Modality and embedded temporal operators*

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Abstract This paper presents a relative theory of tense which accounts for
tense behaviors in English in both matrix and embedded contexts. Crucial
to this proposal is novel data which shows that the temporal orientation of
finite embedded clauses is constrained by the attitude verbs which embed
them. While such constraints have been observed in modal auxiliaries and
non-finite-embedding attitude verbs, finite-embedding-attitudes present an
important new perspective because they show that whatever constraints are
introduced by the modal must be able to coexist with a tensed prejacent.
This proposal is compositional, and a formal analysis is given, by which
modals, including attitude verbs, may constrain the temporal possibilities
of an embedded clause, without themselves introducing a reference time
argument. The constraining effect of attitude verbs also eliminates the need
to stipulate a general Upper Limit Constraint, and allows for a means to
capture correspondences between modal flavor and temporal orientation. The
result is an elegant accounting of embedded tense with empirical coverage
superior to previous proposals.

Keywords: tense, embedded tense, modality, embedding, sequence of tense

Most semantic analyses of tense say something along these lines: the role
of tense is to relate a reference time (RT) to an evaluation time (EvalT). In the

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absence of aspect[1] the RT of tense can be conflated with the event time (ET) of the verb it embeds. Many theories argue in addition for equating EvalT of tense with speech time (ST); call these theories deictic. Such theories neatly capture the fact that for both instances of Past Tense in (1), the RT precedes ST.

(1)   Martina thought Carissa was pregnant.

A significant caveat, however, concerns the embedded Past Tense in (1) — its RT (the time of Carissa being pregnant) is limited not just to preceding ST, but in fact to being no later than the RT[2] of the matrix Past Tense. Abusch (1997) called this the Upper Limit Constraint (ULC); precise implementations of this constraint vary.

An alternative theory would say that EvalT is only equated with ST in matrix contexts. Embedded tenses are instead interpreted in a relative manner — their EvalT corresponds to the RT of the matrix tense; call these theories relative. This neatly pre-empts the need for a ULC, but it springs a new leak in the process: the so-called simultaneous reading of (1), whereby Martina's thoughts and Carissa's thought-of pregnancy are concurrent. In the ULC's place, a different stipulation must therefore arise: a Sequence of Tense (SOT) rule, which says very roughly that (what looks like) a Past Tense embedded under another Past Tense is ambiguous between a true (relative) past meaning and a meaning which is more like a relative present — the one responsible for the simultaneous reading.[3] As with the ULC, there are many distinct proposals in the literature for implementing SOT, but they are all alike in that they allow for the possibility that a tense may look like Past Tense, but not have the semantic content of true Past Tense.

You may at this point be convinced of the truth of one or the other of these approaches, either because you began reading this paper with your own ideas, or because you have found one of the two preceding paragraphs terribly convincing. Or you may, like many authors, believe that elements of both the ULC and the SOT are needed to fully explain everything. Regardless, you will be surprised to find such naturally occurring data as those in (2)

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1 Which remains absent for much of this paper.

2 The true constraint does not concern RT of the matrix past tense, but rather another temporal parameter which is closely related to said RT. See Section 3.4.

3 Some authors, like Altshuler & Schwarzschild (2013b), get around this problem by denying the existence of simultaneous readings. More on this later.

and (3), all of which are culled from the Corpus of Contemporary American English (Davies 2008); further attestations can be found in Appendix A.

(2)   a.   "But none of that has put Singh in the headlines like his comments after finishing second at the Wachovia Championship in Charlotte, two weeks before the Colonial. He said Sorenstam had no business playing the PGA Tour, *he hoped she missed the cut* and he'd withdraw if paired with her, the AP reported."

        b.   "He was going to find that Guardian and do what he had to do. But his gut dropped at the thought of killing anyone in cold blood, even to save his brother. *He hoped she tried to kill him first.* Then he could behead her with a clean conscience."

(3)   a.   "'There were times when I picked one receiver and *prayed he got open*,' recalled Collins, who completed 49.4 percent of his passes as a rookie out of Penn State, and finished with a quarterback rating of 61.9. 'If he got open great; If not, I took the sack or threw it away.'"

        b.   "Thirteen months and she would legally be able to walk out the door and live on her own. Her trust fund would be hers. She would no longer be dependent on her mother and Victor. Thirteen months. *She prayed she survived that long.* It wasn't that she was worried about Victor killing her. She feared her own hand."

The data in (2) and (3) are surprising because they seem to fly in the face of both the ULC and SOT.[4] They all admit relative future readings; for example, in (3a), the time of the (prayed for) getting-open follows the time of the praying. This is explicitly banned by the ULC, while SOT approaches only allow either the relative past reading of true Past Tense or the simultaneous reading of 'fake past'.

The point of this paper is to introduce these important data, and to explain them. This explanation consists mainly in the proposal that, while constraints on time reference like the Upper Limit Constraint do exist in the grammar, such constraints are the product of the semantics of the embedding modal or attitude verb. In other words, I propose that modals, including attitudes, may constrain the temporal possibilities of their prejacents and, therefore, the

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4 Again, authors like Altshuler & Schwarzschild (2013b) are an exception; they actually deny that either the ULC or the SOT is needed. But for reasons I explain in Section 5.1 these accounts have trouble with this new data too.

temporal properties of embedded clauses may vary from modal to modal, from attitude verb to attitude verb. Attitudes like *think* impose an upper limit; attitudes like *hope* do not.

Note that it has been proposed before that modal auxiliaries (e.g., Condoravdi 2002) and non-finite-embedding attitudes (e.g., Abusch 2004) have temporal components which affect the temporal interpretation of their prejacents, but these accounts essentially pre-empt the role of embedded tense in determining embedded RT. To put it another way, these accounts don't propose that modal *operators* affect the temporal possibilities of their prejacents, so much as they propose that modal *vocabulary* often consists of a combination of modal and temporal operators. These vocabulary fill both the role of modal, and that of embedded tense.

The novel observation that this phenomenon (modals affecting the temporality of their prejacents) extends to *finite*-embedding attitudes is important because it shows a clear case in which RT is constrained *both* by an *in situ* tense and by the embedding attitude. What makes the present theory unique, therefore, is the proposal that modals may *constrain* an RT which is nonetheless introduced by a temporal operator within its prejacent, where this constraining occurs at a distance. This is accomplished by positing that world variables (which are quantified over by modals) may themselves convey temporal information.

Further support for this move comes from correspondences between modal flavor and temporal orientation. Many modal auxiliaries and verbs are compatible with different modal bases, but admit different temporal orientations depending on which modal base they take. This is an especially good reason to build the temporal constraints directly into the worlds themselves.

Several other points must also be made for this all to hang together. I adopt a relative theory of tense and, accordingly, an SOT rule. The point of these two assumptions is to capture these essential data:

(4)   Martina hoped Carissa got pregnant.

(5)   a.   Martina hopes Carissa gets pregnant.
        b.   Martina hopes Carissa got pregnant.

(6)   Martina thought Carissa got pregnant.

(7)   a.   *Martina thinks Carissa gets pregnant.
        b.   Martina thinks Carissa got pregnant.

The takeaway from these data is that if a Past-under-Past sentence is uttered at t, it conveys the disjunction of what is conveyed by its Present-under-Present and Past-under-Present equivalents, uttered at some earlier t'. In other words, the view that a Past Tense embedded under a Past Tense is ambiguous between a true relative past and a disguised relative present is actually unharmed by this new data; what is harmed is just the view that the Present Tense really denotes an equality relation between EvalT and RT. I therefore adopt the view that the Present Tense is semantically non-past. The lack of a relative future reading in (6) and the unacceptability of (7a) are explained by the same thing: the temporal constraints induced by *think*.

Note that a relative account predicts that not only should embedded RT be allowed to follow matrix RT, but that it may even follow ST. Indeed this is the case.

(8)   *In the middle of a chess match:*
       At the beginning of this match, I hoped I lost. (But now, I want to win...)

It should be pointed out that some speakers do not share the judgment of (8) as acceptable. It's possible that such speakers have a deictic semantics for tense (and no SOT rule), although data like (9) (which is readily accounted for on a relative theory and which I suspect admits less variation in judgment) would still need to be explained for such speakers.

(9)   a.   Alan will think everyone hid.
       b.   Alan will think everyone is hiding.

In any case, I will not probe this issue too much further. The main point of this paper is to propose that modals can constrain the temporal properties of their prejacents, and as such there may be variation in the temporal properties of embedded clauses, depending on the embedding operator. In order to best capture the whole range of data, I adopt a relative theory of tense, plus SOT and a non-past Present Tense.

The rest of the paper proceeds as follows. In Section 1 I show the correspondences between modal flavor and temporal orientation which help motivate this account. In Section 2 I provide the formal framework that allows for modals to constrain temporal possibilities. In Section 3 I provide the core analysis. In Section 4 I review prior explanations of the interaction between tense and modality and demonstrate how my account is superior. In Section

[5](#) I review issues created by the adoption of SOT rules, comparing my analysis to deletion and non-SOT accounts, and discussing ways in which my analysis may be extended to account for Present-under-Past cases.

1 Modality and temporal orientation

One thing that may be troubling to the reader at this point about the proposal regarding the ULC is that this appears to take a phenomenon which had a systematic explanation and replace it with one which has a lexically variable, idiosyncratic one. But this is not what I claim. Rather, the temporal constraints imposed by attitude verbs are a function of what kind of modal domain they have — deontic, bouletic, epistemic, etc. Epistemic, doxastic, and reportative attitude verbs impose an upper limit, but deontic, bouletic, and teleological ones do not. Since *hope* and *pray* are the only *finite*-embedding attitude verbs in English which are not epistemic, doxastic, or reportative, this may be hard to see; but consider non-finite-embedding attitude verbs, many of which are not epistemic, doxastic, or reportative.

(10)   Itamar believed his daughter to...

    a. #...go to bed.
    b. ...be in bed {at that moment, #by ten}.
    c. ...have gone to bed.

(11)   Itamar told his daughter to...

    a. ...go to bed.
    b. ...be in bed {#at that moment, by ten}.
    c. #...have gone to bed.

The doxastic attitude verb *believe* imposes an upper limit, while the deontic/imperative attitude verb *tell* does not (and in fact imposes a lower limit).[5]

So what kind of domain a modal has determines its *temporal orientation*: The constraints it places on the RT associated with its prejacent. In this

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[5] Note that here I am speaking of the nonfinite-embedding *tell*, which is used to describe imperative speech acts, rather than the finite-embedding *tell*, which is used to describe assertions. Owing to the different kind of speech acts they describe, their temporal orientations are different, as seen in (i).

(i)   Itamar told his daughter that her mother went to bed.

section I make a sustained argument for this generalization before presenting a formal analysis in the following sections.

1.1 Modality basics

Following Kratzer (1981) I assume the domain of a modal is determined by the interplay of two contextually determined sets of propositions — the modal base and the ordering source.

I assume two basic kinds of modal bases. The first is the *doxastic* modal base, a set of propositions believed by some agent(s). The *epistemic* modal base is a special kind of doxastic one, namely a set of *true* propositions believed by some agent(s). Thus for the present discussion whatever I say for doxastic modal bases goes for epistemic ones as well.

The second modal base type is *circumstantial*, a set of propositions objectively true of the evaluation world. I assume the *metaphysical* modal base is a special case of the circumstantial modal base. It is the set of all true propositions indexed up to a given time. When this set of propositions is intersected, it gives a set of worlds identical to the evaluation world up to that time. This is also referred to as the set of worlds which *branch from* the evaluation world at that time. Branching will be discussed in more detail below.

Normative modals, including deontic, teleological, and bouletic modals, arise from the application of an ordering source to a modal base, typically circumstantial.[6] Thus these modals operate over narrower modal domains.

I propose that modals with doxastic modal bases have past/present orientation, while modals with circumstantial modal bases have future orientation. I present data that supports this generalization just below in Section 1.2. A few caveats must be made first, however. Since I am speaking only of modal bases, ordering sources may yet have some effect on temporal orientation. Variation beyond what I observe below could be due to this. And since my analysis ultimately is a semantic one, variation could also simply be due to lexical idiosyncrasy. But this generalization is too strong to chalk up entirely to the fickle whims of the lexicon.

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6 Below I will discuss a case of a bouletic modal with an epistemic modal base.

1.2 Modal-temporal correspondence

Consider the necessity modal *have to*. Though *have to* is a verb, it may take either circumstantial or epistemic modal bases, and so in this regard it is very much like a typical modal auxiliary.

(12)   Given that it was supposed to rain all day today,
         that Bill's primary goal is staying dry,
         and that he was supposed to be running errands all day:

   a.   He has to wear a raincoat.
   b.   He has to be wearing a raincoat when he leaves.
   c.   He has to be wearing a raincoat right now.
   d.   He has to have worn a raincoat.

In (12a-b), there can only be a teleological (circumstantial) reading — one where we are stating something about Bill's options for fulfilling his stated goals given the circumstances.[7] The modality cannot be epistemic. Additionally, the temporal orientation must be future. In (12c-d), there can only be an epistemic reading — one where both the circumstances and Bill's goals serve as (indirect) evidence of his wearing or having worn a raincoat. In (12c) there is only a present reading; in (12d), only a past one.

