Outline for a Truth Conditional Semantics for Tense

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1   Introduction

The use of verbs inflected or modified for tense, and temporal adverbs, indexicals, and quantifiers, pervades everyday speech. Getting clearer about their semantics promises not only to help us to understand how we understand each other, but is also a step toward clarifying the nature of time and temporally located thoughts. Our aim in the present paper is to investigate, from the standpoint of *truth-theoretic semantics*, English tense, temporal designators and quantifiers, and other expressions we use to relate ourselves and other things to the temporal order. Truth-theoretic semantics provides a particularly illuminating standpoint from which to discuss issues about the semantics of tense, and their relation to thoughts at, and about, times. Tense, and temporal modifiers, contribute systematically to conditions under which sentences we utter are true or false. A Tarski-style truth-theoretic semantics, by requiring explicitly represented truth conditions, helps to sharpen questions about the function of tense, and to deepen our insight into the contribution the tenses and temporal modifiers make to what we say by using them.

We are interested in a semantic, rather than syntactic, phenomenon. Although tense is identified traditionally with verb inflection, our concern is with linguistic devices used for indicating a time interval, relative to, or in, which a state or activity is to be understood to occur or obtain. For ease of exposition, we will press into use 'tense' to cover any verb form we use to indicate time intervals in which the event or state expressed by a verb is to occur or obtain. In English, verb inflection, such as adding '-ed' to a truncation of an infinitive, is one such device. But the phenomenon occurs even in languages like Chinese which lack inflection for tense. Though we will be concerned solely with tense in English, we are interested in it as an example of a semantic phenomenon common to natural language. The structure of a semantic phenomenon may be expected to reflect underlying facts about the structure of our thoughts about contingent particulars. We expect that all languages share basic expressive resources, even when they are realized by diverse syntactical devices.[1]

Our basic approach, which goes back to (Frege 1977) and (Russell 1903), treats tense as an indexical device for referring to times or time intervals at which events take place or states obtain. Where the time interval picked out is not the present, tense involves what we will call *indexically restricted quantifiers*. The indexical element functions to pick out a time of utterance as a reference point for indicating quantificationally the relative location of temporally bound states and events. While the central idea is intuitively appealing, it has not been systematically explored within a truth-theoretic framework. It turns out to be particularly powerful in its application to systematizing the often puzzling interaction of tense with other temporal devices. Treating tense as quantificational will enable us to give a uniform account of tense and temporal modifiers and quantifiers in English, and it can be shown to complement in a compelling way the standard event/state analyses of adverbial modification. If the basic account is correct, in our most ordinary remarks we reveal a commitment to the existence of time intervals. Hence, time is real, or virtually everything we say is false.

We begin in §2 with an overview of how to deploy a truth theory as a compositional meaning theory. We show that the requirement that the theory be *interpersonal* precludes a semantics for tense which employs tense operators. In §3, we present an account of the simple tenses (present, past, future) and of the present progressive, and discuss several methodological points about tense and semantics. In §4, we give an account of deictic and structured temporal referring expressions. In §5, we consider how our basic account interacts with temporal adverbials, and in §6, how it interacts with 'before' and 'after', used as sentential connectives. §7 examines how tense interacts with temporal quantifiers. §8 treats so-called habitual sentences and frequency adverbials. §9 examines how our account of tense interacts with the event analysis of adverbial modification. In §10, we consider the interaction of tense in main and complement clauses of indirect discourse reports and attitude sentences. §11 applies the account to issues in the philosophy of time, and discusses the limitations of semantics in metaphysics. §12 is a summary and conclusion. In the appendix we provide a truth-conditional semantics for the perfect tenses.

2 Truth-theoretic semantics

A compositional meaning theory for a natural language L should provide,

(R)   from a specification of the meanings of finitely many primitive expressions and rules, a specification of the meaning of an utterance of any of the infinitely many sentences of L.

