bit of a mystery why negation seems scopeless with respect to *if*, as highlighted by the apparent equivalence of (5a) and (5b):

(5) a. If John took the exam, he did not pass.
    b. It is not the case that if John took the exam, he passed.

Specifically, if conditionals are strict, the mere possibility of John's failing the test seems sufficient to license the negation of "If John took the exam, he passed" and so (5b) does not entail (5a).

Similarly, it is natural to assign to a conditional such as (6) a nontrivial probability, assuming that the die under consideration is fair. Yet a strict analysis renders (6) certainly false, for certainly the die did not come up 1 at *all* contextually relevant worlds at which it came up odd (it might have come up 3, for instance).[8]

(6) If the die came up odd, it came up 1.

It is well established that the facts about (5) and (6) work out smoothly in a selection function semantics for *if*.

A selection function semantics for conditionals treats "If *A*, *C*" as true at *w* just in case *C* is true at the antedent-verifying world that is selected as "most similar" to *w*. Likewise, a selection function semantics for future auxiliaries treats "The butler will do it" as true at *w* just in case the butler does the deed at the world selected as most similar to *w* from the set of its historical alternatives (i.e., those worlds that have the same past as *w*). Since the butler either does or does not do the deed at the world thus selected, *will* is scopeless with respect to negation. And given that every world is most similar to itself, we expect the probability of a prediction such as (4) to be nontrivial, assuming that its prejacent is true at some but not all worlds that are deemed possible in context.

My goal here is to show how the classical analysis of modals as existential or universal quantifiers can capture the data surrounding future auxiliaries.[9] Doing so is not to deny the attractions of a selection function semantics for predictive expressions, but it has the distinct advantage of preserving a uniform outlook on natural language modality, not least because there is little temptation to go for a selection function semantics when it comes to ordinary modal expressions such as epistemic *might* and *must*.

The plan is as follows. Section 2 addresses the scopelessness issue for future auxiliaries and explains the contrast with other modals just in the way one would expect from a fully general account of natural language modality, viz. in terms of structural differences between various modal domains of quantification. This itself is not enough to allow for nontrivial credences in predictive constructions, but Section 3 explains what will do the trick. Section 4 ties up some loose ends. The concluding Section 5 highlights the explanatory potential of the framework by showing how it deflects yet another case against a quantifier analysis and in favor of a selection function analysis of natural language modality.

## 2 | Negating Future Auxiliaries

Modals, so the hypothesis I will pursue here goes, are universal or existential quantifiers over sets of possible worlds; such sets are effectively information carriers—some ways the world could be are ruled out, others ruled in—and so we will sometimes speak here of modals as quantifiers over STATES OF INFORMATION. This hypothesis, I said, leads us to expect that modals enter into nontrivial scope relations with negation. But there is a twist: whenever the states quantified over are maximally opinionated—rule in or rule out every proposition—negated universals amount to universal negations and vice versa. Pedantic as that point may be, I suggest it is the first step toward a successful quantifier analysis of *will*: in evaluating a *will*-claim, we are, in effect, entertaining maximally opinionated states of information; for ordinary modals, in contrast, a domain of quantification may be less opinionated, leaving room for nontrivial scope interactions with negation. In other words, "The butler will be the culprit" and "The butler must be the culprit" are both of the form $\ulcorner\Box\phi\urcorner$ and *still* we can capture the former's distinct interaction with negation, given minimal assumptions about the modal domain for future auxiliaries. Let me explain.

Begin with an intuitive case for a *non-modal* analysis of future auxiliaries. Run-of-the-mill necessity modals such as epistemic *must* and deontic *ought* ask, at their core, whether their prejacent is entailed by some contextually salient corpus—a set of epistemically possible propositions, a set of norms, or what have you. But, one may continue, a prediction such as "The butler will do it" is not obviously corpus-sensitive in the same way: it is simply concerned with how things play out in the actual world. That consideration favors the idea that the semantic contribution of a future auxiliary is a mere shift of temporal orientation: just as "There was a sea battle" locates some sea battle in the past, so "There will be a sea battle" locates it in the future. But the argument is not irresistible, and a modal analysis of *will* that appeals to a selection function semantics à la Cariani and Santorio (2018) and Cariani (2021) shows why: if the world selected just is the world of evaluation *w*, a *will*-claim at *w* amounts to checking whether the prejacent is true at *w*. So, a modal analysis of *will* is in principle perfectly compatible with the fact that (unembedded) predictive judgments are "about" the actual world.

The key additional observation now is that nothing about the defensive maneuver I have just outlined depends on the choice of a modal selection function analysis of future auxiliaries. Taking Stalnaker's (1968) remark that a possible world is the ontological analogue of an information carrier as an inspiration, we may just as well say that future auxiliaries are modal expressions alright but are interpreted in light of a "totally realistic" conversational background:[10] the corpus relevant for evaluating a prediction at some world *w* is the set of all and only those propositions that are true at *w*. That makes *will* at *w* a universal quantifier over $\{w\}$ and so of course "$will(p)$" effectively requires that *p* be among the propositions true at *w*. Scopelessness follows straightaway for whenever *p* fails to be included among the propositions true at

$w$, the negation of $p$ must be included and so "$\neg will(p)$" and "$will(\neg p)$" are equivalent. Given minimal assumptions about the modal domain for future auxiliaries, a quantifier analysis of *will* is compatible with the fact that (unembedded) predictive judgments are "about" the actual world.

The key wrinkle for a quantified analysis of future auxiliaries as I am envisioning it here is that—in ordinary conversations anyway—there are multiple candidates for being the actual world and so the quantifier domain for *will* is underdetermined. The natural suggestion then is to evaluate predictive expressions by SUPERVALUATING over the (maximally opinionated) quantifier domains corresponding to each live candidate for being the actual world in context. While existential and universal quantification collapse against a totally realistic conversational background, the fact that we end up supervaluating over a set of quantifier domains provides *will*-statements—and their negations—with genuine universal quantificational force. Let me now spell out the proposal in more detail. (I defer discussing the issue of how to account for the temporal orientation of future auxiliaries to Section 4.)