   Consider next a context which favors a deontic interpretation; the pattern is the same as in the teleological case.[8]

(13)   a.   He knows the rules; #he {has to/%must} have done the dishes last Tuesday.
       b.   He knows the rules; #he {has to/%must} be doing the dishes right now.
       c.   He knows the rules; he {has to/%must} do the dishes next Tuesday.

Again, where a deontic interpretation is forced, there can only be a future reading.[9]

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7 There is also a deontic reading, but it is rather unlikely to be true in the context as stated.

8 I use the stigma % to represent dialectal variation.

9 Some deontics, like *supposed to*, allow present readings. Some deontics may also allow present readings in particular contexts, like in *I'm here because I have to be.* Thanks to Kai von Fintel (p.c.) for pointing out data like this. I don't know what factors condition the possibility or impossibility of present orientation — I will restrict myself to claiming that deontics allow for future orientation while epistemics do not. As mentioned above, fine variation in ordering sources may be responsible for such fine variations in temporal orientation.

	Past	Present	Future
Epistemic	✓	✓	#
Circumstantial	#	#	✓

Table 1 Co-variation of temporal orientation and flavor in *have to*.

Note that *should* on its deontic reading is acceptable with the past-shifting *have*.

(14)   You know the rules; you should have done the dishes last Tuesday.

This is not a counterexample. Following [Condoravdi (2002)](), I take this to be a case of a past-perspective, future-orientation modal. In this case, the past-shifter *have* scopes over the modal and anchors it to a past time, from which "last Tuesday" is the future. Thus there was some obligation active before last Tuesday, in light of which doing the dishes last Tuesday was necessary.

Now consider a context which favors an epistemic interpretation; (15c) can only have a deontic or teleological reading.[10]

(15)   a.   He's a smart guy. He {has got to/must/has to} have aced his test yesterday.
        b.   He's a smart guy. He {has got to/must/has to} be acing his test right now.
        c.   He's a smart guy. #He {has got to/must/has to} ace his test tomorrow.

A reviewer points out the following apparent counterexamples to the claim that epistemic necessity modals cannot have future orientation.

(16)   a.   *A:* The ship leaves the Spanish harbor next Tuesday.
        b.   *B:* It has to/ must reach Athens next Friday (then).

(17)   a.   *A:* The doctor will be in London either next week or the following week.
        b.   *B:* Actually, she will be at a conference in the US next week.
        c.   *A:* Oh, she must be in London the following week then.

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10 Note that the context-establishing sentence *he's a smart guy* does not make an epistemic reading obligatory; it just makes one more likely than a deontic reading.

But these should both be analyzed as cases of *must/have to* embedding a present futurate, which can be seen in unembedded contexts in (16a) or (18).

(18)   The doctor is in London the week after next.

Following Copley (2002) and others, we can posit a null, future-oriented schedule modal, which is responsible for the acceptability of (18). This modal is present only in the case of futurates, and not otherwise. This modal presupposes that its prejacent describes a schedulable event, capturing the badness of (19b) and (20b).

(19)   a.   The Red Wings play tomorrow.
         b.   #The Red Wings win tomorrow.

(20)   a.   The weather forecaster said it's going to rain tomorrow.
         b.   #The weather forecaster said it rains tomorrow.

The same pattern occurs under epistemic modals.

(21)   a.   *A:* The meteorologist either predicted rain Tuesday and snow
               Wednesday, or vice versa. But I can't remember which.
         b.   *B:* I heard the meteorologist predict rain for Tuesday.
         c.   *A:* #Ah, so, (must be) it snows on Wednesday.
         c′.   *A:* #Ah, so it must snow on Wednesday.
         c″.   *A:* Ah, so, (must be) it's going to snow Wednesday.

(21c-c′) are unacceptable for the same reason that (19b) and (20b) are.
    Thus, (22) is ambiguous between having the covert futurate modal operator and not; this it is ambiguous between a reading where my hope is about the plane actually leaving, and where my hope is about what the schedule is.

(22)   I hope my flight leaves at 7.

I will avoid dealing with futurates for the rest of the paper.
    So necessity modals like *have to* and *must* have future orientation when they have a circumstantial (i.e., teleological or deontic) reading, but present or past orientation when they have an epistemic one. Thus temporal orientation cannot be a lexical property of the modals themselves. For this reason I propose that it is the temporal structure of the worlds of the modal domain which is responsible for imposing these temporal constraints (what I mean

by 'temporal structure' is made formally clear in Section 2). This explains how it can be that temporal orientation co-varies with modal base flavor.

Condoravdi (2002) first argued that modal base flavor co-varies with temporal interpretation in the case of metaphysical modals like *might*.

(23)   John might be at the store.

While (23) can have an present-oriented epistemic reading, as well as a future-oriented metaphysical one, a present-oriented metaphysical reading is predicted to be synonymous with (24).[11]

(24)   John is at the store.

But no such reading exists. So metaphysical modals don't ever have past or present orientation.

1.3   Pragmatic motivations

Why should epistemic, doxastic, and reportative attitudes only be present- or past-oriented, while other attitudes may be future-oriented?

First of all, as discussed by many authors (Thomason 1970, Abusch 1997, Copley 2002, S. Kaufmann 2005, Klecha 2014b), humans can only truly know things about the present or past, since the future is in some sense inherently unknowable. This, perhaps in conjunction with the Maxim of Quality (Grice 1989), motivates epistemic and doxastic modals being associated only with present and past temporal orientations. This is very similar to Abusch's own motivation of the Upper Limit Constraint.

I include reportatives, like *say*, in this as well; following many authors I take reportatives to be modals as well, quantifying over the set of worlds of the common ground of the discourse which they describe. Since common grounds are taken to be sets of worlds representing information which interlocutors mutually acknowledge that they (are acting as if they) believe, it is very natural that reportatives be subject to the same constraints as epistemics and doxastics. Stalnaker (1984) for example puts epistemics, doxastics, and reportatives together in the category called *attitudes of acceptance*. For Anand

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11 The set of worlds identical to the evaluation world up to speech time are necessarily identical with respect to any proposition indexed at speech time or prior. John is therefore at the store in all or none of them. Thus if we say that John is at the store in one such world, we are really saying he is at the store at all of them, or put more simply, that he is at the store at the evaluation world.

& Hacquard (2013) this forms a part of a larger category of *representational* attitudes.

Second, as Condoravdi (2002) argues, since the circumstances in a given world are fully settled up to evaluation time, it makes sense that circumstantial modal expressions would be restricted to the future, which is the only contingent part of a set of circumstantially accessible worlds. This is motivated by the Maxim of Manner, since a circumstantial modal embedding a proposition with a past reference time could always just be replaced with the bare proposition with no change in meaning.

I want to be careful to make it clear that these are just *motivations* — reasons for the grammar to have developed the way that it has. Ultimately my account writes the temporal constraints being discussed into the semantics, by making them part of the meanings of modal base pronouns which combine with modal auxiliaries and attitude verbs, as is explained and formalized below. Since these constraints are therefore an aspect of lexical meaning, nothing in my theory predicts that there may not be idiosyncrasies; so the generalization I propose about correspondences between modal flavor and temporal constraints may have exceptions. But that does not mean that the generalizations that *are* seen are a total accident either; rather, the lexicon of English is what it is because pragmatic pressures have caused it to evolve in a way that supports the generalization.

Note that I have pinned all the observed variation on the distinction in modal bases, between doxastic/epistemic and metaphysical/circumstantial. There is at least one other kind of modal base, the empty modal base, and maybe more. Moreover I have not discussed any effect of ordering sources, but they may very well have one. Deliberative modals like *ought* have been argued by Cariani, M. Kaufmann & S. Kaufmann (2013) to have an epistemic modal base. This could still be squared with the future orientation of *ought* by arguing that the ordering source plays a role in temporal orientation as well. Since this paper is focused mainly on attitudes, I will not pursue this question any further.

The exact method by which modal bases may affect temporal orientation must be given a formal, compositional analysis, and I do this in the next two sections.

2 Formal foundations

In order to formalize my analysis, I adopt a $W \times T$ framework ([Thomason 1984](#)). On this framework, *worlds* and *times* are basic parameters of evaluation, and propositions may be understood, at a basic level, as being sets of world-time pairs.

However, the main thesis of this paper is that modals, which are taken to quantify over worlds, may contribute temporal information. I argue that this can all be explained by positing that *worlds themselves* contribute temporal information in a way that is *distinct* from the time argument. So I will replace worlds with something more akin to what are called *histories* on branching times (BT) models. A BT model would probably be the most natural way to formalize this; a situation semantics might also suffice. But I choose to formalize this system in $W \times T$-terms, since this is a much more familiar system, and the same proposal can just as readily be made with it. Thus on my system, sentences denote sets of history-time pairs, where histories are world-time pairs.

2.1 Formalism

Define worlds and times in the usual way. Times may be instants or intervals. Histories, then, are pairs of a world and a time. I will use s as the type for histories, w as the type for worlds, and i as the type for times. I will use the variables h, i, j, k for histories and s, t, u, v for times.

> **Definition 1: Intervals and Instants** For all t, u, v,
>
>   i. t is an interval iff t is a non-empty set of times which is dense and linearly ordered by $<$.
>
>   ii. If u, v are instants, then $[u, v] := \{t : u \leq t \leq v\}$.
>
>   iii. If u, v are instants, then $(u, v) := \{t : u < t < v\}$.
>
>   iv. $[u, v)$ and $(u, v]$ are also defined accordingly.

> **Definition 2: Histories** For history h, world w, and times t, u,
>
>   i. If $h = \langle w, t \rangle$, then $\omega(h) := w$.
>
>   ii. If $h = \langle w, t \rangle$, then $\tau(h) := t$.

  iii. $h|u$ is defined iff $\tau(h) \cap u \neq \emptyset$; if defined,
    $h|u := \langle \omega(h), \tau(h) \cap u \rangle$.

  Histories can be thought of as temporal sections of worlds, but they are formalized as pairs of worlds and times. The operator | can be used to restrict the temporal component of a history by reference to another interval, but can only be used if the result is a proper interval; thus $h|t$ is only defined if $\tau(h) \cap t$ is non-empty.

  Definition 3: Partial Histories   For world w and time t,

   i. The maximal history of w: $max(w) := \langle w, (-\infty, \infty) \rangle$

   ii. The actual history of w at t: $act(w,t) = \langle w, (-\infty, t] \rangle$

   iii. The past history of w at t: $pst(w,t) = \langle w, (-\infty, t) \rangle$

   iv. The future history of w at t: $fut(w,t) = \langle w, (t, \infty) \rangle$

   v. The prospective history of w at t: $pro(w,t) = \langle w, [t, \infty) \rangle$

   vi. Actual histories of t: $\mathcal{A}_t := \{i \colon \tau(i) = (-\infty, t]\}$

   vii. Future histories of t: $\mathcal{F}_t := \{j \colon \tau(j) = (t, \infty)\}$

  Definition 3 defines the terms maximal history, actual history, past history, future history, and prospective history. Note that actual and past histories are distinguished solely by whether their upper bound is included in the interval. Likewise for the future and prospective histories and the lower bound. In principle, histories of any temporal shape might be useful to the study of natural language. In this paper I will make the most use of actual and future histories; maximal, past, prospective, and other kinds of histories may well be needed to describe the temporal characteristics of modals not discussed here. Note that the definitions in Definition 3 are extended in the following way: If h is a history, $max(h) := max(\omega(h))$, etc.

2.2 Verbs

Declarative sentences denote objects of type $\langle i, st \rangle$ — functions from a time and a history to a truth value. I will use the term 'proposition' to refer to objects of such type, unless noted otherwise.

  I assume VPs denote intensional properties of events — functions from an event and a world to a truth value, where ϵ is the type for events.

(25) *VPs; Type $\langle \epsilon, wt \rangle$*
$[\![VP]\!] = \lambda e \lambda w [VP'(e, w)]$

English has two aspectual heads in complementary distribution. If e is an event, let $\tau(e)$ be the run-time or temporal trace of e.

(26) *English Aspectual Inventory; Type $\langle \langle \epsilon, wt \rangle, \langle i, st \rangle \rangle$*
  a. $[\![be/\text{--}ing]\!] = \lambda P_{\langle \epsilon, wt \rangle} \lambda t \lambda h [\exists e [P(e, \omega(h)) \,\&\, \tau(h|t) \subseteq \tau(e)]]$
  b. $[\![PRV]\!] = \lambda P_{\langle \epsilon, wt \rangle} \lambda t \lambda h [\exists e [P(e, \omega(h)) \,\&\, \tau(h|t) = \tau(e)]]$

Note that the analysis of the progressive (26a) is vastly simplified; the imperfective paradox, aktionsart, and many other issues are abstracted away from here. In this paper I focus on perfective cases, making use of (26b).

Examine (26b). Note that $\tau(h|t)$ is equivalent to t if $t \subseteq \tau(h)$. And if t does not overlap $\tau(h)$, then $\tau(h|t)$ is undefined. So the temporal component of the history argument has the effect of narrowing the range of possible times that can be associated with the event.