We confine our attention to declaratives.[2] A compositional meaning theory for a context insensitive language L, i.e., a language without elements whose semantic contribution depends on context of use, would issue in theorems of the form,

(M)   s in L means that p,

where 's' is replaced by a structural description of a sentence N of L and 'p' is replaced by a metalanguage sentence that translates it.

For context insensitive languages, the connection between a theory meeting Tarski's famous Convention T and a compositional meaning theory is straightforward: a truth theory meets that convention only if it entails every instance of (T),

(T) s is true in L iff p,

in which a structural description of a sentence N of L replaces 's', and a metalanguage sentence synonymous with N replaces 'p'. We shall call such instances of (T) *T-sentences*. The relation between a structural description that replaces 's' and a metalanguage sentence that replaces 'p' in a T-sentence is the same as that between suitable substitution pairs in (M). Therefore, every instance of (S) is true when what replaces 'p' translates the sentence denoted by what replaces 's'.

(S) If s is true in L iff p, then s in L means that p.

Given a T-sentence for s, (S) enables us to specify its meaning. An advantage of a truth-theoretic approach (over one trying to generate instances of (M) more directly) is its ability to provide the recursions needed to generate meaning specifications for object language sentences from a finite base with no more ontological or logical resources than required for a theory of reference.

In natural languages, many (arguably all) sentences lack truth values independently of use. 'I am tired' is not true or false *simpliciter*, but only as used. This requires discarding our simple accounts of

the forms of theories of meaning and truth. Theories issuing in instances of (M) and (T) for 'I am tried'
would yield [1]-[2].

[1] 'I am tired' in L means that I am tired.
[2] 'I am tired' in L is true iff I am tired.

But [1]-[2] express nothing unless relativized to a context of utterance, and what they express in a
context depends on who utters them, and the time of utterance. This creates two related difficulties.
First, theorists employing identical adequacy criteria will arrive at non-equivalent theories, since they will
express different propositions by the sentences they use. Second, no one will give the correct account
of the meanings or truth conditions of sentences with context sensitive elements. Were we each to
assert [1], one of us would assert that 'I am tired' means that Ludwig is tired at such and such a time,
while the other would assert that it means that Lepore is tired at such and such a time. But 'I am tired'
means neither.

A semantics for a language should be couched in a context insensitive metalanguage. We want
theories any inquirer can reach by meeting generally agreed upon theoretical constraints, and which can
be used to express the same thing in every context. This requires metalanguage expressions, including
semantic predicates, to be untensed. This requirement shows why tense operators cannot be employed
to give a semantics for English. An operator like 'it was the case that' is *itself* tensed, and hence is
unsuitable for use in our metalanguage. Tense logics don't provide a semantics for tense expressions in
natural languages, but represent, rather, a regimentation of them, which itself stands in need of a
semantics couched in a context insensitive metalanguage.

In modifying a compositional meaning theory to accommodate context sensitivity, and a truth theory
that serves as its recursive engine, a theorist must choose between two options. The first retains the
basic form of the meaning specification, 'x means in language y that p', and correspondingly retains
within the truth theory a two-place predicate relating a truth bearer and a language. The second adds an
argument place to each semantic predicate in the theory for every contextual parameter required to fix a
context sensitive element's contribution when used. Both approaches require metalanguage semantic
predicates to be untensed. For concreteness, we will suppose that the fundamental contextual

parameters are utterer and time of utterance.[3] On the first option, which adds no argument places to its semantic predicates, a theory must take utterances as the bearers of meaning and truth and will yield theorems of the forms (M1) and (T1).

(M1)   For any speaker s, time t, sentence φ of L, utterance u by s at t of φ, u means in L that p.
(T1)   For any speaker s, time t, sentence φ of L, utterance u of φ by s at t, u is true in L iff p.

Since different utterances of the same sentence may take different truth values and express different propositions, what replaces 'p' can be an open sentence with variables bound by the initial quantifiers. The second option adds argument places to semantic predicates, which issues in instances of (M2)-(T2).

(M2)   For any speaker s, time t, sentence φ of L, φ means$_{[s,t,L]}$ that p.
(T2)   For any speaker s, time t, sentence φ of L, φ is true$_{[s,t,L]}$ iff p.