Our target language $\mathcal{L}$ is a standard propositional language extended with a set of necessity and possibility modals "$\Box_f$" and "$\Diamond_f$," with the subscript indicating the modal flavor (epistemic, deontic, and so on); $\mathcal{L}_0$ is the nonmodal fragment of $\mathcal{L}$. The proposal has two critical components: a mechanism for determining MODAL QUANTIFIER DOMAINS and a BILATERAL setting to articulate the proposed semantic entries for modal constructions and their negations. Modal quantifier domains, I shall assume, are provided by context and capture the "flavor" of the modality in question. The key idea, recall, is that all modals are quantifiers over information carriers (sets of possible worlds)—it is just that future *will*, but not (say) epistemic *must*, quantifies over *maximally opinionated* information carriers. To model this idea, I shall make a somewhat nonclassical move and let the conversational background determine a *set of propositions* as the MODAL DOMAIN; modals quantify over sets of possible worlds that are *derived* from such modal domains using choice functions.

**Choice Function**. A *choice function* $\gamma$ on some collection $X$ of nonempty sets assigns to each set $x$ in that collection some element $\gamma(x)$ of $x$.

**Specification**. A set of worlds $u$ is a *specification* of a set of sets of worlds $X$, $u \rhd X$, just in case there is a choice function $\gamma$ on $X$ such that $u = \{z : \exists x \in X.\gamma(x) = z\}$.

In words, a specification of a set of propositions is simply the result of gathering one possible world from each proposition in that set.

If modals quantify over specifications of a set of propositions, there will sometimes be no *unique* set of possible worlds to quantify over. The natural step is then to evaluate modals by SUPERVALUATING over the relevant specifications of their modal domains: necessity modals require that their prejacent be *entailed* by every such specification, possibility modals that their prejacent be *compatible* with every such specification. To make this precise, we go for a BILATERAL semantic setting, and we give that setting a DYNAMIC spin by specifying a positive, acceptance inducing and a negative, rejection inducing update function.[11] (A truth-conditional spin would do as well—more on this in Subsection 4.4—but the key ideas of the proposal are naturally articulated in a dynamic setting.) The basic semantic entries (for a standard modal propositional language) look as follows:

(7) a. $s[p]^+ = \{w \in s : w(p) = 1\}$
b. $s[p]^- = \{w \in s : w(p) = 0\}$

(8) a. $s[\neg\phi]^+ = s[\phi]^-$
b. $s[\neg\phi]^- = s[\phi]^+$

(9) a. $s[\phi \wedge \psi]^+ = s[\phi]^+ \cap s[\psi]^+$
b. $s[\phi \wedge \psi]^- = s[\phi]^- \cup s[\psi]^-$

A positive update with $p$ eliminates from an input state $s$ all possible worlds at which $p$ is false, while a negative update with $p$ eliminates all possible worlds at which $p$ is true. A positive update with $\ulcorner\neg\phi\urcorner$ is a negative update with $\phi$, and a negative update with $\ulcorner\neg\phi\urcorner$ is a positive update with $\phi$. Conjunction is set intersection; the negative update rule for conjunction thus makes disjunction set union, given its usual definition in terms of conjunction and negation.[12] To introduce a bit of terminology: $s$ accepts $\phi$, $s \Vdash^+ \phi$, just in case $s[\phi|^+ = s$; $s$ rejects $\phi$, $s \Vdash^- \phi$, just in case $s[\phi|^- = s$.

The entries in (7)–(9) are not very interesting but the bilateral setting allows us to articulate the earlier stated semantic proposal for necessity and possibility modals.

(10) a. $s[\Box_f\phi]^+ = \{w \in s : \forall u \rhd f(s).u[\phi]^+ = u\}$
b. $s[\Box_f\phi]^- = \{w \in s : \forall u \rhd f(s).u[\phi]^- \neq \emptyset\}$

Modals come with acceptance or rejection conditions: for a necessity claim to be accepted, every specification of the modal domain must entail the prejacent; for it to be rejected, the negation of the prejacent must be compatible with every such specification. A modal update returns the input state if the relevant acceptance or rejection condition is met, and the absurd state ($\emptyset$) otherwise.

Assuming that necessity and possibility modals are duals, we get:

(11) a. $s[\Diamond_f\phi]^+ = \{w \in s : \forall u \rhd f(s).u[\phi]^+ \neq \emptyset\}$
b. $s[\Diamond_f\phi]^- = \{w \in s : \forall u \rhd f(s).u[\phi]^- = u\}$

This is straightforward: for a possibility modal to be accepted (rejected), its prejacent must be compatible (incompatible) with every set of possible worlds specifying the modal domain.

Following standard protocol, we explain differences in modal flavor in terms of differences between the modal selection functions at work so that, for instance, epistemic modals quantify over a set of worlds that is "best" in terms of stereotypicality, while deontic modals quantify over worlds that are normatively ideal. But the current setup allows us to do a bit more: future auxiliaries, recall, differ from other modals such as epistemic *must* in that the former, but not the latter, are scopeless with respect to negation. That raises the question of how *will* could be a (universal) quantifier to begin with, but we can now propose to

explain the contrast in terms of how the modal domain for *will* contrasts with the ones for other modals. Observe the following two facts:

**Fact 1** Let $f$ be a mapping from an information carrier to modal domains: if $f(s) = \{t\}$ for some proposition $t$, then $\{u : u \rhd f(s)\} = \{\{w\} : w \in t\}$; and if $f(s) = \{\{w\} : w \in t\}$, then $\{u : u \rhd f(s)\} = \{t\}$.

This just follows from the definition of a specification.

**Fact 2** Suppose that $f(s) = \{t\}$ for some proposition $t$, then $s[\neg\Box_f\phi]^+ = s[\Box_f\neg\phi]^+$.

To see this, simply note that $s[\neg\Box_f\phi]^+ = s[\Box_f\phi]^- = \{w \in s : \forall u \rhd f(s).u[\phi]^- \neq \emptyset\} = \{w \in s : \forall u \rhd f(s).u[\neg\phi]^+ \neq \emptyset\}$; furthermore, if $f(s) = \{t\}$, then $u \rhd f(s)$ just in case $u = \{w\}$ for some $w \in t$. Now, since updating is "eliminative" in the sense that $s[\phi]^+ \subseteq s$ for all $s$ and $\phi$, $\{w\}[\neg\phi]^+ \neq \emptyset$ just in case $\{w\}[\neg\phi]^+ = \{w\}$ for all $w$, and so we have $\{w \in s : \forall u \rhd f(s).u[\neg\phi]^+ \neq \emptyset\} = \{w \in s : \forall u \rhd f(s).u[\neg\phi]^+ = u\} = s[\Box_f\neg\phi]^+$, which establishes the result. So, negation is scopeless with respect to necessity modals whose modal domain is a singleton set.