Crucially the history and time arguments can be manipulated separately (e.g., by modals and tenses respectively) but are ultimately interdependent; if a given history h does not extend far enough to overlap a given time t, then $h|t$ will be undefined. This is exactly what is desired, since the basic phenomenon being studied here is the constraints that certain modals place on temporal interpretation.

2.3 Modals

As discussed above, the domain of a modal is determined by two contextual parameters: a modal base and an ordering source. These (and many other contextual parameters in natural language) are mediated by the use of assignment functions, which map indices to semantic objects. As discourse evolves the assignment function may change, but I will eschew a fully dynamic analysis here in order to focus on the relevant semantic phenomena.

The semantics of the modal maps at least the evaluation world argument it takes to a set of worlds which constitute its domain. Other arguments may factor in as well, such as individual or temporal anchors. I will assume, following many authors, that all modals require a temporal argument for the determination of their domain. I follow Condoravdi (2002) in calling this temporal argument the *temporal perspective* of the modal; elsewhere it is

called the "temporal parameter" of a modal or simply "modal time", among other things.

Given this, a schematic semantics can be given for modals. I assume that modals combine with a propositional radical, an accessibility relation (determined from a modal base), and an ordering source, and return a proposition. Below, the variables f and o range over accessibility relations and ordering sources respectively.

(27)   *Modals*

    a. $[\![modal_\square]\!] = \lambda p \lambda f \lambda o \lambda t \lambda h [\forall k \in \text{BEST}_{o(h,t)}(f(t)(h))[p(t)(k)]]$

    b. $[\![modal_\diamond]\!] = \lambda p \lambda f \lambda o \lambda t \lambda h [\exists k \in \text{BEST}_{o(h,t)}(f(t)(h))[p(t)(k)]]$

Following Hintikka (1969) among many others I assume attitude verbs quantify over worlds as well. However, as Lewis (1979a) and many others argue, attitude verbs must be more complicated, quantifying over *centered worlds* — tuples of (at least) a world, a time, and an individual. This is to account for *de se* and *de re* interpretations of both DPs and tense. This is discussed in greater detail in Section 3, but often it will be sufficient to think of attitude verbs as having a semantics like that in (27a).[12]

I assume that modal bases and ordering sources are represented as silent pronouns at the level of LF, combining with the modal as in (29); for brevity I later treat the ordering source as a lexical feature of the modal.
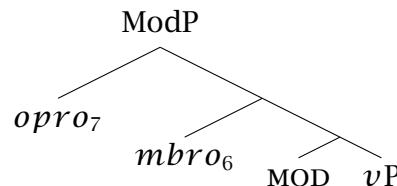
(28)   a. *Modal Base Pronoun*
        $[\![mbro_n]\!] = \lambda t \lambda h \{k \colon \langle k, t \rangle \in \cap(g(n)(t)(\omega(h)))\}$

    b. *Ordering Source Pronoun*
        $[\![opro_n]\!] = \lambda t \lambda h \{p \colon p \in (g(n)(t)(\omega(h)))\}$

(29)

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12 The crucial difference, compositionally, is that a non-attitude modal passes down its time argument, whereas an attitude verb binds the time argument of its prejacent. But I argue in Section 3.4 that the only time this makes a difference truth-conditionally is in cases where the attitude-holder self-locates in a time other than the actual time of the attitude — for example, the attitude holder thinks it's 2pm, when in fact it is 3pm.

2.4 Temporal operators

On my proposal, in embedded clauses, EvalT is determined by the embedding predicate. In matrix clauses, EvalT is equal to ST by default, in much the same way that the evaluation world is associated with the actual world by default. This is captured in the following static definition of truth; any dynamic system could replicate the same result.

(30)   *Static Truth*
       For sentence ϕ, time t, world w,
       an utterance of ϕ at t in w is true iff $[\![\phi]\!](t)(max(w)) = 1$.

The time argument of tenses may be introduced semantically in one of (at least) two ways. There may be pronouns denoting indices which are mapped by the assignment function to times, as in Heim 1994, or times may be quantified over. Following Partee (1973, 1984) and Enç (1986, 1987) I assume the pronominal account for episodic tenses, whereby RT is denoted by a temporal pronoun, but see Ogihara 2011 for discussion of the alternative, and see Sharvit 2014, which proposes that the question of pronoun or quantifier does bear on the analysis of embedded tense.

Following Heim (1994) and Kratzer (1998) I assume that tense features are responsible for restricting the possible values of RT, but I depart from their syntax in assuming that tense and the RT-denoting temporal pronoun are distinct lexical items. I assume tense is a functional head which takes a temporal pronoun in its specifier; this is along the lines of Demirdache & Uribe-Etxebarria (2004) and Stowell (2007). This temporal pronoun (which I term TRO) bears no presuppositions itself, except that the object its index maps to is a time.

A schematic semantics for these lexical items is below; more precise ones are given later.
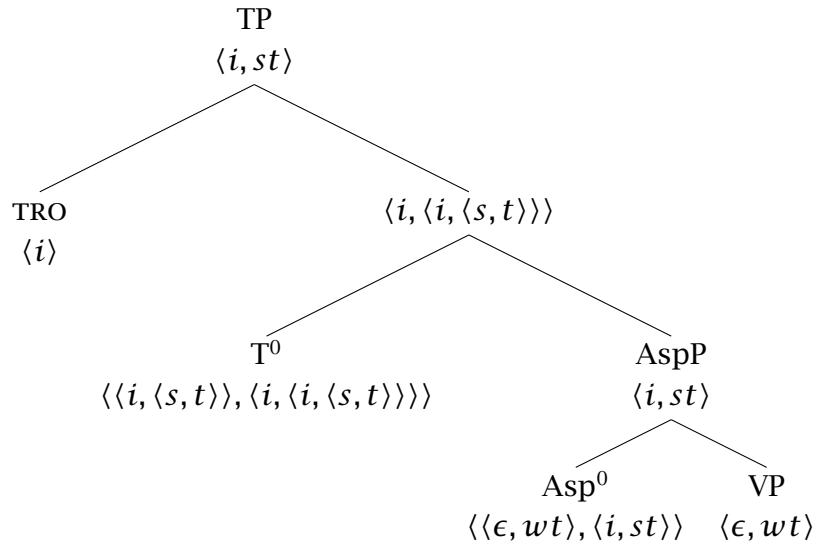
(31)   *Temporal Pronouns; Type $\langle i \rangle$*
       $[\![\text{TRO}_8]\!] = g(8)$ iff $g(8) \in D_{\langle i \rangle}$

(32)   *Temporal Operators; Type $\langle \langle i, \langle s, t \rangle \rangle, \langle i, \langle i, \langle s, t \rangle \rangle \rangle \rangle$*
       $[\![TO]\!] = \lambda p_{\langle i,st \rangle} \lambda t \lambda u \lambda h [p(t)(h) \, \& \, uRt]$

The following schematic tree shows the interaction of the various operators discussed so far (with no modals).

(33)

$$\text{TP}$$
$$\langle i, st \rangle$$

$$\text{TRO}$$
$$\langle i \rangle$$

$$\langle i, \langle i, \langle s, t \rangle \rangle \rangle$$

$$\text{T}^0$$
$$\langle \langle i, \langle s, t \rangle \rangle, \langle i, \langle i, \langle s, t \rangle \rangle \rangle \rangle$$

$$\text{AspP}$$
$$\langle i, st \rangle$$

$$\text{Asp}^0$$
$$\langle \langle \epsilon, wt \rangle, \langle i, st \rangle \rangle$$

$$\text{VP}$$
$$\langle \epsilon, wt \rangle$$

3 The semantic analysis

Here I provide the formal analysis. I first provide denotations for the relevant modals and modal base pronouns, following the schema given above. I then provide denotations for the English tenses. After providing derivations which show the empirical adequacy of my proposal, I address a few concerns that my analysis may raise.

3.1 Modals

Assume the following denotations[13] for the attitude verbs *think* and *hope*; note that i) these denotations are simplified as discussed above, thus they do not quantify over centered worlds and their ordering sources are represented lexically and ii) these denotations differ only in their ordering source. Let ST be the stereotypical ordering source and BO the bouletic ordering source. I assume they are syntactically constrained in terms of what kind of modal base they may combine with, so that *think* can only combine with the doxastic modal base pronoun, while *hope* can combine with either the doxastic or the circumstantial modal base pronoun.[14]

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13 Note that although they are verbs, these attitude verbs are not represented as properties of events; correspondingly, I assume they combine directly with tense rather than with aspect. But nothing hinges on this choice, and the analysis could be easily modified to allow for representation of hoping and thinking events, etc.

14 Let $\text{ST}_{h,t,x}(f(t)(h))$ abbreviate $\text{BEST}_{\text{ST}(h,t,x)}(f(t)(h))$; likewise for BO.

(34)   Attitude Verbs (simplified)

    a. $[\![\text{think}]\!] = \lambda p \lambda f \lambda x \lambda t \lambda h [\forall k \in \text{ST}_{h,t,x}(f(t)(h))[p(t)(k)]]$

    b. $[\![\text{hope}]\!] = \lambda p \lambda f \lambda x \lambda t \lambda h [\forall k \in \text{BO}_{h,t,x}(f(t)(h))[p(t)(k)]]$

In each case, the attitude verb takes a prejacent proposition p (denoted by its complement), an accessibility relation f (denoted by the modal base pronoun), an individual x (denoted by its subject), and a time t and history h, and returns true if every history in the set of best histories in $f(x)(t)(h)$ is a history where p is true at t. In the case of *think*, 'best' means best given a stereotypical ordering, and in the case of *hope*, a bouletic ordering.

    I assume at least the two following modal base pronouns; the crucial temporal constraints are lexicalized in these.

(35)   *Modal Base Pronouns*

    a. $[\![\text{DOX}_{m,n}]\!] = \lambda t \lambda h \{i \in \mathcal{A}_t : \langle i, t \rangle \in \cap(g(n)(t)(\omega(h)))\}$
          iff $g(n)(t)(\omega(h)) \subseteq \{p : \text{believes}(g(m), p, h, t)\}$

    b. $[\![\text{CIR}_n]\!] = \lambda t \lambda h \{j \in \mathcal{F}_t : \langle act(j), t \rangle \in \cap(g(n)(t)(\omega(h)))\}$
          iff $g(n)(t)(\omega(h)) \subseteq \{p : p(t)(act(h))\}$

    As shown in (35a), the lexical item DOX bears a pair of indices; one maps to an individual, the other maps to a function from a world and a time to a set of propositions. (Recall that propositions are sets of history-time pairs.) The meaning of DOX relative to those indices m, n and an assignment g is then a function from a time t and a history h to the set of actual histories (ending at t) in the intersection of the set of propositions that is determined by applying t and $\omega(h)$ to the function that the assignment g maps the index n to. Crucially DOX also carries the presupposition that g maps n to a subset of the propositions which some agent believes in $\omega(h)$ at t. That agent is determined by the index m, which I assume is bound by the subject in the case of attitude verbs.

    Likewise the lexical item CIR in (35b) bears an index n which similarly maps to a function from a world and a time to a set of propositions. However, CIR maps a time t and history h to the set of future histories (departing from t) such that for each future history in the set, its actual history is in the intersection of the set returned by applying t and h to the function that g maps n to. And crucially CIR presupposes that the set of propositions returned by applying t and h to $g(n)$ is a subset of the propositions true at the actual history of $\omega(h)$ at t.

More succinctly, (35a) takes individual, time, and history arguments and returns the set of actual histories compatible with a given set of propositions that individual knows/believes at that time and history. (35b) takes the same arguments and returns the set of future histories whose maximal history is compatible with a given set of propositions which are true at that time and history.

Note what is not being formalized here, namely the constraints on possible meanings of modals or possible modal bases. Neither is the mechanism (which I assume is syntactic) which determines which modals (or attitude verbs in this case) can combine with which modal bases — that is, how the pairing of (34a) with (35b) is ruled out. The theory as presented here may therefore predict too much variation, both within English and cross-linguistically. But I leave these details to future research.

3.2 Tense

I propose that tenses have a strictly relative meaning. This follows from the schematic denotation given for tenses and temporal pronouns above and the assumption that there are no other higher semantic operators within the clause which scope over the tense operator and interact with it. This relative account is directly motivated by data like (36).

(36)   Alan will give$_i$ an A to every student who turned$_j$ in their homework on time.

To account for simultaneous readings seen in (37), repeated below, I also adopt a version of SOT, namely a tense agreement rule (Kratzer 1998, Schlenker 2004). A polarity account a la Stowell (2007) would do just as well. See Section 5 for my reasons for not choosing a deletion account of SOT.

(37)   a.   On the 23rd, Martina thought$_i$ Carissa was$_j$ pregnant.
        b.   *Paraphrase:* Martina thought to herself "Carissa is pregnant".

To account for the relative future reading of (38), I propose that the Present Tense is actually semantically non-past. This is not a novel proposal. S. Kaufmann (2005) makes it for English, and the same claim has also been made for the 'present' tenses of many other languages.