As a first gloss, we might try to treat 'means$_{[s,t,L]}$' and 'is true$_{[s,t,L]}$' as equivalent to 'means as potentially spoken by s at t in L' and 'is true as potentially spoken by s at t in L'. However, as (Evans 1985, p. 359-60) points out, we cannot read these as, ⌜if φ were used by s at t in L, then φ would be true iff/mean that⌝, since, aside from worries about how to evaluate counterfactuals, these interpretations would assign sentences such as 'I am silent' false T-theorems. What we need are the readings, ⌜if φ were used by s at t in L, as things actually stand φ would be true iff/mean that⌝, or, alternatively, ⌜φ understood as it would be in L if spoken by s at t is true iff/means that⌝. *Mutatis mutandis* for other semantic predicates.

If either option issues in an adequate meaning theory, so does the other. Both treat actual uses of sentences as fundamental in understanding truth and propositional meaning. We adopt the second because it issues in theorems more directly informative about *sentence* meaning, which is our stated subject. We therefore replace adequacy criterion (R) with (Rφ):

(Rφ)   A compositional meaning theory for a natural language L should entail, from a specification of the meanings of primitive expressions of L, all true sentences of form (M2)

The analog of Tarski's Convention T for recursive truth theories for natural languages we shall call Davidson's Convention D.

(D)   An adequate truth theory for a natural language L must entail every instance of (T2) such that corresponding instances of (M2) are true.

A truth theory for L meeting (D) with axioms that interpret primitive expressions of L (henceforth 'an interpretive truth theory') provides the resources to meet (RN).

3   The simple tenses

We consider in this section the semantics of simple tenses, beginning with state verbs in §3.1, and proceeding to event verbs in §3.2. In §3.3, we will argue that the tradition that treats the progressive as a tense is poorly conceived from the standpoint of truth-theoretic semantics.

3.1 Indexicality of tense for state verbs

The most salient feature of tense is that its contribution to the meaning of utterances is sensitive to the time of utterance. [3]-[5], in present, past, and future tense[4], respectively, may be true when uttered by a speaker at some times but not at others.

[3]   Mary loves Bill.
[4]   Mary loved Bill.
[5]   Mary will love Bill.[5]

This indicates that [3]-[5] contain a deictic element, either an indexical or demonstrative device (we will use 'deictic' as generic for context sensitivity). From the standpoint of truth-theoretic semantics, a sentence contains a deictic element iff its T-sentence has variables on its right hand side bound by quantifiers which bind contextual parameters in its truth predicate. If the values of the minimal set of contextual parameters alone suffice to understand what the semantic value of a deictic element is, it is an indexical device; otherwise, it is (in part at least) a demonstrative device.   With [3]-[5], in which tense is the only deictic element, knowing the time of utterance suffices for understanding the contributions of their deictic elements. So the simple tenses are indexicals. This requires that the propositions [3]-[5] express in a context involve direct reference to the time of utterance, since the variable bound by the temporal quantifier in whose scope the biconditional falls is a directly referring term. On the assumption that the proposition expressed by an utterance provides the content of the speaker's belief, every thought expressed using the present, past, and future tense is singular, since it directly refers to the time of utterance.

The case for regarding at least some tenses as quantifying over times is straightforward. When asserting [3], a speaker intends to say that Mary loves Bill then. When using [4], he intends to say that *at some time prior to his utterance* Mary loved Bill. Similarly, when using [5], he intends to say that *at some time after the time of his utterance* Mary will love Bill. In the latter two, clearly, the thoughts expressed quantify, respectively, over past and future times.

Unfortunately, in stating this, we re-used the tenses we intend to explain. Even if untensed verbs are used in English, they cannot grammatically replace simple tensed ones.[6] This has an important consequence for the semantics of English, namely, *its semantic theory is unspecifiable in English*. For reasons provided in §2, interpretive truth theories cannot use deictic elements in specifying truth conditions of object language expressions, on pain of being uninterpretive. So providing an adequate interpersonal interpretive truth theory for English requires enriching the metalanguage with tenseless verbs which express relations between objects or events and times. For this purpose, we will use the present tense form, adding a variable in parentheses for the temporal argument place; e.g., 'loves(t)' is the tenseless verb in the metalanguage corresponding to 'loves' in English.