The simple proposal then is that the modal domain for future auxiliaries such as *will* is a singleton set while the one for epistemic and deontic *must* is not. Specifically, we shall say for now:

**Modal Selection Functions (v.1)**. Let $\mu$ and $\epsilon$ be the selection function for future auxiliaries and epistemic modals, respectively: then for all information carriers $s$, $\mu(s) = \{s\}$ and $\epsilon(s) = \{\{w\} : w \in s\}$.

What matters here, really, is the hypothesis that *will* and its negation receive a totally realistic interpretation; they quantify over maximally opinionated specifications of $\{s\}$ and their universal force, I have suggested, stems from the fact that context does not settle a unique domain of quantification for future auxiliaries. Epistemic *must*, in contrast, quantifies over a set of possible worlds that is, in general anyway, uniquely determined in context; as long as the domain does not settle every question, we expect there to be nontrivial scope interactions with negation. Even from a perspective that analyzes modals as quantifiers across the board, then, it is no surprise that negation is scopeless with respect to future auxiliaries but not with respect to ordinary modals.[13]

Modals, I have said, are evaluated for acceptance or rejection by supervaluating over sets of possible worlds. As a consequence, updating some state with a future contingent or its negation will result in the empty set, and I will later explain (in Section 4) what to make of the LAW OF EXCLUDED MIDDLE in this setting. Supervaluations, of course, play a prominent role in the classical analysis of talk and thought about the future in the philosophical literature (Thomason 1970; Belnap and Green 1994). What distinguishes the current proposal from these accounts is that it leverages supervaluations to offer a *modal* analysis of future auxiliaries that explains how these expressions can be (universal) quantifiers over possible worlds that are scopeless with respect to negation. Let me further elaborate this story so that is has something useful to say about graded future judgments.

## 3 | Graded Modal Judgment

We have addressed the problem with negation; it remains to explain how to assign nontrivial credences to future contingents. Consider again:

(4) The die will come up 1.

Take a state of information $s$ treating the die as fair. Then (4) fails to be accepted in $s$, since $s$ includes a possible world it at which the die comes up 1. Now, consider Yalcin's (2012) proposal for how to assign probabilities to sentences in a dynamic setting. Start with a probability function $Pr$ that assigns to each subset of $W$ (the set of possible worlds) a number in $[0, 1]$ so that $Pr(W) = 1$ and $Pr(p \cup q) = Pr(p) + Pr(q)$ if $p$ and $q$ are disjoint. If $Pr_s(p) = Pr(p|s)$ for all $p \subseteq W$ is the result of conditionalizing $Pr$ on $s$, then the probability of $\phi$ in light of some information carrier $s$, $Pr(s, \phi)$, is the probability of $s[\phi]$ conditional on $s$:

$$Pr(s, \phi) = Pr_s(s[\phi])$$

Determining probabilities, then, is a matter of updating one's current state of information $s$ and considering the probability of the resulting proposition. That makes perfect sense in principle, but it also means that, since *will* tests for acceptance and returns the absurd state otherwise, future contingents such as (4) have a probability of 0 across the board.

To see how we can do better, start with the observation that while (4) fails to be accepted, our bilateral setting avoids the conclusion that (4) is rejected in $s$, as that would require the falsity of its prejacent at every world in $s$. Accordingly, $s$ fails to accept (4) but does not—as the classical analysis of *will* as a universal quantifier over historical alternatives would have it—reject it. The difference between failing to accept some $\phi$ and rejecting it matters since the former, intuitively, leaves room for coming to accept $\phi$ in light of some additional information, and we can exploit this feature in our explanation of the phenomena surrounding less-than-certain future judgments. The obvious proposal then is that it is the likelihood of the information that would lead one to accept rather than to reject $\phi$ that determines the probability of $\phi$ in light of some information carrier. Here is a way to make this proposal precise:

$$Pr(s, \phi) = Pr_s(\{w : \{w\} \Vdash^+ \phi\})$$

Assuming again that $\mu(s) = \{s\}$, $\{w\} \Vdash^+ will(\phi)$ just in case $\{w\} \Vdash^+ \phi$. It follows immediately that the probability of (4) in light of $s$ is nonzero just in case $s$ recognizes the die coming up as a possibility.

There remains an issue, however, namely that we now seem to miss a crucial difference between future auxiliaries and, say, epistemic modals. For consider (9):

(9) The die might come up 2.

Assuming again that the die is fair, (9) is a certainty. And so (10) is certainly false:

(10) The die must come up 1.

And yet if the die comes up 1 at $w$, then (10) is accepted by $\{w\}$ and so its nonzero probability should match the one of (4), contrary to the facts.

The idea for resolving this issue is straightforward and so is its technical implementation. The simple point is that even in adopting a maximally opinionated state of mind we do not lose track of the actual context and that epistemic modals are INFORMATIONAL MODALS in the sense that their modal domain is sensitive of what is settled by a separately provided informational parameter (Yalcin 2007; Kolodny and MacFarlane 2010). So, we now let our modal selection function $f$ take *two* arguments, the input state $s$ and, in addition, a separately provided informational parameter $i$:

(11) a. $s[\Box_f \phi]^+_i = \{ w \in s : \forall u \rhd f(s,i).u[\phi]^+_u = u\}$

b. $s[\Box_f \phi]^-_i = \{ w \in s : \forall u \rhd f(s,i).u[\phi]^-_u \neq \emptyset\}$

(12) a. $s[\Diamond_f \phi]^+_i = \{ w \in s : \forall u \rhd f(s,i).u[\phi]^+_u \neq \emptyset\}$

b. $s[\Diamond_f \phi]^-_i = \{ w \in s : \forall u \rhd f(s,i).u[\phi]^-_u = u\}$

Here, we now say that $s$ accepts $\phi$, $s \Vdash^+ \phi$, just in case $s \Vdash^+_s \phi$, which in turn is (once again) a question as to whether updating idles, that is, $s \Vdash^+_u \phi$ just in case $s[\phi]^+_u = s$. (Relatedly, $s$ now rejects $\phi$, $s \Vdash^- \phi$, just in case $s \Vdash^-_s \phi$; and $s$ admits $\phi$ just in case $s[\phi]^+_s$ is defined.) We will also write "$s[\phi]^+$" and "$s[\phi]^-$" as short for "$s[\phi]^+_s$" and "$s[\phi]^-_s$", respectively.