(38)   Martina hoped Carissa got pregnant.

Since a Past-under-Past may actually be interpreted as relative non-past, relative future readings in cases like (39) must be ruled out. This is handled by the theory of modality articulated above. In (38), *hope* quantifies over future histories, so future temporal reference (but not past or present) is allowed. Since *think* in (39) quantifies over actual histories, past and present temporal reference (but not future) is allowed. Derivations are given later in this section.

(39)   Martina thought Carissa got pregnant.

This proposal of course makes the prediction that the Present Tense should have future reference in cases where it is not embedded under the past tense as well. This prediction is born out by (40a).

(40)   a.   Martina hopes Carissa gets pregnant.
        b.   Martina hopes Carissa got pregnant.

Future reference in a clause embedded under Present Tense is possible only with Present Tense. Past reference in a clause embedded under Present Tense is possible only with Past Tense. On the present theory, the same goes for clauses embedded under Past Tense; this is just obscured by agreement.

Future reference with Present Tense can be seen in other contexts, further supporting this proposal.

(41)   a.   If John *leaves*, Mary should stay.
        b.   I have to pull the car around before he *gets* back.

(42)   He put up a sign so she *sees* where to go.

In (41a-b) the Present Tense is interpreted in the scope of a circumstantial modal and in both cases has a future reading. In (42), Present is in the scope of *so*, which I assume also has a circumstantial modal meaning.

Denotations for the tenses are given below.

(43)   *English Inventory of Tenses*
        a. $[\![\text{PAST}]\!] = \lambda p \lambda t \lambda u \lambda h [p(t)(h) \ \& \ u > t]$
        b. $[\![\text{NPST}]\!] = \lambda p \lambda t \lambda u \lambda h [p(t)(h) \ \& \ u \le t]$

Reference Time in a given clause is therefore constrained by three factors, two of which have already been discussed extensively. The first is the contribution of tense itself, seen above. The second is the contribution of the immediately

scoping modal, as outlined in prior sections. The third, briefly mentioned above, is aktionsart, which limits the use of eventives with the simple episodic reading of Present Tense; I make no attempt to spell out this last constraint since it plays no special role in my proposal, but will simply note that this third factor is what is relied on to rule out the episodic reading of (44a) as well as the episodic simultaneous reading of (44b).[15]

(44) a. *John eats a hamburger.
      b.   John said he ate a hamburger.

Note that, with the move to treating Present Tense as a non-past, (45a) should be acceptable, with the same essential meaning as (45b).

(45) a. *It rains tomorrow.
      b.   It's gonna rain tomorrow.

The meaning of the non-past is not quite the same as that of predictive expressions like *will* and *gonna*, however. Klecha (2014b) shows that those English predictive expressions are modals rather than simple temporal operators, based on a number of diagnostics, supporting previous claims made by Condoravdi (2002, 2003), Copley (2002), S. Kaufmann (2005) and others; see also Giannakidou & Mari (2016a, 2016b) for arguments for Italian and Greek futures. One diagnostic employed by Klecha for English is modal sub-

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15 A reviewer asks whether aktionsart plays a bigger role, pointing out the apparent lack of a future-oriented reading of (i).

(i)   Mary hoped she was pregnant.

First of all, I would point out that, given an appropriately rich context, a future-oriented reading is possible.

(ii)   Mary knew that her parents would arrive a week later. She hoped she was pregnant by then.

I won't speculate as to why future-oriented readings are hard with statives, but I will simply point out that this is a general problem. In both of the following, a future-oriented reading is strongly dispreferred; this is ameliorated by additional context or changing the verb to an eventive one.

(iii) a.   Mary hopes she is pregnant.
       b.   John might be pregnant.

ordination. Only modals should give rise to implicit conditional meanings due to modal subordination.

(46)   a.   Martina might have gone to New York. #She had fun.
       b.   Martina might go to New York. She'll have fun.

Only (46b) gives rise to modal subordination; (46a) does not.

But what is the motivation for treating predictive expressions as modals rather than temporal operators? In other words, why should English lack an apparently much simpler strategy for future reference? Why not have tenses instead of modals? As argued above, it is not that English lacks a future tense; it has one in the form of the non-past. So why then can it not be used in matrix contexts with future reference?

The answer is that there is a 'Matrix Upper Limit Constraint', motivated by the notion discussed above that the future is inherently unknowable. S. Kaufmann's (2005) approach to this (his Certainty Condition) is to posit a covert epistemic necessity modal which scopes over all sentences. Since the future can never be truly known, a simple epistemic necessity claim about the future can never be true. Thus any simple future reference is ruled out pragmatically.

What is troubling about this approach is that (45a) is not merely 'too strong' or otherwise pragmatically odd; it sounds entirely ill-formed. Thus while plenty of propositions about the present and past are also, given what we know, impossible to be sure about, they do not sound categorically ill-formed, just too strong.

(47)   The last thought to go through Ötzi the 5000 year old mummy's mind just before he died was about fish.

The framework introduced above, however, provides a very simple way to derive the *ill-formedness* of (45a): since epistemics constrain their prejacents to have only present or past orientation, the same epistemic modal posited by Kaufmann should itself have the effect of limiting its prejacent to only present or past orientation. No additional pragmatic constraint is required. Moreover, S. Kaufmann (2005) is not the only author to propose this covert epistemic necessity modal; see also Kratzer (2012). The non-futurity of the

Non-Past Tense in matrix contexts is therefore accounted for in exactly the same way as when it is embedded under visible doxastic/epistemic modals.[16]

3.3 Derivations

Consider (48), a forward shifted case of Past-under-Past.

(48)   Bill hoped it rained.

First, a number of silent features must be fixed: there are temporal pronouns in both the matrix and embedded clauses, and the modal base pronoun taken by the attitude verb is the circumstantial one. And the embedded tense is base generated as Present, rather than Past.

Next consider the morphosyntactic lifespan of this expression. The embedded tense remains semantically non-past throughout the derivation; no deletion rule or anything else alters its interpretation. An SOT rule will, however, alter the morphological features of this tense or, perhaps more accurately, the morphological features of the main verb in the same clause as this tense. This SOT rule can be seen as effecting the change from narrow syntax (49a) to PF (49b).[17] LF (49c) is unaffected by this operation.

(49)   *Abridged Syntactic Derivation of (48)*
   a.   NS: [TRO$_5$ PAST$_{[iF:pst]}$ bill CIR$_3$ hope$_{[uF:\_]}$
                              [TRO$_8$ NPST PRV rain$_{[uF:\_]}$]]
   b.   PF: [TRO$_5$ PAST$_{[iF:pst]}$ bill CIR$_3$ hope$_{[uF:pst]}$
                              [TRO$_8$ NPST PRV rain$_{[uF:pst]}$]]
   c.   LF: [TRO$_5$ PAST bill CIR$_3$ hope [TRO$_8$ NPST PRV rain]]

The interpretation of (48), on the analysis of its LF given in (49), is shown in (50). It is derived as in (51).

(50)   *Denotation of (48)*
   a. $\lambda u \lambda h [\forall k \in \text{BO}_{h,g(5),b}(\llbracket \text{CIR}_3 \rrbracket (g(5))(h))[\exists e[\text{rain}(e, \omega(k))$
                    $\& \; \tau(k|g(8)) = \tau(e)] \& g(5) \leq g(8)] \& u > g(5)]$

---

16 A reviewer asks whether this could be subject to variation; the equivalent of (45a) is acceptable, for example, in Russian. Speculating on this is beyond the scope of this paper, but nothing I say here rules out the possibility that this could vary across languages, since it is a feature of the semantics of a particular lexical item — the silent epistemic modal.

17 Of course, this is nothing close to a full morphosyntactic theory of SOT. This is well beyond the scope of this paper.

b. $[\![\mathrm{CIR}_3]\!](g(5))(h) =$
$$\{j \in \mathcal{F}_{g(5)}\colon \langle act(j), g(5)\rangle \in \cap(g(3)(g(5))(\omega(h)))\}$$

(51) *Semantic Derivation of (48)*

i. $[\![\mathrm{rain}]\!] = \lambda e \lambda w [\mathrm{rain}(e, w)]$

ii. $[\![\mathrm{PRV}]\!] = \lambda P_{\langle \epsilon, \omega t \rangle} \lambda t \lambda h [\exists e[P(e, \omega(h)) \& \tau(h|t) = \tau(e)]]$

iii. $[\![\mathrm{PRV\ rain}]\!] = \lambda t \lambda h [\exists e[\mathrm{rain}(e, \omega(h)) \& \tau(h|t) = \tau(e)]]$

iv. $[\![\mathrm{NPST}]\!] = \lambda p \lambda t \lambda u \lambda h [p(t)(h) \& u \le t]$

v. $[\![\mathrm{NPST\ PRV\ rain}]\!] =$
$$\lambda t \lambda u \lambda h [\exists e[\mathrm{rain}(e, \omega(h)) \& \tau(h|t) = \tau(e)] \& u \le t]$$

vi. $[\![\mathrm{TRO}_8]\!] = g(8) \text{ iff } g(8) \in D_{\langle \tau \rangle}$

vii. $[\![\mathrm{TRO}_8\ \mathrm{NPST\ PRV\ rain}]\!] =$
$$\lambda u \lambda h [\exists e[\mathrm{rain}(e, \omega(h)) \& \tau(h|g(8)) = \tau(e)] \& u \le g(8)]$$

viii. $[\![\mathrm{hope}]\!] = \lambda p \lambda f \lambda x \lambda t \lambda h [\forall k \in \mathrm{BO}_{h,t,x}(f(t)(h))[p(t)(k)]]$

ix. $[\![\mathrm{hope\ TRO}_8\ \mathrm{NPST\ PRV\ rain}]\!] =$
$$\lambda f \lambda x \lambda t \lambda h [\forall k \in \mathrm{BO}_{h,t,x}(f(t)(h))[\exists e[\mathrm{rain}(e, \omega(k))$$
$$\& \tau(k|g(8)) = \tau(e)] \& t \le g(8)]]$$

x. $[\![\mathrm{Bill\ CIR}_3\ \mathrm{hope\ TRO}_8\ \mathrm{NPST\ PRV\ rain}]\!] =$
$$\lambda t \lambda h [\forall k \in \mathrm{BO}_{h,t,b}([\![\mathrm{CIR}_3]\!](t)(h))[\exists e[\mathrm{rain}(e, \omega(k))$$
$$\& \tau(k|g(8)) = \tau(e)] \& t \le g(8)]]$$

xi. $[\![\mathrm{PAST}]\!] = \lambda p \lambda t \lambda u \lambda h [p(t)(h) \& u > t]$

xii. $[\![\mathrm{PAST\ Bill\ CIR}_3\ \mathrm{hope\ TRO}_8\ \mathrm{NPST\ PRV\ rain}]\!] =$
$$\lambda t \lambda u \lambda h [\forall k \in \mathrm{BO}_{h,t,b}([\![\mathrm{CIR}_3]\!](t)(h))[\exists e[\mathrm{rain}(e, \omega(k))$$
$$\& \tau(k|g(8)) = \tau(e)] \& t \le g(8)] \& u > t]$$

xiii. $[\![\mathrm{TRO}_5]\!] = g(5) \text{ iff } g(5) \in D_{\langle \tau \rangle}$

xiv. $[\![\mathrm{TRO}_5\ \mathrm{PAST\ Bill\ CIR}_3\ \mathrm{hope\ TRO}_8\ \mathrm{NPST\ PRV\ rain}]\!] =$
$$\lambda u \lambda h [\forall k \in \mathrm{BO}_{h,g(5),b}([\![\mathrm{CIR}_3]\!](g(5))(h))[\exists e[\mathrm{rain}(e, \omega(k))$$
$$\& \tau(k|g(8)) = \tau(e)] \& g(5) \le g(8)] \& u > g(5)]$$

There are three crucial terms in (50a), as derived by (51). The first is (52).

(52) $\lambda u \lambda h [\ldots [\ldots g(5) \le g(8)] \& u > g(5)]$

By the definition of Static Truth in (30), u in (52) ends up as ST. So $g(5)$ (i.e., matrix RT) is prior to ST by the contribution of matrix Past Tense, and $g(8)$ (i.e., embedded RT) is no earlier than $g(5)$, by the contribution of embedded Present Tense. Thus it could be that $g(8) = g(5)$, or that $g(8) > g(5)$; let's suppose the latter.

(53) $\dots \forall k \in \mathrm{BO}_{h,g(5),b}(\llbracket \mathrm{CIR}_3 \rrbracket(g(5))(h)) \dots$

Note that $\mathrm{BO}_{h,g(5),b}(X)$ determines a subset of X. Moreover, $\llbracket \mathrm{CIR}_3 \rrbracket(g(5))(h)$ is a subset of $\mathcal{F}_{g(5)}$. Therefore by the definition of $\mathcal{F}$, k ranges over histories whose time component is $(g(5), \infty)$.