Treating past and future tenses as indexical quantifiers introduces a second difficulty, namely, the object language lacks explicit markers for temporal variables. Natural language syntax, from the perspective of semantics, is understated. In trying to gain an explicit understanding of how languages work, we inevitably are drawn to paraphrases which yield more explicit syntactical representations of the semantic structures of expressions we study. This is familiar from the study of (other) quantifier phrases in natural languages, whose resources for indicating binding relations show all the marks of having been cobbled together on an as-needed basis. Tense makes this particularly vivid, since, unlike more general quantifiers, even familiar devices of pronominal cross-reference are missing, and binding relations are indicated more subtly. As from a cloven pine Ariel was released by Prospero's art, so from its syntactic binding the semantic function of tense is released by its paraphrase in a more articulated form.

For present purposes, we will simply specify satisfaction conditions for an extension of English in what we will call 'English*'. English* includes the usual apparatus for regimenting restricted

quantification, and tenseless verbs which homophonically translate the tenseless verbs required in the metalanguage to provide tenseless truth conditions. English* also includes a referring term 't*' with the following reference axiom (stipulated to be interpretive): For any speaker s, time t, $ref_{[s,t]}$('t*') = t.[7] (While this may seem also to be a natural axiom for 'now', we introduce 't*' because it is unclear whether they are synonymous (see §4).)

With this as background, leaving implicit the relativization of semantic predicates to English*, we can present satisfaction conditions for [3]-[5] in [6]-[8] respectively.[8]

[6] For any speaker s, time t, function f, f $satisfies_{[s,t]}$ 'Mary loves Bill' iff f $satisfies_{[s,t]}$ 'Mary loves(t*) Bill'.

[7] For any speaker s, time t, function f, f $satisfies_{[s,t]}$ 'Mary loved Bill' iff f $satisfies_{[s,t]}$ '[There is a time t_1: $t_1 < t^*$](Mary loves(t_1) Bill)'.

[8] For any speaker s, time t, function f, f $satisfies_{[s,t]}$ 'Mary will love Bill' iff f $satisfies_{[s,t]}$ '[There is a time t_1: $t_1 > t^*$](Mary loves(t_1) Bill)'.

('x < y' and 'x > y' mean 'x is earlier than y' and 'x is later than y'). Given the reference clause for 't*', it is clear that each of [6]-[8] indexes to utterance time. Appropriate reference axioms applied to [6] yield [9], which in turn yields the T-sentence [10]. Similarly, [8] yields [11].

[9] For any speaker s, time t, function f, f $satisfies_{[s,t]}$ 'Mary loves Bill' iff Mary loves(t)Bill.

[10] For any speaker s, time t, 'Mary loves Bill' is $true_{[s,t]}$ iff Mary loves(t) Bill.

[11] For any speaker s, time t, 'Mary will love Bill' is $true_{[s,t]}$ iff [there is a t_1: $t_1 > t$](Mary loves(t_1) Bill).

Satisfaction clauses for English tensed and corresponding English* untensed sentences are the same. Since satisfaction conditions for English* sentences present no special difficulty,[9] where appropriate, we will use English* to represent satisfaction conditions of an appropriate English sentence.

Satisfaction conditions [6]-[8] treat the present tense differently from the past and future tenses. The past and future tenses function as restricted indexical quantifiers, whereas the present tense functions as a simple indexical. We might try to treat the present tense as requiring restricted quantification, as in [12].

[12] [There is a time t_1: $t_1 = t^*$](Mary loves(t_1) Bill).

But in addition to the quantification in [12] being superfluous, considerations about how simple tenses embed in complex expressions provide reasons against it (see §5).