The additional hypothesis then is that the modal selection function for future auxiliaries is sensitive to the input state while epistemic modals qua informational modals are sensitive to the informational parameter $i$. Precisely:

**Modal Selection Functions (v.2)**. Let $\mu$ and $\epsilon$ be the selection functions for future auxiliaries and epistemic modals, respectively: then for all information carriers $s$ and $i$, $\mu(s,i) = \{s\}$ and $\epsilon(s,i) = \{\{w\} : w \in i\}$.

This preserves the basic dynamic story about epistemic *must*, including that $s \Vdash^+ \Box_e \phi$ iff $s \Vdash^+ \phi$ for all $s$. But since restrictions on the input state do not affect the informational parameter $u$, our DOUBLE-INDEXED setting allows us to disentangle the credences of future auxiliaries from the ones of epistemic necessity modals. To see this, tweak the definition of the probability of $\phi$ in light of $s$ one last time:

$$Pr(s,\phi) = Pr_s(\{w : \{w\} \Vdash^+_s \phi\})$$

The probability of $\phi$ in light of $s$ is thus the likelihood of information leading to acceptance of $\phi$ in light of $s$, that is, in probabilistic reasoning, we keep track of the global information state and (given what we have just said about our epistemic modal selection function $\epsilon$) evaluate epistemic *might* and *must* in these lights.

The proposed refinement does not affect what we said about degrees of confidence in future judgments but we can now observe that lack of acceptance in light of $i$ is *persistent* for epistemic modals in the sense that if $s \nVdash^+_i \Box_e \phi$, then $s' \nVdash^+_i \Box_e \phi$ for all $s' \subseteq s$. As a consequence, epistemic *must* does not allow for middling credence: once $s$ is fixed, every state either accepts or rejects the *must*-claim.[14] So, if we are concerned with a fair die, (9) receives credence 1 and (10) receives credence 0, as desired. The framework is thus perfectly able to capture the difference in probabilistic profile between future auxiliaries and epistemic modals.

Any analysis of future auxiliaries as necessity modals must explain how one can have middling probabilistic attitudes toward future contingents. The key move is to insist that, even from the perspective of a quantifier analysis, a future contingent may fail to be accepted in context without it being rejected, and then add that the former leaves room for the possibility of coming to accept the prediction if better informed. The probability of any sentence of our target language is then modeled as the likelihood of acceptance in light of a fully opinionated state of information. The key slogan here is that future auxiliaries are universal quantifiers alright, but their domain gets *restricted* when we are engaging in probabilistic reasoning. The proposal is in need of some finishing touches, but I submit that it has enough initial promise to warrant further investigation.

## 4 | Loose Ends

I have responded to two worries about the thesis that future *will*, like other necessity modals, is a universal quantifier over ways the world could be: the problem of negation and the problem of future credence. My response to these concerns involves some nonclassical moves, but I submit that these are straightforward to implement and well-motivated. All modals, I have said, supervaluate over specifications of sets of propositions (modal domains); the fact that *will* is scopeless with respect to negation—unlike epistemic or deontic modals—is due to the simple fact that future auxiliaries supervaluate over maximally opinionated information carriers. In Section 5, I will show that the appeal to modal domains and their specifications is not hand-tailored to deal with the specifics of future auxiliaries but instead allows us to address yet another notorious case where modal expressions behave in unexpected ways.

The problem of future credence, I have suggested, does not speak against a quantifier analysis of future auxiliaries but rather tells us something about the specifics of probabilistic reasoning, viz. that assigning credences to some sentence $\phi$ is a process of evaluating $\phi$ against a set of fully opinionated states of mind compatible with the information taken for granted in context (as discussed in Willer (2025), this idea also allows us to assign middling credences to conditionals in a strict setting). The familiar suggestion (going back to Yalcin (2007)) that epistemic *must* is an informational modal—the set of worlds over which the modal operators quantify is provided by a separate informational parameter—allows us to preserve the critical difference between the probabilistic profiles of future auxiliaries and epistemic modals.

The remainder of this section briefly addresses some key questions about the logic of future discourse as well as a few prominent remaining issues concerning its semantics and pragmatics: the nontrivial role of future auxiliaries in discourse

and when embedded under certain epistemic modals, and their temporal orientation. I will also address the question of how to translate what has been said before into a truth-conditional semantic setting.

### 4.1 | Validity

An important part of the story told here is that whenever (say) the die coming up 6 is considered neither impossible nor inevitable—whenever, that is, the die comes up 6 at some but not all worlds that are treated as live in context—none of the following sentences is accepted or rejected.

(13) a. The die will come up 6.
b. It is not the case that the die will come up 6.
c. The die will not come up 6.

That raises the question of what to make of the LAW OF EXCLUDED MIDDLE (LEM), stated in (14), and, for that matter, the principle of WILL EXCLUDED MIDDLE (WEM), stated in (15).

(14) $\vDash \phi \vee \neg\phi$

(15) $\vDash will(\phi) \vee will(\neg\phi)$

A standard dynamic "update-to-test" conception of logical consequence, which asks whether the conclusion is guaranteed to be accepted by every state once it has been updated with the premises, will deliver both principles as plainly invalid.

**Validity$_1$ (Acceptance)**. A sequence $\phi_1, \ldots \phi_n$ *guarantees acceptance* of $\psi$, $\phi_1, \ldots \phi_n \vDash_1 \psi$, iff $s[\phi_1]^+ \cdots [\phi_n]^+ \Vdash^+ \psi$ for all states $s$. $\phi$ is valid$_1$ iff every state $s$ accepts $\phi$.

WEM fails to be valid$_1$, for whenever $p$ is contingent there is a state that accepts neither "$will(p)$" nor "$will(\neg p)$"; since *will* is scopeless with respect to negation, "$\neg will(p)$" fails to be accepted as well, leaving LEM invalid. LEM-violations are contrary to classical instincts but it is also fair to note that WEM-instances such as (16) have the air of validity:

(16) The die will come up 6, or it will not come up 6.

Coupling the formal semantic proposal developed so far with a standard dynamic update-to-test conception of validity thus leaves something to be desired.

The previous counterexample to WEM and LEM exploits the fact that a state need not settle the question as to whether $p$ is true. But, one may add, every way of resolving that uncertainty does end up accepting "$will(p)$" or "$will(\neg p)$" (and thus "$\neg will(p)$"). Strengthenings of a state of information already figured prominently in our previous proposal for assigning probabilities to $\phi$ given $s$, for there we essentially asked which maximally opinionated strengthenings of $s$ accept rather than reject $\phi$. The natural suggestion then is to introduce a notion of validity that essentially supervaluates over such "precisifications." We begin by stating what it would mean to accept a sentence in this sense and then define an alternative notion of entailment on that basis.