(54) $\dots \tau(k|g(8)) = \tau(e) \dots$

The variable e is existentially bound and represents the (hoped-for) rain event. $\tau(e)$ is therefore embedded ET. Recall that for all x, y, $\tau(x|y) = y$ if $y \subseteq \tau(x)$. Since $g(8) \subseteq (g(5), \infty)$, it must be (for all k) that $\tau(k|g(8)) = g(8)$.

Suppose now that we replaced the circumstantial modal base in the above LF and derivation with a doxastic one. That would result in the same denotation, except that section in (53) would be replaced by (55).

(55) $\dots \forall k \in \mathrm{BO}_{h,g(5),b}(\llbracket \mathrm{DOX}_3 \rrbracket(g(5))(h)) \dots$

This will fail because $\llbracket \mathrm{DOX}_3 \rrbracket(g(5))(h)$ is a subset of $\mathcal{A}_{g(5)}$; therefore k ranges over histories whose time component is $(-\infty, g(5)]$. Now, $\tau(k|g(8))$ will be undefined unless $g(8) \subseteq (-\infty, g(5))$, which, given the contribution of NPST, can only happen if $g(8) = g(5)$. The attitude verb *think*, and others like it, are compatible only with a doxastic modal base, so they will look just like this second case, having only a present reading with NPST. The upper limit for such verbs (but not for *hope*) is thus derived.

3.4   Caveat: Temporal *de se*

One way in which the theory laid out about is obviously insufficient is that it does not account for *de se* readings of tense. Consider (56).

(56)   Jackson thinks he is in Miami.

A simple way to analyze (56) would be to say that embedded RT is strictly equal to matrix RT/ET — the time that Jackson has the thought is the same

as the time that Jackson is thinking about. Such a coarse view is sufficient to account for most cases.

But a complicating factor discussed at length by Ogihara (1995), von Stechow (1995), Abusch (1997), Kratzer (1998), Schlenker (2004) and others is the possibility of what are called *de se* readings of embedded tense, like in (57).

(57)   Jackson thinks$_i$ it's$_j$ 10 o'clock (but really it's 11).

Since we have a Present Tense embedded under a Present Tense, on the naïve view, the time of thinking should be the time of it being 10 o'clock ($RT_i = RT_j$). But this leads to a contradiction, since it is really 11 o'clock. It is fine of course for Jackson to have a false belief, but it is much less fine for him to have a contradictory belief. And of course we would never describe him as having the belief that 'it is 10 o'clock at 11 o'clock'.

Rather, we should say something like this: Jackson doxastically self-locates at 10 o'clock. Or put another way, a doxastic model is not, as we might otherwise think, a set of worlds, such that the believer thinks that one of them is the real world, but rather a set of world-time pairs, such that the believer thinks one of the pairs contains the real world and the current time. On this view, attitude verbs quantify over *centered worlds* or world-time pairs (or in our case, history-time pairs).[18]

When the attitude binds a variable to the centered worlds that it quantifies over, that is a *de se* reading of the expression that provides that variable. On anyone's theory of attitude verbs, if an embedded tense is not deictic, it is *de se*—what we have been calling relative.

Thus evaluation time for the prejacent is naturally the time variable quantified over by the attitude verb, much as the evaluation world for the prejacent is the world variable so quantified over. So the 'simultaneous' reading of (1) is not really simultaneous with matrix clause RT or ET, but rather with the time quantified over by the attitude verb, which is the evaluation time of the embedded clause. Embedded EvalT is related to matrix ET much the same way the embedded evaluation world is related to the evaluation world of the embedding modal: by the accessibility relation of the modal. This allows for the possibility that a person could be wrong about what time it is. Consider (58), adapted from Schlenker 2004:

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18 Other kinds of *de se* readings are possible; see Lewis 1979a; for this reason centered worlds should be at least as complex as world-time-individual triples, or perhaps more complex tuples.

(58)   *Context: The year is 2002.*
       In 1999, Mary believed that it was already 2005, and she thought that
       Clinton was still president.

Here, the reference time of the embedded clause is, relative to utterance
time, future. But this is not analogous to the *hope* data — the embedded RT
is still present relative to the evaluation time of the clause (i.e., the time Mary
believes it to be). If Mary were to verbalize her belief she would say, "Clinton
is still president now." Thus her belief is still a present-oriented one in the
relevant sense.

   It's worth pointing out that Schlenker (2004) *does* pin the future-oriented
behavior of *hope* on this "shifting" property of *de se*. It should be stressed
that Schlenker does not make accounting for this property of *hope* a central
goal, nor does he even acknowledge that *hope*'s behavior is unusual; it is
certainly an off-hand analysis. But as the only other account or mention of
the future-orientation of *hope*, I feel the need to address it.

   Schlenker provides an analysis for (59) in which the RT of the embedded
clause is interpreted as relative-present, with a *de se* reading of tense.

(59)   He hopes he is elected.

This requires saying that *hope*, like *believe* in (58), has a perspective which
is future relative to utterance time. But this suggests something very odd
about the context of utterance for (59), namely that the agent of the hoping
has a hope about what time it is that does not reflect reality. In other words,
for (60a) to have the reading it does, the speaker must also be committed to
(60b).

(60)   *Context: The year is 2002.*
       a.   He hopes he is elected in 2003.
       b.   He hopes it is 2003.

We can imagine scenarios in which a person wakes up from a coma and
has a hope about what year it is (i.e., a hope about how long they were
unconscious), but this is a very special case that is not implicated in any of
the future-oriented examples for *hope* or *pray* discussed above. Moreover, if
(60a) really is present-oriented with a future-shifted perspective, it should

be infelicitous, since eventive predicates like *elect* are not licensed (see discussion of aktionsart above).[19]

So appeal to *de se* semantics alone cannot account for *hope*. Note that such an account may in fact explain apparent future-orientation of verbs like *dream* and *imagine*.[20]

(61)   (In 2015,) She dreamed she graduated college in 2016.

These may in fact be cases of genuine future-shifted perspective (and present-orientation), because in these cases, the perspectival center seems to be future-shifted as well.

(62)   a. #She dreamed it was 2015, and that she graduated in 2016.
        b.   In 2015, she dreamed that it was 2016 and she was graduating.

Note that nothing about the theory I present in Section 3 above precludes enriching the meaning of attitude verbs to allow for quantification over centered worlds (centered histories) and capturing *de se* readings like (62); and such a move surely must be made to fully account for all the facts. I have only saved this discussion until now in order to simplify the discussion and the denotations, since invoking *de se* semantics is not critical to explaining the relevant facts on my theory. In Appendix B, I provide a worked out example of an enrichment of the present proposal to account for *de se* cases.

4   The temporality of modals

In this section I review other approaches to the relation between modality and temporality and explain why the approach outlined above is superior.

4.1   How modals constrain the temporality of their prejacents

The idea that modals may affect the temporal interpretation of their preja-cents is certainly not a new one. Abusch (2004) was the first to have noted variation in temporal orientation among attitude verbs, namely non-finite

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19 To be clear, (i) is acceptable to the extent that it can be read as a result-state, meaning more or less 'I think I have been elected'. But I don't think such a reading is possible.

(i)   #I think I am elected.

20 Thanks to a reviewer for raising this point.

embedding attitude verbs; Katz (2001) also provided an analysis of the phenomenon.

The proposals offered by Abusch and Katz both involve the modal actually binding the open time argument in its complement, which corresponds to the EvalT of the embedded tense. Katz goes further and argues that certain modals, namely the future-oriented ones, actually bind *both* EvalT and RT. This move forces a stipulation that in a case like (63), the finite complement must have two open time arguments to be bound.

(63)   Alec expects that Zach will drive to school.

This is not unreasonable — many accounts of tense posit that tenses simply provide the relation between times, not introducing a temporal pronoun or a quantifier over times. This view divorces tense from RT and posits that a silent pronoun, a silent existential, or a default rule of existential closure may then bind off RT. This view is usually espoused in light of data like (64).

(64)   Zach drove to school three times last week.

Since *three times* is taken to bind RT, it cannot be that the past tense in (64) itself introduces an RT pronoun or existentially quantifies over RT. But for the same reason, Katz's account falters.

(65)   Alec expects that Zach will drive to school three times next week.

If we take *three times*, or other expressions like *often* or *usually* to bind RT, it cannot also be bindable by the matrix verb.

Abusch, on the other hand, has the modal bind only EvalT. In order to account for the future-shifting behavior of attitude verbs like *want*, Abusch proposes that such attitude verbs incorporate a future-shifting element.[21] This element has the semantics given to *will* by Abusch (1998) — having the effect of shifting EvalT into the future.

But this account does not extend to cases in which modals embed finite clauses. Take *hope*, which can be future-oriented. If we account for this by positing that its future-oriented behavior is due to a future-shifting property of its meaning, then (66a) should be able to have the meaning that (66b) does, namely, past with respect to a future time.

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21 This future-shifting element is represented on its own branch in the tree as if it were a separate lexical item from the modal itself, but Abusch is non-committal as to whether its meaning should be incorporated into the lexical item itself.

(66)   Mary may leave tomorrow, but she hasn't decided yet. John won't find out either way until he gets back home the day after.

    a.   He's going to get back home on Tuesday, and *I hope she left (when he does).

    b.   He's going to get back home on Tuesday, and I hope she has left when he does.

The past-from-the-future reading of (66b) can be explained if Present Tense allows for future temporal reference, with the perfect having a past-shifting meaning. The unacceptability of (66a) shows that the meaning of *hope* alone is not sufficient to shift EvalT of the embedded clause into the future.

Condoravdi (2002) faces a similar problem for modal auxiliaries. Observing that an 'unmarked' instance of *might* can have a future or present reading, she builds future-shifting into the meaning of the modal, essentially like that in (67).

(67) $\llbracket \text{might} \rrbracket = \lambda P \lambda w, t [\exists w' \in MB(w,t)[AT([t,\infty),w',P)]]$

The operator AT is defined in such a way that encodes existential quantification if P is an event property. So (68a) is true if there is some accessible world in which there is a raining event whose runtime is *contained in* the interval $[t,\infty)$.

(68)   a.   It might rain.
       b.   It might have rained.

But if P is a property of times, which is what the phrase headed by the perfect aspect in (68b) denotes, then AT simply applies its time argument to that property. So the backshifting semantics of *have* is not applied to some time *within* the future interval, but rather the whole future interval itself. This cleverly allows for the pure-past reading of (68b). But this is a faulty prediction too, since *might have* is capable of getting the same future-shifted-then-past-shifted reading seen in (66b).

(69)   Don't go book your ticket to Cuba for next summer just yet.
       The government might have re-established the embargo (by then).

So there has to be some element distinct from the modal itself which imparts the future-shifting.

This is the central claim of the paper, and what distinguishes my claim from prior approaches: Modals and attitude verbs may *constrain* the RT of their prejacents and require them to bear a certain relation to their EvalT, but they cannot cause an RT to shift. If a modal requires its prejacent to have a future RT, then a future-shifting operator is still separately needed in the prejacent to introduce it.

Another problem for claims like Abusch's, Katz's, and Condoravdi's comes from modal auxiliaries and modal (non-attitude) verbs. This is because, as has been shown above, even within a given lexical modal auxiliary or modal verb, the modal domain may vary contextually and crucially, the temporal orientation varies with it. So this is a secondary claim of the paper: The constraints that modals impose may vary with the modal domain of that modal. Thus the temporal constraints should be wired into the modal domains themselves, rather than the lexical entries for particular modals and attitude verbs.

4.2 Why modality and temporality co-vary

Since temporal orientation may vary within a given modal, depending on its modal base, one way to handle this might be with a systematic constraint, either as a constraint on well-formed LFs or on interpretation/assignment functions or as a truly pragmatic constraint on felicitous utterances.

Condoravdi (2002) takes the former route, proposing that present and past orientations for metaphysical possibility modals are ruled out by the ingenious Diversity Condition. The Diversity Condition is a constraint on modal bases that may be "assigned" by the context to a modal; so this could be read as a constraint on assignment functions. The Diversity Condition says that the modal base of *might* must be diverse with respect to the prejacent — there must be p and not-p worlds in the domain. Thus given that all worlds metaphysically accessible from a given evaluation world are identical to that evaluation world up to evaluation time, Diversity is guaranteed not to hold for all non-future times. This captures the generalization that metaphysical modals do not have past/present orientations.

However, this does not help us constrain the temporal orientation of necessity modals, since necessity modals universally quantify over their domain. In fact the Diversity Condition, as explicitly formulated by Condoravdi, applies only to possibility modals when their modal bases are metaphysical. It's unclear how a constraint could actually be stated formally to apply only

to possibility modals. A perhaps simpler route would be to say that this is a lexical presupposition of *might*, but again, this would do nothing for us with regard to necessity modals. If a necessity modal had this presupposition, it would always result in a contradiction or a tautology.

Werner's (2006) proposal is that necessity modals are saved by the omnipresence of an ordering source; in cases where there is an ordering source, the modal *base* may be diverse, while the modal *domain* is not. Thus necessity modals may satisfy Diversity (or what Werner calls 'Disparity') while still being true. For Werner, this is a truly pragmatic constraint.