[7]-[8] reveal that the past and future tenses are, from the perspective of truth-theoretic semantics, restricted indexical existential quantifiers. Existential quantification is required, since utterances in these tenses reveal only that some event occurred in the past or will occur in the future *at some time or other*. They are *indexical* quantifier expressions because the predicate restrictions on the quantifier in their English* translations contain an indexical.

One important consequence of this treatment is that we can never re-express in English what we express on a given occasion using a tensed sentence. (This has important consequences for the semantics of indirect discourse and attitudes sentences. See §7.) If someone were to assert 'Mary loves Bill' at t, he would express a proposition directly about t. To re-express that same proposition later, it would not do to use the present tense, since any new utterance would be about a *different* time. But using the past tense, even with an adverbial modifier, would still involve direct reference to the time of utterance, which would be later than t. Suppose someone were to utter, 'Mary loved Bill at t'. Since 'at t' determines a time earlier than *the time of utterance* at which Mary is asserted to have loved Bill, the speaker still refers to the utterance time, and, hence, fails to express the original. There is nothing conceptually incoherent about re-expressing a proposition; English* allows us to do so. But this feature of natural languages is surely no accident. Our access to time in thought involves reference to the present time. We step into the river of time only at that point at the bank on which we stand, the perpetual present, and locate other times fundamentally by reference to that standpoint. Re-expressing the same proposition twice in English* would involve using a directly referring term to pick the time out rigidly. But we would secure the referent of directly referring term in thought only by describing its relation to the present time.[10]

As we represent tense, the future and past tenses involve quantification. However, unlike explicit quantification, quantification in tense, because it is lexically internal, takes narrow scope with respect to explicit quantifiers.[11] Sentences with explicit quantifiers receive recursive clauses in the truth theory, as in [13].

[13]   For any speaker s, time t, function f, f satisfies$_{[s,t]}$ 'Everyone(x) met someone(y)'   iff
         every 'x'-variant f℩ of f satisfies$_{[s,t]}$ 'x met someone(y)'.

In the standard sort of truth theory we are envisaging, both explicit quantifiers in 'Everyone met

someone' would be unpacked before the axiom for its verb could be invoked, forcing the quantifier

involved in tense always to take narrow scope, as in [14]-[15].

[14]   For any speaker s, time t, function f, f satisfies$_{[s,t]}$ 'Everyone(x) met someone(y)' iff every
         'x'-variant f℩ of f is such that some 'y'-variant f0 of f℩ satisfies$_{[s,t]}$ 'x met y'.
[15]   For all speakers s, times t, functions f, f satisfies$_{[s,t]}$ 'Everyone(x) met someone(y)' iff every
         'x'-variant f℩ of f is such that some 'y'-variant f0 of f℩ is such that f0 satisfies$_{[s,t]}$ '[There is a
         time t_1: $t_1 < t^*$](x meets(t_1) y)'.[12,13]

3.2 Event verbs

In contrast to state verbs, event verbs apply to an object at a time only if it is undergoing some change.

Neither 'Bill loved Mary' nor 'Bill weighed 145 lbs.' implies Bill has undergone change. But 'Bill left'

implies that Bill underwent a change, minimally, of position. Also, event verbs, in contrast to most state

verbs, take a progressive form by concatenating 'is' with the present participle morpheme.

Corresponding to 'leave' is 'is leaving'. The same operation on state verbs is generally ill-formed; no

form 'is knowing' corresponds to 'know'. (This is not uniform, as is shown by 'block', 'stand', and

'occupy'. But these have uses as event verbs as well.)

    It is natural to suppose that the simple tenses function uniformly independently of the semantic

category of a verb. If so, we should be able to provide a uniform treatment for state and event verbs.

While this works smoothly for the past and future tenses of event verbs, it doesn't for the present tense.

Compare [16] with [17]-[18].

[16]   Mary loves Bill.
[17]   Mary leaves.
[18]   Mary opens the door.