**Super-Acceptance**. A state $s$ *super-accepts* $\phi$ just in case for all $w \in s$, $\{w\} \Vdash^+_s \phi$.

**Validity$_2$ (Super-Acceptance)**. A sequence $\phi_1, \ldots \phi_n$ *guarantees super-acceptance* of $\psi$, $\phi_1, \ldots \phi_n \vDash_2 \psi$, iff $s[\phi_1]^+ \cdots [\phi_n]^+$ super-accepts $\psi$ for all states $s$. $\phi$ is valid$_2$ iff every state $s$ super-accepts $\phi$.

A state $s$ super-accepts $\phi$ just in case it is guaranteed to end up accepting $\phi$ "no matter what," that is, every way of completely resolving its remaining open questions results in a state that accepts $\phi$. An argument is then labeled "valid$_2$" just in case updating with its premises guarantees super-acceptance of its conclusion.

**Fact 3** If $\phi \in \mathcal{L}_0$, then $\ulcorner will(\phi) \vee will(\neg\phi)\urcorner$ as well as $\ulcorner will(\phi) \vee \neg will(\phi)\urcorner$ are valid$_2$. At the same time, if $p$ is atomic, then there are states that fail to super-accept "$must(p) \vee must(\neg p)$."

If $\phi$ is from the propositional fragment of $\mathcal{L}$, then $\{w\}$ either accepts or rejects $\phi$, depending on whether $w$ is a $\phi$-world or not. So, every $\{w\}$ accepts either "$will(\phi)$" or "$will(\neg\phi)$"; if the latter is the case, $\{w\}$ accepts "$\neg will(p)$" as well. So, the previous problem cases for WEM and LEM disappear.[15] It is also worth observing that we continue to have nontrivial scopal interactions between negation and epistemic modals. Take any $s$ and $i$: since $p$ is either accepted or not by an information carrier, "$must(p)$" or "$\neg must(p)$" is accepted by $s$ given $i$. But since $i$ can be agnostic about $p$ and $i$ remains fixed when checking for super-acceptance, a state may fail to super-accept both "$must(p)$" and "$must(\neg p)$" and so their disjunction is not valid$_2$.

### 4.2 | Nontriviality

A test semantics for future auxiliaries (indeed, any modal expression) raises the question of how they could have any meaningful discourse effect. I have mentioned in passing that an input state $s$ tracks the live candidates for being the actual world; I now add that context need not uniquely settle what the live candidates are supposed to be. To say that the die will (or will not) come up 6 is thus a proposal to *constrain* what possibilities to treat as live in discourse: only those at which the die does (does not) come up 6.

Once again it is easy to make this a tad more precise. Think of a context $\Sigma$ as a set of sets of possible worlds; updating a context proceeds by updating each candidate for the set of possible worlds to be taken seriously in context (Willer 2013):

$$\Sigma \uparrow \phi = \{t : t \neq \emptyset \text{ and } \exists s \in \Sigma. s[\phi]^+ = t\}$$

There is thus no conflict between a test semantics for future auxiliaries and the fact that predictive assertions have nontrivial discourse effects.

Another issue concerns embedding of future auxiliaries under other modals, most notably epistemic modals. The following examples sound perfectly comprehensible:

(17) a. Maybe the die will come up 6.
b. It might be that the die will come up 6.

If *will* runs a test on the input state and epistemic possibility is a matter of the prejacent being consistent with the input state, the cases in (17) amount to the prediction that the die will come up 6, period. That is not a good result.

Gillies (2020) notes that data semantics (Veltman 1985) offers an interesting analysis of *maybe* as testing for coherence (rather than consistency):

(18) a. $s[\diamond_d \phi]_i^+ = \{ w \in s : \forall u \rhd \epsilon(s,i). \exists v \subseteq u. v[\phi]_v^+ = v \}$
b. $s[\diamond_d \phi]_i^- = \{ w \in s : \forall u \rhd \epsilon(s,i). \nexists v \subseteq u. v[\phi]_v^+ = v \}$

The data semantics reading of *maybe* makes perfect sense of the cases in (17), and for familiar reasons: it has a built-in restriction on the domain of any embedded modal.

Needless to say we now face the concern that we are multiplying possible meanings of *maybe*. But we can observe here (again following Gillies (2020)) that the data semantics reading is derivable from the original together with a "meta-assertion" operator that can be defined in the current bilateral setting as follows:

(19) a. $s[\mathbf{A}\phi]_i^+ = \{ w \in s : \exists t \subseteq s. t[\phi]_t^+ = t \}$
b. $s[\mathbf{A}\phi]_i^- = \{ w \in s : \nexists t \subseteq s. t[\phi]_t^+ = t \}$

We may then observe that $\ulcorner \Diamond_d \phi \urcorner$ is equivalent with $\ulcorner \Diamond_e \mathbf{A} \phi \urcorner$. This indeed fits in nicely with the story told so far, as it highlights yet another application of the idea that modal domain restriction is crucial for the understanding of natural language modality: such restrictions do not only figure prominently in logical and probabilistic reasoning but also for deriving nontrivial interpretations of modal embeddings.

### 4.3 | Future Orientation

I have set aside so far the issue that future auxiliaries are devices for talking about what is happening at some time in the future. The goal here is not to arrive at a comprehensive discussion; instead, I shall sketch a proposal that captures the future temporal orientation of *will* and the like without undermining the earlier observed facts about negation.

Possible worlds now assign truth-values to propositions at times; updates are relative to INTERVALS defined as follows:

**Interval** An *interval* $\mathcal{I}$ is a set of times satisfying the property that for every $t, t'' \in \mathcal{I}$, if $t \leq t' \leq t''$, then $t' \in \mathcal{I}$.

Intervals are convex sets of times (with respect to the temporal precedence ordering).[16]

We then add the following (straightforward) twists to our update rules for atomics, negation, and conjunction.