However, this does not extend to temporal constraints on epistemic modals, like those seen in (15). In order to account for this, Werner proposes a Non-Disparity Principle, which he claims is a violable constraint on all modal expressions which says: "A proposition must make no distinction between speech-time branching worlds" (Werner 2006: p. 248). When it "conflicts" with the Disparity Principle, the Non-Disparity Principle does not hold. However, in the case of epistemics, this constraint can hold and, according to Werner, has the effect of restricting to a present or past interpretation only.

It's not clear what the motivation for the Non-Disparity Principle is, however, or how to formalize it. Moreover, Werner's proposal requires all necessity modals to have a non-empty ordering source, lest they be filtered out by the Disparity Principle. This seems unlikely, especially in the case of purely logical modals, like (70).

(70)   It logically must be the case that 1 + 1 = 2.

Thus, while the Diversity/Disparity approach is able to capture some modal constraints on temporal reference, it fails to get them all.

I propose a different approach, in which modals quantify over partial histories, with different kinds of modals quantifying over different kinds of intervals. If the difference between, for example, circumstantial and epistemic readings of *have to* comes from different modal base pronouns in the syntax, then modal-temporal correspondences can be captured by positing that those modal base pronouns encode different temporal orientations. All that's needed are the denotations I provide and simple principles of compositionality; no additional constraints on well-formed meanings are required, nor any additional pragmatic rules. As noted above, however, there is a good pragmatic motivation for these correspondences.

This approach to the Upper Limit Constraint is identical in spirit, if not in implementation, to Abusch's (1997). Abusch relies on the exact same motiva-

tion; the future viewed as inherently unsettled and therefore unknowable. The constraint against referring to a future time, even a relative future, derives from our inability to know the future directly. This is only a motivation for Abusch (as it is for me); she relies on Heim's (1994) method of fleshing out of this constraint as a presupposition imposed directly by the interpretation function. It is a constraint on T nodes, which are obligatorily mapped to temporal-pronoun type meanings with the added presupposition that they may not temporally follow local evaluation time. Schlenker (2004) also proposes a variant which does not depend on morphosyntactic labels. But the theory presented here is superior for two reasons. First, it does not require an additional semantic constraint beyond lexical meanings and principles of composition to explain the full range of data. But second, and more importantly, it explains the status of *non*-doxastic attitude verbs like *hope* in a principled way as well.

Anand & Hacquard's (2008) proposal is also motivated by the same concerns. On their account, simultaneous readings are derived by deletion (a kind of SOT rule). But *all* non-simultaneous readings are derived by *de re* interpretation. Since *de re* interpretation is mediated by contextually provided functions known as *acquaintance relations* (Lewis 1979b), Anand & Hacquard capture the Upper Limit Constraint by imposing it as a constraint on possible acquaintance relations. If we were to assume that this constraint could be sensitive to attitude-type, it could perhaps even extend to the new data I have presented here. But there are several problems with this. First, there are arguments against *de re* treatments of embedded tense (Gennari 2003). Second, (8) shows that Past tense under *hope* does not constrain the embedded RT to be prior to ST, which a *de re* theory would predict. Third, it does not extend to modal auxiliaries.

Lastly, on the topic of modal-temporal covariance, it is worth mentioning that Condoravdi (2002) claims that some epistemic possibility modals are compatible with future orientation, contrary to the generalization I made above. She provides an example like the following.

(71)   a.   John is going to meet either the provost or the dean.
        b.   It has been decided who he will meet, but I don't know who it is.
        c.   He may meet the dean, and he may meet the provost.

However, my judgment is that (71c) is infelicitous in the context of (71a-b); it sounds contradictory with regard to whether or not who John will meet is settled.[22]

Consider another contrast, which may make this point more clearly. Epistemic modals, when embedded under certain attitudes, are known to take as their modal base the content of the attitude that embeds them (Anand & Hacquard 2013). Metaphysical modals do not behave this way. But when *might* is embedded under an attitude verb, it only relativizes to this content when past/present-oriented.

(72)   *The police have learned that a radical front is planning to assassinate the mayor. They figure out that the front has hired someone, whose identity remains a mystery, to do this. Whoever has been hired will definitely try to kill the mayor, and is currently preparing to do so. There is evidence suggesting that this person is John, as well as evidence suggesting that this person is Bill. I know all of this and wish to communicate some of it to you, so I say...*

     a. The evidence suggests that John might have been hired to shoot the mayor.

     b. The evidence suggests that John might be preparing to shoot the mayor.

     c. #The evidence suggests that John might shoot the mayor.

(72c) is meaningful, but it does not mean (73), which it ought to mean if future-oriented-*might* can be epistemic.

(73)   The evidence suggests that it's possible that John is going to try to kill the mayor.

Instead, it is consistent with the following scenario: p is true iff John is going to, at some future point in time, flip a coin, and then, iff it comes up heads, attempt to kill the mayor; and the evidence suggests that p is definitely true. Another scenario consistent with (72c) is one where John has *definitely*

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22 A reviewer asks whether I predict (71c) to be acceptable because I allow for the possibility of a futurate under *may*. It's true that I predict (71c) to be exactly as good as (i), but I think (i) is quite bad given a setup of (71a-b).

(i)   #John meets the dean.

I don't know why (i) is bad, but that is for a theory of futurates to explain.

(according to the evidence) been asked to serve as hitman, but he has yet to make up his mind as to whether he'll follow through with it. But (72c) is not consistent with the scenario laid out in (72).

Admittedly, these are subtle judgments. Unclarity about whether there is a future-epistemic reading for possibility modals is unsurprising since *might* and similar possibility modals (*may*, *could*) are all compatible with future-metaphysical readings, and the distinction between the two is very fine. Classically, the metaphysical modal base is a superset of the epistemic modal base (the set of true propositions is a superset of the set of known propositions), so the metaphysical modal domain is always a subset of the epistemic modal domain. Therefore, metaphysical possibility entails epistemic possibility. What's more, finding a context in which metaphysical possibility is false but epistemic possibility is true is difficult because epistemic modals are anchored to the knowledge of the speaker, the assessor, the common ground, or some other thing which is ultimately reflective of the speaker's knowledge state. So asserting the metaphysical impossibility of a proposition makes it pragmatically impossible to assert epistemic possibility of the same proposition.

My claim, that *might* cannot have a future-oriented, epistemic reading, therefore, does not rest solely on this data; it is also simply the best way to explain the pattern which is observed in other modals.

As mentioned before, *must, have to*, and *got to* are all incompatible with future-oriented readings; it's also true that none of them are compatible with metaphysical readings. The epistemic reading of *can*, only possible when negated, cannot be future-oriented. The modal adjective *possible* is epistemic when it embeds a finite complement, and circumstantial (ability) when it embeds a non-finite complement; only in the latter case can it be future-oriented.

(74)   a.   He cannot be home already!
         b. #He cannot be home tomorrow!
           (Intended meaning of (74b): 'It must not be the case that he's going to be home tomorrow!')

(75)   a. *It's possible that he leaves.
         b. It's possible for him to leave.

The simplest way to explain this data is to posit that i) epistemics are past/present-oriented, ii) metaphysicals are future-oriented, and iii) *might*,

may, and *could* have both metaphysical and epistemic readings, which are very difficult to distinguish except in their temporal properties, resulting in mixed judgments.

5   Sequence of tense

In this section I review concerns that arise due to the choice of Sequence of Tense rules. Particularly I examine hybrid analyses, which dispense with SOT rules, and deletion accounts, which implement SOT as a semantic rather than morphosyntactic transformation. Finally I consider the issue of Present-under-Past, which is on its face problematic for the agreement account of SOT I adopt here.

5.1   Hybridity

While the discussion at the very beginning of this paper sets up a contrast between deictic/ULC theories on the one hand and relative/SOT theories on the other, most analyses of embedded tense straddle this divide in one way or another. One example is what can be called the Hybrid Theory of embedded tense, which embraces *both* deictic and relative tense relations, while eschewing *both* the ULC and SOT rules. This was first proposed by Gennari (2003) and has been revived by Altshuler & Schwarzschild (2013a,b).

On this view Past Tense has a simple relative denotation along the lines of what I adopt. Present Tense, however, has a mixed deictic/relative interpretation, as in Gennari's formulation below; it also has features of both traditional analyses of Present Tense, as well as the non-past proposal offered here and elsewhere. Let $*$ mean 'overlap'.

(76) $[\![\text{pres}]\!]_{hyb} = \lambda P \lambda t [\exists u [u * t \,\&\, \neg(u < st) \,\&\, P(u)]]$

Crucial to this approach is the reconsideration of so-called simultaneous readings. Altshuler & Schwarzschild (2013a,b) argue that they do not exist; rather, the illusion of simultaneity results from a simple relative past reading and the absence of an implicature of cessation. Thus (77) has only one reading: where there is a time prior to John's thinking time such that Mary is (believed to be) sick at that time.

(77)   John thought Mary was sick.

On Altshuler & Schwarzschild's account, nothing about (77) rules out the possibility that the believed-sickness-time is in the very near past relative to the thinking time, nor does anything rule out the possibility that the sickness has continued up to and perhaps beyond the time of thinking (unlike in the case of matrix Past Tense, where this is ruled out by scalar implicature, given the alternative provided by Present Tense).

This account cannot extend to the data presented here, however.

(78)   John hoped Mary caught the ball.

(78) can describe a hoped-for catching event which is entirely after the time of hoping. This simply cannot be captured on the assumption that the embedded past tense denotes a simple relative past and cannot represent a deleted or agreed-with tense. On the other hand, if it is indeed true that so-called simultaneous readings really are just a pragmatic illusion, and not derived semantically, then my theory has a very serious difficulty.

Note that Altshuler & Schwarzschild's account is an important predecessor of the present account; they too argue against a uniform ULC, on the basis of (79).

(79)   a.   Customer: I believe you have my bags.
       b.   Employee: Who said I have your bags?
       c.   Customer: The stewardess told me you have my bags.
       d.   Employee: When did she tell you that?
       e.   Customer: On the flight.

Altshuler & Schwarzschild analyze (79c) as a case of temporal *de re*.[23] Temporal *de re* is beyond the scope of this article, so I won't discuss (79) any more, other than to point out that the attitude verb *tell* (on its finite-embeddding use) behaves like other reportatives in imposing an upper limit, at least outside of cases like (79).

(80)   *I told John that it rains tomorrow.

So to the extent that (79c) is acceptable, the present theory does not have an account for it. However, this depends on the analysis of temporal *de re*; I leave the extension of this theory to that domain to future research.

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23 But not Double Access. More on Double Access immediately below.

5.2 Deletion

In this section I argue that the deletion rule proposed by Ogihara (1989) cannot be extended to account for the novel data I present. Of course, since this is novel data, no analysis on the market currently accounts for it. But deletion (and the specific version of agreement posited by Kratzer (1998) which is very similar to it) actually represents a kind of overfit theory in that these proposals are intrinsically unable to account for this data.

Ogihara (1989) proposes that the lower Past Tense on the simultaneous reading of (80) is a fake-past, having just the meaning of a relative present.

(81)   Martina thought Carissa was pregnant.

He accounts for this by positing an LF Tense-Deletion Rule, stated in (82).

(82)   Tense which is c-commanded by another tense of the same type is deleted at LF.

This is a kind of SOT rule which runs in the opposite direction of agreement; while the embedded past in (81) begins its derivational life as a true Past Tense, it is essentially not interpreted.[24] This results in a simultaneous interpretation, (i.e., $EvalT = RT$). Note that the above formulation generalizes for all tense; so the embedded tenses in (83a-b) are both interpreted as having been deleted on this view. This cleverly defuses one argument against deictic treatments of Present Tense, namely the relative reading of (83b).

(83)   a.   Martina thought Carissa was pregnant.
        b.   Martina will think Carissa is pregnant.

This view is also adopted by von Stechow (1995) and Anand & Hacquard (2008). von Stechow (1995) treats English tenses as relations like I do, but where the time arguments are provided anaphorically, rather than as λ-abstracted arguments. For von Stechow (1995) this means that they can have several interpretations depending how the time variables are bound, or not bound. First, a tense can be interpreted deictically, where the evaluation time argument of a tense refers to speech time. Second, a tense can be interpreted relatively, where the evaluation time argument of tense is bound by a higher attitude verb. Third, a tense can be interpreted as 'bound'. According to

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24 Technically it is interpreted as a variable which is then later abstracted over; so it makes no contribution to interpretation.

von Stechow's interpretation of the Tense-Deletion Rule, a deleted tense is not vacuous, but rather denotes a variable ranging over times. This variable can then be bound by the higher attitude verb. Note that this has the same effect as if the deleted tense were simply to denote the identity function. The so-called bound reading therefore differs from the so-called relative reading in terms of what is bound: On the relative reading, evaluation time is bound; on the bound reading, reference time is bound (and evaluation time plays no separate role).

Thus the bound reading corresponds to we have been calling a 'relative present' or simultaneous reading. The relative reading of Past Tense corresponds to what we have been calling relative past. A relative reading of Present Tense would be identical to the bound reading of either tense. Thus von Stechow (1995) accounts for the basic data with a combination of relative and deictic accounts presented above. But this means he must make the stipulations that each of these kinds of accounts require, the first being an SOT rule (deletion).