An utterance of [16] is true if Mary loves Bill at the time of utterance. But it is difficult to find

circumstances under which we comfortably assert [17] or [18] unembedded or unmodified (in contrast

to, e.g., 'if Mary leaves, I will too', or 'Mary leaves on the 23rd of this month').[14] Even though events

typically require more time to complete than utterances of sentences with present tensed event verbs,

this hardly explains the data. [17] is no less odd when said slowly enough for Mary to leave during its utterance. Moreover, many events require no more time than would an assertion that they were occurring, e.g., 'Bill speaks', but their present tense utterances are no less odd. (We will consider sentences like 'Bill works for a living' in §8. These typically express generality.) We know of no adequate explanation of this aspect of present tense event verbs.

Since there doesn't seem to be anything conceptually incoherent about a semantics for present tense event verbs that parallels our semantics for present tense state verbs, this strongly suggests that whatever oddity attaches to utterances of present tense unembedded and unmodified event verbs is structural. But then there should be an account of that oddity within a compositional meaning theory. If we are right, present tense event verbs do not index to the time of utterance. Yet from our treatment of past and future tenses, which parallels that for state verbs, it is clear that event verbs express a relation between one or more things and a time. If the implicit argument places for time in present tense event verbs were bound by a quantifier in sentences containing them, there would not be a puzzle about the truth value of their utterances. We suggest, then, that the argument place for time in present tense event verbs is unbound in unembedded and unmodified uses, and that the oddity in uttering [17]-[18] is due to their being open sentences, and thereby truth-valueless. If we are right, [17] will receive [19] as its satisfaction clause, where 'tℕ' is a free variable. Satisfaction conditions for past and future tenses for 'leaves', in contrast, are given by [20]-[21].

[19] For any speaker s, time t, function f, f satisfies$_{[s,t]}$ 'Mary leaves' iff f satisfies$_{[s,t]}$ 'Mary leaves(tℕ)'.
[20] [There is a t_1: $t_1 < t^*$](Mary leaves(t_1)).
[21] [There is a t_1: $t_1 > t^*$](Mary leaves(t_1)).

[20]-[21] represent past and future tenses with an indexical reference to the time of utterance because of the indexical 't*' in the restriction on their quantifiers. The asymmetry in treatments of past and future tenses of event verbs, on the one hand, and present tense, on the other, might be regarded as a defect. But it explains the oddity of utterances of [17]-[18], which an account treating them as parallel to state verbs would fail to do. Whether the proposal is satisfactory depends on how well it integrates into an account of how present tense event verbs interact with temporal adverbials and quantifiers, and on

whether a simpler account of the data can be given. While we cannot show no simpler account is available, we will show in §4-5 how to integrate our treatment with one for adverbials and temporal quantifiers.

3.3 The progressive

The progressive is formed by adding '-ing' to (the truncation of) the infinitive of an event verb. The concatenation of 'is' with a gerund has traditionally been treated as a tense. From our perspective, however, classifying the progressive as a tense is a mistake.[15] While 'is leaving' is tensed, since it indexes to time of utterance, its treatment in a truth-theoretic semantics should not distinguish it from the present tense state verbs. The contribution of tense to 'is leaving' (the dimension of variation among 'is leaving', 'was leaving', and 'will be leaving') is represented by the tenseless English* [22].

    [22]   Bill is leaving(t^*).

So represented, the present progressive picks out the time of utterance relative to which an implicit argument in the verb is evaluated, just like present tense state verbs. (However, progressives behave like event verbs in their interaction with future looking or neutral adverbials, like 'noon', or 'on Tuesday'; this looks to be because of the pull of the analogy of form with the future formed from 'to be' plus 'going' plus the infinitive.)

    Treating 'is leaving' as a tense of 'leave' requires exhibiting its satisfaction conditions as derived from those for the untensed verb 'leaves(t)' in English*. This may seem intuitively the right thing to do, since 'is leaving' is clearly related to the infinitive 'to leave'. But this is insufficient to settle whether the connection is conceptual or structural. A virtue of the truth-theoretic approach is that it provides a precise way of distinguishing conceptual from structural connections.