(20) a. $s[p]_i^+(\mathcal{I}) = \{ w \in s : \exists t \in \mathcal{I}. w(p,t) = 1 \}$
b. $s[p]_i^-(\mathcal{I}) = \{ w \in s : \nexists t \in \mathcal{I}. w(p,t) = 1 \}$

(21) a. $s[\neg\phi]_i^+(\mathcal{I}) = s[\phi]_i^-(\mathcal{I})$
b. $s[\neg\phi]_i^-(\mathcal{I}) = s[\phi]_i^+(\mathcal{I})$

(22) a. $s[\phi \wedge \psi]_i^+(\mathcal{I}) = s[\phi]_i^+(\mathcal{I}) \cap s[\psi]_i^+(\mathcal{I})$
b. $s[\phi \wedge \psi]_i^-(\mathcal{I}) = s[\phi]_i^-(\mathcal{I}) \cup s[\psi]_i^-(\mathcal{I})$

The analysis of the connectives is a simple re-write of what was said earlier. The critical maneuver for atomics is that a positive update with $p$ at $\mathcal{I}$ selects those worlds in the input state that make $p$ true at some time during the interval; a negative update with $p$ at $\mathcal{I}$ selects those worlds in the input state that make $p$ true at no time during the interval.

We then add the simple idea that modal selection functions may also affect intervals:

(23) a. $s[\Box_f \phi]_i^+(\mathcal{I}) = \{ w \in s : \forall u \rhd f(s,i). u[\phi]_u^+(\mathcal{I}_f) = u \}$
b. $s[\Box_f \phi]_i^-(\mathcal{I}) = \{ w \in s : \forall u \rhd f(s,i). u[\phi]_u^-(\mathcal{I}_f) \neq \emptyset \}$

(24) a. $s[\diamond_f \phi]_i^+(\mathcal{I}) = \{ w \in s : \forall u \rhd f(s,i). u[\phi]_u^+(\mathcal{I}_f) \neq \emptyset \}$
b. $s[\diamond_f \phi]_i^-(\mathcal{I}) = \{ w \in s : \forall u \rhd f(s,i). u[\phi]_u^-(\mathcal{I}_f) = u \}$

The future orientation of predictive *will* can then be captured by the hypothesis that future auxiliaries extend the interval into the future. Specifically, define two functions extending some interval into the future and into the past, respectively: $\mathcal{I}^+ = \mathcal{I} \cup \{t' : t' > t \text{ for all } t \in \mathcal{I}\}$ and $\mathcal{I}^- = \mathcal{I} \cup \{t' : t > t' \text{ for all } t \in \mathcal{I}\}$. As before we say that $\mu(s,i) = \{s\}$, but we now add that $\mathcal{I}_\mu = \mathcal{I}^+$.

To give one example, "$will(p)$" effectively tests whether for each $w \in s$, $\{w\}[p]^+(\mathcal{I}^+) = \{w\}$, which is just to say: it is settled that, at some point in the future, $p$ is true. The negation "$\neg will(p)$" requires that for each $w \in s$, $\{w\}[p]^-(\mathcal{I}^+) = \{w\}$, which is just to say: it is settled that, at no point in the future, $p$ is true. (More generally, $\ulcorner \neg will(\phi) \urcorner$ requires that for each $w \in s$, $\{w\}[\phi]^-(\mathcal{I}^+) = \{w\}$, which is just what $\ulcorner will(\neg\phi) \urcorner$ requires.) As in the system developed by Cariani (2021), *will* has a distinct existential temporal flavor while its negation has universal temporal flavor.

(25) a. There will be a sea battle.
b. There will not be a sea battle.
c. It is not the case that there will be a sea battle.

All of the above assert something about the possibilities that are live in context: (25a) that a sea battle happens at some point in the future, (25b) and (25c) that it happens at no point in the future.

It is also worth pointing out that given the obvious suggestion that PAST extends an interval into the past, that is, $s[PAST(\phi)]_i^+(\mathcal{I}) = s[\phi]_i^+(\mathcal{I}^-)$ and $s[PAST(\phi)]_i^-(\mathcal{I}) = s[\phi]_i^+(\mathcal{I}^-)$, we get the following result:

**Fact 4** If $s \Vdash^+ \phi$, then $s \Vdash^+ PAST(will(\phi))$

Say then that a state is agnostic about some $\phi$ at $t$ just in case it neither accepts nor rejects a positive update with $\phi$ at the interval $\{t\}$. Then it may very well be that a state $s$ is agnostic about a future contingent "$will(p)$" at $t$ but then, after updating with $p$ at some later time $t'$, accepts "$PAST(will(p))$." That, I suggest, accounts for the observation that we often evaluate predictions about the future as right or wrong in hindsight even if the matter

was unsettled at the time the prediction was made (cf. MacFarlane 2003).

Finally, language provides devices to talk about specific intervals, including deictic expressions such as *now* and *tomorrow* whose semantics, I shall assume, appeals to the intervals **now** and **tom** in context. So, to sketch a proposal, say that $s[Tomorrow(\phi)]_i^+(\mathcal{I}) = s[\phi]_i^+(\mathcal{I} \cap \mathbf{tom})$. Then (26a) says that a sea battle happens at some future point in **tom** and (26b) and (26c) say that battle will not happen at some future point in **tom** (but may very well happen at a future time outside **tom**).

(26) a. There will be a sea battle tomorrow.
b. There will not be a sea battle tomorrow.
c. It is not the case that there will be a sea battle tomorrow.

### 4.4 | Truth

The ideas developed here have received a dynamic gloss because they are, I submit, naturally articulated in terms of what it takes for a state and its strengthenings to accept or reject a modal claim. But they can be articulated in alternative settings. An approach closer to the truth-conditional story told by Kratzer (1977, 1981, 1991, 2012) would involve two modal selection functions that are determined by some context $c$, the first one $f$ mapping a world $w$ to a MODAL BASE and the second $g$ somehow determining a set of "best" worlds from $f(w)$ (I avoid writing "$g_c$" and "$f_c$" to simplify the notation). To deal with the phenomena surrounding informational modals we also let context determine an informational parameter $i$ (which may, for instance, just be the ways the world could be compatible with the common ground). The MODAL DOMAIN at $w$ is (again) a set of propositions and we can then state the truth-conditions for modals as follows:

(27) a. $[\![\Box\phi]\!]^{c,w} = 1$ iff $\forall u \rhd g(f(w), i) \cdot \forall v \in u : [\![\phi]\!]^{c,v} = 1$
b. $[\![\Box\phi]\!]^{c,w} = 0$ iff $\forall u \rhd g(f(w), i) \cdot \exists v \in u : [\![\phi]\!]^{c,v} = 0$

(28) a. $[\![\Diamond\phi]\!]^{c,w} = 1$ iff $\forall u \rhd g(f(w), i) \cdot \exists v \in u : [\![\phi]\!]^{c,v} = 1$
b. $[\![\Diamond\phi]\!]^{c,w} = 0$ iff $\forall u \rhd g(f(w), i) \cdot \forall v \in u : [\![\phi]\!]^{c,v} = 0$

We say that $g(s_1, s_2)$ is fixed by $s_1$ in case the expression is a future auxiliary and by $s_2$ in case the modal is epistemic. Adopting the ideas developed earlier, the more concrete proposal would be that $g(s_1, s_2) = \{s_1\}$ for future auxiliaries and that $g(s_1, s_2) = \{\{w\} : w \in s_2\}$ for epistemic *might* and *must*.