Relative future readings are predicted for (83a) if the embedded tense is allowed to be deictic — so von Stechow's second stipulation is a constraint against deictic tenses being embedded (at LF); it is this constraint which is functionally equivalent to the ULC for his theory, because it rules out (84).

(84) #On the 22nd, Martina thought Carissa was pregnant on the 23rd.

Kratzer (1998) improves upon von Stechow's constraint against deictic tenses at LF by arguing that it simply falls out from compositional principles. She also replaces Tense-Deletion with an agreement-based implementation of SOT; but note that this crucially differs from what I propose in that what undergoes the agreement is a null-tense, not Present Tense. For this reason, her account is more like deletion accounts than mine, in that fake Past Tense is associated with (essentially) the absence of a semantic tense. So on accounts like Kratzer's and von Stechow's, things actually look very relative: The past can be interpreted relatively, there is some form of SOT rule, and in the case of Kratzer, no version of the ULC even need be stipulated. But where these accounts diverge from mine is that Present Tense is given an analysis which is *not* analogous to the one given for Past.

Given the fragment of von Stechow's account exposited so far, relative present readings (without any of the special inferences of Double Access) are incorrectly predicted for Double Access cases. So von Stechow (1995) further stipulates that Present Tense cannot have a relative interpretation.

But this stipulation also has an exception: In certain embedded contexts, Present Tense *can* be relative, namely the complement of modal auxiliaries or things like *will* (but crucially not attitude verbs). This exception is a popular feature of deictic accounts.

So one inelegant consequence of all of this is that the apparently relative meanings of (85a) and (85b) are accounted for differently.

(85)   a.   Martina will think Carissa was pregnant.
        b.   Martina will think Carissa is pregnant.

On von Stechow's analysis (85b) is assimilated to (83a); they are both cases of Tense Deletion (or in Kratzer's case, agreement with a null tense). (85a), on the other hand is a true relative reading of the Past. This is related to the differing treatments of Past and Present; only the former is allowed to have a truly relative meaning. The fact that (83b) has the same interpretation that Present *would* have on a uniformly relative theory is an accident.

This inelegant quirk becomes an empirical concern when considering relative future readings of Past Tense under *hope*.

(86)   a.   Martina hoped Carissa got pregnant.
        b.   Martina hopes Carissa gets pregnant.

Neither von Stechow (1995) nor Kratzer (1998) considered or attempted to account for this data. As with all tense-deletion accounts, Past-under-Past is predicted to always be a relative present (due to either deletion or agreement with a null tense) if it is not relative past. On all such accounts, the fact that Past-under-Past has the same interpretation that a Present would have on a relative interpretation (if such a thing were allowed) is simply another accident. But cases like (86) show that in some contexts, Present Tense can have non-simultaneous interpretations, and it is those *same* interpretations which are seen in corresponding Past-under-Past cases. Thus the Tense-deletion rule adopted by Ogihara (1989), von Stechow (1995), Anand & Hacquard (2008) and others simply cannot account for the full range of Past-under-Past cases, even if they were to adopt the non-past semantics for the Present Tense that I do.

Likewise, accounts which say that the tense that undergoes agreement is a null tense distinct from Present Tense suffer the same problem. Accounts like Kratzer's (1998) crucially distinguish null tense and Present Tense, because the latter is a temporal relation, while the former is simply a temporal

variable that is bound. Thus for Kratzer it is only this null tense, and not Present, which undergoes agreement. Such a theory therefore inherits the same problem that deletion has: It predicts that simultaneous readings of Past-under-Past are only accidentally identical to what a relative Present would mean in the same context.

Most previous accounts of embedded tense have taken fake Past Tense to essentially be a lack of tense. Future-oriented cases show that there must be semantic content to such tenses. This militates strongly for an implementation of SOT where the fake past is base generated with the (non-past) semantics of Present Tense.

5.3 Present-under-Past

(87) has two readings, which correspond to the readings of (88a) and (88b) respectively.

(87)   Martina hoped Carissa got pregnant.

(88)   a.   Martina hopes Carissa gets pregnant.
        b.   Martina hopes Carissa got pregnant.

My analysis assumes SOT agreement rules and so says that (87) is a surface representation corresponding to two possible underlying derivations — one which begins like (88a), with Non-Past Tense in the embedded clause, and one which begins like (88b), with Past Tense in the embedded clause.

A major benefit of this proposal is that it allows for a unified treatment of English with languages which do not display Sequence of Tense effects, like Japanese (Kubota et al. 2009). In languages like this, relative present readings are achieved by embedding the Present Tense under a Past Tense, with no Sequence of Tense. Past embedded under Past can only have a relative past meaning.

(89)   *Japanese (Kubota et al. 2009)*
        a.   Ken-wa [Anna-ga   byooki *da*   to]   it-ta.
              Ken-TOP Anna-NOM sick   be.NPST COMP say-PST
              'Ken said$_j$ that Anna was$_i$ sick.' $j \not> i, j = i$
        b.   Ken-wa [Anna-ga   byooki *dat-ta* to]   it-ta.
              Ken-TOP Anna-NOM sick   be-PST COMP say-PST
              'Ken said$_j$ that Anna was$_i$ sick.' $j > i, j \neq i$

The semantics proposed here for Past and Present Tense derive exactly these readings, since the English translations are analyzed as having precisely the same tenses at work, underlyingly. The only difference is a morphological one.[25]

Given the precise account provided here, and assuming a straightforward theory of agreement to implement SOT, it would be on its face surprising to find any cases of morphological Present Tense c-commanded by Past Tense. But two such examples abound in the literature: so-called Double Access readings, where morphological Present Tense is found in the complement of a Past Tense attitude verb (90a) and morphological Present in relative clauses under Past Tense (90b).

(90)   a.   Julian said Chris is sick.
        b.   Mike punched a man who is crying.

Consider first relative clauses. A Present Tense relative clause embedded in a Past Tense clause can only have an absolute present reading, not a relative one. Thus both semantically and morphosyntactically it is behaving as if it is scoping above Past Tense. To account for this, I assume covert movement, similar to Stowell (2007). Thus the relative clause in (90b) is scoping above Past Tense, and that scope is the relevant scope for both interpretation and agreement.

Abusch (1997) considers such a possible explanation for Present-under-Past in the context of an analysis by which SOT is the product of agreement between matrix and embedded tenses. But she rejects the possibility on the grounds that such movement must take place at LF (since it is not reflected in word order) and thus not be able to affect agreement. In other words, if this movement does not affect the PF of the derivation in one way (word order) it should not affect it in another way (the inflections of the verbs).

But recent advances in morphosyntactic theory make this possible. On the T-model of grammar (see e.g., Bobaljik 2008), LF and PF interpret exactly the same syntactic structure. Since movement results in copies not traces,

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25 Note that Russian has been argued by many (e.g., Kubota et al. 2009) to behave like Japanese with respect to (89), but this has been rebutted by Altshuler (2008), who argues that Past-under-Past can give rise to simultaneous readings in Russian. However, Sharvit (2014) argues that these are in fact "pseudo-simultaneous" readings which do not rule out a non-SOT analysis of Russian. What's more, some apparently non-SOT languages allow for apparent SOT effects in *before*-clauses; see Kubota et al. 2009, Sharvit 2014.

each module can simply choose which copy to interpret. If LF interprets a higher copy and PF a lower one, the result is "covert movement".

I assume the existence of a higher copy of Present Tense, even if it is not spelled out, pre-empts agreement, and causes a Present Tense which is interpreted above matrix Past Tense to spell out as if it were an unembedded Present (i.e., not bearing Past Tense morphology). Again, I will not go into the details of morphosyntactic analysis; I simply point out that such an analysis is plausible.

Much more needs to be said about Double Access (Smith 1978), however. A full analysis of Double Access is beyond the scope of this paper, but I do want to make it clear that the present analysis should have no more trouble accounting for Double Access than any other currently on the market. In doing this I will sketch a proposal for Double Access which is compatible with the present analysis; but I will not argue for it at length or flesh out its crucial details.

Characterizing the meaning of Double Access cases is tricky. Very roughly, (90a) is associated with two inferences, (92a-b), with the status of the second inference, (92b), remaining somewhat murky.

(91) a. Julian said that Chris was sick.   (simultaneous reading)
      b. Chris is (still) sick.

I propose that a Double Access sentence like (90a) entails (91a), but also carries the inference that, given Julian's common ground commitments, the matrix and embedded Evaluation Times (i.e., the time of utterance for (90a), and the time of the utterance that it describes) are basically indistinguishable, at least for the purpose of discussing the matrix and embedded eventualities. In other words, Julian's utterance was strictly speaking only about the time of that utterance. However, because it is extremely unlikely that the state of affairs he described could have changed between then and the utterance time of (90a), we can characterize his utterance as essentially being about present time as well, because if he did not receive any new information to make him recant his original utterance, he would probably be committed to (91b) as well.[26]

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26 A reviewer raises this datum:

(i) #Mike said that Chris is sick, and according to Mike, Chris became better only a few minutes ago.

Put another way, we can say that speech time and the reference time of the embedded clause are identical at the relevant *temporal resolution*. The reason (90a) *seems* to carry the inference in (90b) is that if we were willing to believe Mike, we would almost certainly believe (90b). This is supported by the fact that Double Access sentences are unacceptable when the time span between the reporting event and utterance time is too great for the state of affairs described by the embedded clause to plausibly continue to hold, a fact noted by many authors before.

(92)   a.   A few days ago, Martina said Carissa is pregnant.
       b.   #A few years ago, Martina said Carissa is pregnant.

These semantic properties, as well as the morphological nature of the tense in the embedded clause, are expected to be explained if the embedded clause is posited to undergo covert movement to a position above matrix tense. This movement is hypothesized to interrupt agreement, as with relative clauses. It is also hypothesized to result in the evaluation time of the embedded tense being speech time. Thus, event time of the embedded clause is also speech time.

Since the attitude verb *said* imposes an upper limit on the temporal possibilities of its prejacent, this is only coherent if speech time and the embedded reference time are indistinguishable for present purposes. Thus what was actually said was that the relevant eventuality held at the time of the report; but since that time is indistinguishable from speech time, it may as well be called speech time. A theory of imprecision which says that we can say literally false things as long as they are close enough to being true (Lasersohn 1999, Lauer 2012, Klecha 2014a) may be able to make good on this idea.

Double Access is often seen as militating in favor of deictic analyses of tense, because the only cases in which Present Tense is *visibly* present in clauses embedded under Past Tense, there is an apparently deictic reading. However, these analyses usually also adopt an Upper Limit Constraint, so something more needs to be said to account for the fact that the embedded

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This is presumably handled under an account along the lines of what I sketch above, because the second clause, *Chris became better only a few minutes ago* creates a discourse context in which speech time and the time of Chris's becoming better are clearly distinguished. So the time of Mike's utterance and the time of the utterance of (i) are not indistinguishable, therefore Double Access is not licensed.

clause is seemingly evaluated at a time after the embedded evaluation time.[27] For Ogihara (1995), Abusch (1997) and many others who follow them, that something more is a theory on which tenses can be interpreted *de re*. However, Gennari (1999, 2003) has made several compelling arguments against a *de re* treatment of Double Access which have yet to be rebutted in the literature. Therefore I do not take the facts of Double Access to militate one way or the other on the question of relative vs. deictic theories of tense; but this is an open question still to be resolved. Accounting for Double Access on the present theory is a project for the future.

6 Conclusion

Motivated by novel data involving the attitude verb *hope* and generalizations about the relationship between modal base type and temporal orientation in auxiliaries, this paper develops a theory of modality and temporality on which modals quantify over partial histories. On this model the semantics of the attitude verb itself constrains the possible temporal reference of an embedded clause, together with the embedded tense. This requires stipulation of a Sequence of Tense agreement rule to account for morphological disparities between embedded and matrix tenses, although such a rule may yet be shown to follow from principled features of English grammar (and likewise for other SOT languages). This analysis then allows for a simplification of the theory of embedded tense, doing away with such semantic stipulations as the Upper Limit Constraint or the Tense-Deletion Rule. It also treats the tenses exactly analogously in the semantics; they have the same type, and there are no special limitations on one or the other. Tenses are given consistent, relative meanings, and the need for zero-tenses, lexical or derived, is eliminated. This account unifies the analysis of languages which do not have SOT; these languages behave just like English in that the interpretation of tenses always relative to local evaluation time, with English differing only in that it has a morphosyntactic SOT rule. Finally, this provides a unified account of finite tense under attitude verbs with correspondences between temporal and modal properties of modal auxiliaries and non-finite-embedding attitude verbs.