Finally, we can appeal to the idea that some bits of modal reasoning involve adopting a fully opinionated hypothetical state of mind: evaluating some $\phi$ at $w$ in $c$ in this setting is not simply to ask whether $\phi$ is true at $w$ in light of the $c$-relevant conversational background, but whether $\phi$ is true at $w$ in light of the result of *strengthening* the $c$-relevant conversational background with $\{w\}$. To model this, say that $c_w$ is just like $c$ except that $f$ is "fully opinionated" in the sense that $f(w) = \{w\}$ for all $w \in W$, that is, in $c_w$ the selection function $f$ maps each world to the fully opinionated modal base corresponding to $\{w\}$. The simple suggestion then is that, given some context $c$, the probability of $\phi$ in light of $s$ is the probability of $\phi$ being true in given $c_w$.

$$Pr(s, \phi) = Pr(\{w : [\![\phi]\!]^{c_w, w} = 1\})$$

Once again restricting the $c$-relevant background does not affect the informational parameter.

Bells and whistles can be added to capture the other issues we discussed. The future orientation of predictive *will*, to wit, can be captured by the suggestion that truth-values are assigned relative to intervals and that the conversational background for future auxiliaries extends the interval into the future. We can also say that $\phi$ is *quasi-true* in context $c$ just in case $[\![\phi]\!]^{c_w, w_c} = 1$, with $w_c$ being the world of the context $c$. $\phi$ is *quasi-valid*, $\vDash_2 \phi$, just in case $\phi$ is quasi-true in every context. The resulting logic for future auxiliaries (and epistemic modals) matches the dynamic one proposed in Subsection 4.1.

The two critical ideas developed here are, first, that the distinct negation facts about future auxiliaries can be explained in a quantified setting in terms of the distinct modal domain of future auxiliaries and, second, that *will* and the like are strict quantifiers whose domain gets systematically restricted when we entertain questions about probability or validity. The fact that these ideas can be articulated in a variety of semantic settings is a welcome result.

## 5 | Concluding Remarks

I conclude the discussion by taking a brief look at another modal expression that has proven to be problematic for the classical approach. Ability *can* seems to resist a quantifier analysis for essentially the same reason that future auxiliaries do: both its logic and the fact that ability judgments may come in degrees of confidence are unexpected if we think of ability *can* as a quantifier over possible worlds. I shall suggest that the framework developed so far is not just hand-tailored to explain how future *will* could be a necessity modal but also allows us to offer a viable quantifier analysis of ability *can*.

Start with the logic side of things: Kenny (1975, 1976) notes that the *can* of ability seems to resist the inference rule of distribution over disjunction. Imagine that Mary is skilled enough to hit the board, but not skilled enough to hit any particular region of the board. Against this background, it seems as if there is a reading of *can* on which we would accept (29a) but not accept (29b) or (29c):

(29) a. Mary can hit the board.
b. Mary can hit the top half of the board.
c. Mary can hit the lower half of the board.

But to hit the board is to hit its top or its lower half and thus, so the story continues, we have a case in which what looks like an existential modal operator does not distribute over disjunction: a sentence that is apparently equivalent to a disjunctive possibility fails to entail the disjunction of its possibilities (see also Horty 2001; Portner 2009). Epistemic *might* and deontic *may*, in contrast, happily distribute over disjunction. For example, it seems plain weird to accept (30a) without accepting (30b) or (30c), and no less weird to accept (31a) without accepting (31b) or (31c):

(30) a. Mary might hit the board.
b. Mary might hit the top half of the board.
c. Mary might hit the lower half of the board.

(31) a. Mary may/is permitted to hit the board.
b. Mary may/is permitted to hit the top half of the board.
c. Mary may/is permitted to hit the lower half of the board.

We thus need an explanation for why the *can* of ability in particular seems to resist distribution over disjunction, while ordinary possibility modals—such as epistemic and deontic ones—do not.

One possible lesson to draw is that ability *can* has universal, rather than existential, force (Brown 1988; Giannakidou 2001; Giannakidou and Staraki 2012). Another is that the *can* of ability is best understood as a conditional operator stating, roughly, what would happen if the subject tried to bring about the prejacent (see Cross 1986; Mandelkern et al. 2017; Thomason 2005). We can then no longer maintain the *can* of ability shares a common semantics with its epistemic or deontic cousin:

(32) a. Mary can dance.
b. You can have another beer.
c. The butler can be the murderer.

On the views under consideration, *can* denotes a universal or conditional operator in an ability attribution, as in (32a). On its deontic interpretation in (32b), *can* is existential, and likewise on its epistemic interpretation in (32c).

Willer (2021) suggests that a uniform analysis of *can* as an existential quantifier can be retained, the key idea being that ability requires control and thus ability *can* asserts the existence of a contextually salient action guaranteeing the truth of the prejacent. Since an action may guarantee "$p \vee q$" without guaranteeing either $p$ or $q$, distribution over disjunction failures are expected. The more complex structure that has been proposed here in previous sections for modal domains can easily capture all this. Specifically, in Kenny's scenario, we may assume that the modal domain that is relevant for the interpretation of *can* includes a set $\{w_1, w_2\}$, where Mary hits the top half of the board at $w_1$ and the lower half at $w_2$, but neither $\{w_1\}$ nor $\{w_2\}$, reflecting the fact that she has control over whether to hit the board but not over whether the dart hits the top or the lower half. In this context, (29a) but neither (29b) nor (29c) is accepted. That some possibility modals fail to distribute over disjunction is thus perfectly compatible with an analysis that treats these as existential quantifiers over possible worlds.

Here is the issue with graded ability attributions. Mandelkern (2024) argues that an analysis of ability *can* as requiring control has trouble with the probability of ability ascriptions. Mary, we just said, cannot control whether the dart hits the top half of the board. But we do not want to say that (29b) is certainly false; rather, it is natural to assign to (29b) the probability that Mary hits the top half of the board if she tries.[17] This suggests that a conditional analysis of ability *can* is on the right track after all.

The general form of the puzzle presented here is by now familiar: some natural language modal expression has a distinct air of necessity to it—here, the fact is that ability *can* seemingly requires some kind of control over the relevant action—and yet that makes it hard to see how there could be room for middling credences. So is the general shape of the solution: the domain of the modal in question gets restricted in probabilistic reasoning. Specifically, everything we have said so far is compatible with the suggestion that, as some ways the world could be are ruled out, certain outcomes become easier to secure and so the modal domain of ability *can* expands. So, if $\alpha$ is the modal selection function for ability *can*, then it may very well be that for some proposition $p$ and states $s, s', i$ such that $s' \subset s$, $p \notin \alpha(s, i)$ but $p \in \alpha(s', i)$. In that case, an ability attribution may fail to be acceptable in light of $s$ and $i$ since the agent is deemed to lack sufficient control over the action at play, and still have nonzero probability.

Here is one way (among others) to make the proposal more precise. We continue to think of ability *can* as a possibility modal but grant the conditional analysis this much: that to say that an agent $A$ has control over some action $a$ just is to say that if $A$ tried to do $a$, $A$ would succeed. Precisely: the proposition that $A$ does $a$ is an element of $\alpha(s, i)$ just in case $s$ accepts that if $A$ were to try to do $a$, $A$ would succeed. The probability that $A$ can do $a$ then matches, by design, the probability that $A$ would succeed at doing $a$ if she tried. This proposal is, strictly speaking, incomplete without a story about how to assign probabilities to conditionals. But the question need not detain us here. The current discussion takes no official stance on the semantics of conditionals, so pick whatever analysis of conditionals you think is best (a Stalnaker-style selection function analysis would do, for instance): the fact remains that nothing about the thesis that ability *can* requires control is incompatible with the suggestion that *can*-attributions come with middling credences that align with the predictions of a conditional analysis.

The underlying approach to ability *can* certainly requires additional elaboration and justification (see Willer (2021) for plenty of details). The point of this brief exercise was to highlight that there is a whole family of challenges to the classical analysis of modals (and conditionals) as quantifiers over possible worlds, all of which center on unexpected inference patterns and probability judgments. This set of challenges calls for a systematic response. I have argued that the framework developed here is in a position to provide one.

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**Endnotes**

[1] See, for example, the discussions by Kratzer (1977, 1981, 1991, 2012) for an approach to natural language modality pursuing this hypothesis.

[2] See in particular Klecha (2014) for discussion; Partee (1973) is an early endorsement of the thesis that *will* is a modal. A sample of modal analyses of future auxiliaries: Enç (1996), Condoravdi (2002), Kaufmann (2005), Copley (2009), Cariani and Santorio (2018), Giannakidou and Mari (2017), and Cariani (2021). A nonmodal analysis is proposed, for example by Kissine (2008).

[3] The point goes back at least Thomason (1970) and has been recently stressed by Cariani and Santorio (2018). See also Copley (2009), MacFarlane (2014), and Cariani (2021) for relevant discussion. Everything said here about future *will* applies, in English anyway, to other future auxiliaries.

[4] Prior (1967) is an early discussion of the (what he labels PEIRCEAN) view that *will* is a universal quantifier over possible futures.

[5] The suggestion that *will* comes with existential, rather than universal, modal force is hopeless, not least because it wrongly predicts that (4) is a certainty.

[6] Kratzer (2021) also opts for a selection functions for *will*, but her concerns are different from ours.

[7] The usual list of classics from the debate: Stalnaker (1968), Stalnaker and Thomason (1970), and Lewis (1973).

[8] Edgington (1995, 2008) raises this kind of concern about Lewis (1973)-style variably strict analyses of counterfactuals.

[9] I explain how a strict outlook on the semantics of conditionals can address the trouble with negation and graded conditional judgment in Willer (2022, 2025).

[10] The label "totally realistic" is borrowed from Kratzer (1981, 1991, 2012).

[11] Bilateral approaches have been employed in a variety of semantic settings, including data semantics (Veltman 1981, 1985) and truth-maker semantics (Fine 2017). The usual list of classical dynamic frameworks: DISCOURSE REPRESENTATION THEORY (Kamp 1981; Kamp and Reyle 1993; Kamp et al. 2011), DYNAMIC PREDICATE LOGIC (Groenendijk and Stokhof 1991), FILE CHANGE SEMANTICS (Heim 1982), and UPDATE SEMANTICS (Veltman 1985, 1996).

[12] Conjunction is commonly modeled as sequential updating in dynamic semantics—see, for instance, von Fintel and Gillies (2008) and Willer (2015)—but here we do not need to worry about internal dynamics, and so a simple intersective approach will do. I also choose a rather simple approach to disjunction: Willer (2018), for instance, shows how a more sophisticated approach can account for phenomena such as the FREE CHOICE EFFECT.

[13] An alternative response from Todd (2020, 2021) is that *will* is scopeless with respect to negation because it is a "neg-raiser" (see also Winans 2016), the general phenomenon being that certain negated predicates have a tendency to give to a reading where negation takes scope from an embedded clause: "Mary doesn't think it's raining" conveys, for instance, the meaning of "Mary thinks it's not raining." See Cariani (2021) for a discussion of this way of handling the interaction between future auxiliaries and negation.

[14] Whether epistemic modality judgments can come in degrees is a difficult question (see, e.g., Moss (2015) and Charlow (2020) for discussion). A more complex framework may allow for uncertainty about what $s$ is and thus leave room for graded judgments about epistemic modality. I say we already have enough on our plate and set the issue aside for the time being.

[15] These results generalize to all $\phi \in \mathcal{L}$ under the assumption that for all modal selection functions $f$, worlds $w$, and information states $i$, there is a unique specification of $f(\{w\}, i)$. For then it is assured that even an arbitrary modal claim is accepted or rejected by $\{w\}$ given some $i$, which secures LEM and WEM in full generality.

[16] The appeal to intervals in the semantics dealing with temporal orientation has a long history, see Bennett and Partee (1972), Dowty (1982), and Condoravdi (2002), among others.

[17] It also, as Mandelkern notes, seems right to say that Mary might be able to hit the top half of the board. Recall Subsection 4.2 for a discussion of how to draw on some ideas from data semantics to make sense of the *might* at play here.

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