Many questions remain. This is far from a complete analysis of temporality and its interaction with modality even for English. First, the full range of

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27 The exception to this is Altshuler & Schwarzschild (2013a,b), who argue for a deictic component of Present Tense, but no Upper Limit Constraint.

variation among modals in terms of their temporal properties has surely not been revealed in this paper; other temporal orientations besides the two discussed here may well exist, and while my account does not predict that they do not, it remains to be seen whether their analysis can be motivated along the same lines as the ones discussed here. Second, I have not discussed at all the interaction between modal auxiliaries and same-clause tense. Third, a true account of Double Access is needed. And finally a morphosyntactic account of the agreement resulting in SOT, including an explanation of its being blocked by otherwise covert movement, has yet to be given. Moreover, it must be stressed that the analysis proposed here depends crucially on the existence of such an account, or else a polarity account like Stowell's (2007).

Additionally, issues related to event structure, aktionsart, aspect, and the role of temporal adverbials, among other things, have not been touched upon at all. And while the semantics analysis of English has been unified to some extent with that of non-SOT language like Japanese and Russian, in that tenses have a relative interpretation, it has been shown that languages vary in how tense in *before*-clauses is expressed; moreover this variation cuts across the SOT/non-SOT divide; see Kubota et al. 2009, Sharvit 2014 for details. What's more, it remains to be seen whether other languages have truly deictic tenses; nothing in this paper suggests that this is impossible, only that it does not hold for English. Likewise, it remains to be seen whether any languages really have LF constraints like Heim's (1994) constraint on T nodes, Schlenker's (2004) purely semantic variant, or Ogihara's (1989) tense-deletion rule. Again, nothing here has said that such things are in principle impossible, only that the evidence in English does not bear them out. I leave all of these crucial topics to future research, and hope that the present proposal serves as one in a long line of vital stepping stones.

A Attestations of Past-under-Past with *hope* with relative future readings

All from Davies 2008:

(93) "It wouldn't work right, and she hoped she remembered to tell the landlord to fix the damn porch light so she could see what she was doing."

(94) "A part of me hoped he stayed there forever, but a larger part of me felt very sad for Mommy and for Miguel."

(95) "I talked about his brave ancestors, Col. Denman in Europe and Vietnam, my father in the hospital — and how Tommy's great challenge was to be caring and sharing of his bounty with his fellow man. (I was going to say I hoped he stayed forever young, but I decided that staying childlike was not at all a good thing.)"

(96) "She said she was coming and then told Mr. Sam Dallason that she hoped Mrs. Sam Dallason wasn't feeling so puny and that she hoped she got better soon so that she could help them pick some of this cotton."

(97) "On the bus ride, I thought about a lot of things - my family, my friends, Rude Boy's words. I also hoped we crashed so that the bus would split open and I'd be able to escape."

(98) ""We have admired their restraint," Fitzwater said. "We said all along we hoped they continued to show restraint.""

(99) "Following her finger, Beau saw a shrimper standing atop the Speedwell's bobbing cotton bales, claiming a shoal of them for his boat. Beau hoped they came for him before the turning tide took him back toward the torpedoes."

(100) "From the marshall's viewpoint, it- that's what made this case different from any other case because all of a sudden instead of just going after a fugitive - you know, normally they would have just gone right up there and tried to arrest him and hoped everything worked out - but instead of just going after a fugitive, they had all these innocent people that, in their- from their standpoint, were being taken advantage of by someone they saw as very much a coward."

B Incorporation of *de se*

This section gives the denotations needed for a true account of temporal *de se*. First of all, attitudes must quantify over properties rather than propositions. Second, *hope*'s use of a circumstantial modal base must be re-thought — unlike in the case of simple circumstantial modal auxiliaries, an attitude verb is unlikely to take a set of objective facts as a basis. Therefore in lieu of a circumstantial modal base, let's use a *predictive* modal base, the forward shifted equivalent of the doxastic modal base.

(101) *Modal Base Pronouns*

    a. $[\![\mathrm{DOX}_n^{dese}]\!]$ is defined iff
        $g(n)(x,t,h) \subseteq \{P\colon x$ doxastically self-ascribes P in $\omega(h)$ at $t\}$
        if defined, $[\![\mathrm{DOX}_n^{dese}]\!] =$
            $\lambda x,t,h\{\langle y,u,i\rangle \in \mathcal{A}_u \times T \times D\colon \langle y,u,i\rangle \in \cap(g(n)(x,t,h))\}$

    b. $[\![\mathrm{PRE}_n^{dese}]\!]$ is defined iff
        $g(n)(x,t,h) \subseteq \{P\colon x$ predictively self-ascribes P in $\omega(h)$ at $t\}$
        if defined, $[\![\mathrm{PRE}_n^{dese}]\!] =$
            $\lambda x,t,h\{\langle y,u,j\rangle \in \mathcal{F}_u \times T \times D\colon \langle y,u,j\rangle \in \cap(g(n)(x,t,h))\}$

The crucial point here is that the temporal character the histories in the domains determined by each of these lexical items is dependent upon the temporal perspective that they encode. For every triple $\langle y,u,i\rangle$ in the domain determined by DOX, for example, i is an actual history of u. More concretely, suppose that Mary mistakenly believes that it is currently 2:41PM, September 26th, 2007. Thus for every triple $\langle y,u,i\rangle$ in the relevant modal domain, $u = $ 2:41PM, September 26th, 2007. Likewise, for every such triple, $\tau(i) = (-\infty, $ 2:41PM, September 26th, 2007]. So the effective upper limit induced by the verb *believe* will not be the time of the believing, but rather, the time Mary thinks it to be, namely, 2:41PM, September 26th, 2007.

    Continue to assume that application of the ordering source has the effect of narrowing the domain determined by the modal base.

(102)   *Attitude Verbs*
    a. $[\![\text{think}]\!] =$
        $\lambda p\lambda f\lambda x\lambda t\lambda h[\forall \langle y,u,k\rangle \in \mathrm{ST}_{x,t,h}(f(x,t,h))[p(y)(u)(k)]]$
    b. $[\![\text{hope}]\!] =$
        $\lambda p\lambda f\lambda x\lambda t\lambda h[\forall \langle y,u,k\rangle \in \mathrm{BO}_{x,t,h}(f(x,t,h))[p(y)(u)(k)]]$

Assume that a perspectival operator OP binds the appropriate pronouns in embedded clauses to create properties.

(103)   a. $[\![\text{it is 2019}]\!] = \lambda x\lambda t\lambda h[t \subseteq 2019]$
       b. $[\![\text{he}_{dese}\text{ was}_7\text{ elected in 2018}]\!] =$
            $\lambda x\lambda t\lambda k[\exists e[\text{elected}(e,x,\omega(h)) \,\&\, \tau(e) = g(7)] \,\&\, g(7) < t]$

(104)   Bill thought that it was 2019 and (that) he was elected in 2018.

Note that the analysis of the conjoined embedded clause in (104) is that the first conjunct is in the Present Tense (concealed by application of SOT-agreement), while the second conjunct is a true Past Tense.

(105)   *Abridged Syntactic Derivation of (104)*

   a.   NS: [TRO$_5$ PAST$_{[iF:pst]}$ bill DOX$_3$ thought$_{[uF:\_]}$ [OP$_6$ TRO$_8$ NPST be$_{[uF:\_]}$ 2019] and [OP$_6$ TRO$_9$ PAST he$_6$ be$_{[uF:\_]}$ PRV elected in 2018]]

   b.   PF: [TRO$_5$ PAST$_{[iF:pst]}$ bill DOX$_3$ thought$_{[\text{uF:}pst]}$ [OP$_6$ TRO$_8$ NPST be$_{[\text{uF:}pst]}$ 2019] and [OP$_6$ TRO$_9$ PAST he$_6$ be$_{[\text{uF:}pst]}$ PRV elected in 2018]]

   c.   LF: [TRO$_5$ PAST bill DOX$_3$ thought [OP$_6$ TRO$_8$ NPST 2019] and [OP$_6$ TRO$_9$ PAST PRV he$_6$ elected in 2018]]

(106)   *Denotation of (104)*
$$\lambda t\lambda h[\forall\langle y,u,k\rangle \in \text{ST}_{b,g(5),h}(\llbracket \text{DOX}_3^{dese}\rrbracket(b,g(5),h))[g(8)\subseteq 2019$$
$$\&\ u\le g(8)\ \&\ \exists e[\text{elected}(e,y,\omega(k))\ \&\ \tau(k|g(9))=\tau(e)]$$
$$\&\ u>g(9)]\ \&\ t>g(5)]$$

(107) $\llbracket \text{DOX}_3^{dese}\rrbracket(b,g(5),h) =$
$$\{\langle z,i,v\rangle \in \mathcal{A}_i\times T\times D\colon \langle z,i,v\rangle \in \cap(g(3)(b,t,h))\}$$
$$\text{iff } g(3)(b,t,h)\subseteq\{P\colon b \text{ doxastically self-ascribes } P \text{ at } t \text{ in } \omega(h)\}$$

(108)   *Derivation of (104)*

   i. $\llbracket$he$_6$ elected$\rrbracket = \lambda e\lambda w[\text{elected}(e,g(6),w)]$

   ii. $\llbracket$PRV he$_6$ elected$\rrbracket =$
$$\lambda t\lambda h[\exists e[\text{elected}(e,g(6),\omega(h))\ \&\ \tau(h|t)=\tau(e)]]$$

   iii. $\llbracket$PRV he$_6$ elected in 2018$\rrbracket =$
$$\lambda t\lambda h[\exists e[\text{elected}(e,g(6),\omega(h))\ \&\ \tau(h|t|2018)=\tau(e)]]$$

   iv. $\llbracket$TRO$_9$ PAST PRV he$_6 \ldots \rrbracket = \lambda t\lambda h[\exists e[\text{elected}(e,g(6),\omega(h))$
$$\&\ \tau(h|g(9)|2018)=\tau(e)]\ \&\ t>g(9)]$$

   v. $\llbracket$OP$_6$ TRO$_9$ PAST PRV he$_6 \ldots \rrbracket = \lambda x\lambda t\lambda h[\exists e[\text{elected}(e,x,\omega(h))$
$$\&\ \tau(h|g(9)|2018)=\tau(e)]\ \&\ t>g(9)]$$

   vi. $\llbracket 2019\rrbracket = \lambda t\lambda h[t\subseteq 2019]$

   vii. $\llbracket$TRO$_8$ NPST 2019$\rrbracket = \lambda t\lambda h[g(8)\subseteq 2019\ \&\ t\le g(8)]$

   viii. $\llbracket$OP$_6$ TRO$_8$ NPST 2019$\rrbracket = \lambda x\lambda t\lambda h[g(8)\subseteq 2019\ \&\ t\le g(8)]$

   ix. $\llbracket$[OP$_6$ TRO$_8$ NPST 2019] and [OP$_6$ TRO$_9$ PAST PRV he$_6 \ldots$]$\rrbracket =$
$$\lambda x\lambda t\lambda h[g(8)\subseteq 2019\ \&\ t\le g(8)\ \&\ \exists e[\text{elected}(e,x,\omega(h))$$
$$\&\ \tau(h|g(9)|2018)=\tau(e)]\ \&\ t>g(9)]$$

x. $[\![\text{bill } \text{DOX}_3^{dese} \text{ think } [\text{OP}_6 \text{ TRO}_8 \text{ NPST } 2019] \text{ and } [\text{OP}_6 \text{ TRO}_9 \dots]\!]\!] =$
$$\lambda t \lambda h [\forall \langle y, u, k \rangle \in \text{ST}_{b,t,h}([\![\text{DOX}_3^{dese}]\!](b,t,h))[g(8) \subseteq 2019$$
$$\& \, u \le g(8) \, \& \, \exists e[\text{elected}(e, y, \omega(k)) \, \& \, \tau(k|g(9)|2018) = \tau(e)]$$
$$\& \, u > g(9)]]$$

xi. $[\![\text{TRO}_5 \text{ PAST bill } \text{DOX}_3^{dese} \text{ think } [\text{OP}_6 \text{ TRO}_8 \text{ NPST } 2019] \text{ and } \dots]\!] =$
$$\lambda t \lambda h [\forall \langle y, u, k \rangle \in \text{ST}_{b,g(5),h}([\![\text{DOX}_3]\!](b,g(5),h))[g(8) \subseteq 2019$$
$$\& \, u \le g(8) \, \& \, \exists e[\text{elected}(e, y, \omega(k)) \, \& \, \tau(k|g(9)|2018) = \tau(e)]$$
$$\& \, u > g(9)] \, \& \, t > g(5)]$$

Note that the term $\tau(k|g(9)|2018)$ is what provides the crucial temporal restriction; this requires that $g(9)$ overlap both $\tau(k)$ and the year 2018. However, since it is also established that the upper boundary of $\tau(k)$ is within the year 2019, this is perfectly consistent. Thus the theory of temporal restrictions imposed by modals can be made sensitive to *de se* considerations in the case of attitude verbs.

Note also that for all $\langle y, u, k \rangle$ in the domain of the quantifier, $\tau(k) = (-\infty, u]$, so since for all u, $u \le g(8)$, it must be that $g(8) = u$. However, if the domain is not homogenous with respect to u (for example, the attitude holder is unsure what time it is), we would then want RT to covary with u. This is most easily accomplished if we instead take up a quantificational view on RT rather than the pronominal one which we have been assuming in this paper. This assumption has merely been for simplicity, however, so nothing is lost by going quantificational.

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