> When two verbs are *structurally* related, the same (or a synonymous) metalanguage verb is used in their satisfaction conditions, and the only variation between the satisfaction conditions will be variations in the quantificational apparatus invoked by tense. If the connection is not structural, distinct metalanguage verbs will be used in giving satisfaction conditions.

Put this way, [22] represents appropriate satisfaction conditions for 'is leaving' only if the relation expressed by 'is leaving' ('was leaving', and 'will be leaving') is distinct from what is expressed by 'leaves', 'left', and 'will leave'. That they are distinct is shown by the fact that someone can be leaving,

and not leave, or will be leaving, and never leave. While anyone who leaves the room was leaving, his leaving doesn't require he left or ever will: he might collapse halfway out the door. He was leaving, even though he never left. The point is even more transparent with other event verbs: someone may be *writing* a book, but never *write* it. These examples help clarify the relation between 'was leaving' and 'left': the former relates an agent to a time interval in which he is *engaged* in an activity which may lead to the kind of event the latter relates an agent to.

If correct, this completely *dissolves* the so-called imperfective paradox. [16] This paradox arises on the assumption that the progressive of an accomplishment verb like 'leaves' is a tense. 'leaves(t)' applies to an object x at a time t only if after t 'x left' applies to it. If 'is leaving' were a tense of 'leave', then 'is leaving' would apply at t to something only if after t 'left' applied to it. This is obviously incorrect. But the pressure to accept the paradoxical result dissipates once we deny that the progressive of 'leaves' is a tense.

Progressives are neither state verbs nor event verbs. They express the occurrence at a time of a portion of a process which if completed constitutes an event of the type expressed by the verbs from which they are lexically derived. We shall, following common sense, and an earlier tradition, call them process verbs.[17]

4   Temporal Designators

Temporal designators divide into deictic designators, such as 'now' and 'tonight', and structured designators, such as 'December 7th, 1942'.

We begin with 'now' and 'then'. It is natural to treat 'now' as parallel to 'I', and 'then' as parallel to 'that'. Whereas 'I' is used to pick out the speaker of an utterance, 'now' is used to pick out its time. 'that' functions as a demonstrative, and 'then' as a demonstrative restricted to times. A standard reference clause for 'I' is [24]; a reference clause modeled on it for 'now' is [25]. Likewise, a reference clause for 'that' is [26], while a parallel reference clause for 'then' is [27].

[24]   For any speaker s, time t, $\text{ref}_{[s,t]}$('I') = s.
[25]   For any speaker s, time t, $\text{ref}_{[s,t]}$('now') = t.
[26]   For any speaker s, time t, item x, if s demonstrates x at t with 'that', $\text{ref}_{[s,t]}$('that') = x. [18]
[27]   For any speaker s, times t, t_1, if s demonstrates t_1 at t with 'then', $\text{ref}_{[s,t]}$('then') = t_1. [19]

[26]-[27] assign a referent only if a speaker demonstrates something using the demonstrative expression. This is because even relative to a speaker and time, a demonstrative sentence has a truth value only if the speaker performs an act of demonstration. In this way, demonstratives differ from indexicals, whose referents are completely determined by contextual parameters.

Treating 'now' as indexing the time of utterance is standard, but inadequate for many of its uses, e.g., in issuing commands, 'Do it now, not later', or in sentences like 'Now I have a lot more time to do what I am interested in'. Speakers using such sentences would not intend to be interpreted as referring only to the time of their utterances. Someone who says, 'Do it now, not later', would not be thought to have commanded the impossible. We *may* be able to treat these uses as creating conversational implicatures, but they are so routine we are inclined to suggest that 'now' has a demonstrative as well as an indexical element. While a use of 'now' refers to a time which includes the utterance time, it can also refer to time extending beyond, and perhaps before, it. To accommodate these uses, we can modify [25] as in [28].

[28]   For any speaker s, times t, t_1, if t_1 is the interval including t referred to by s at t using 'now', $\text{ref}_{[s,t]}$('now') = t_1.

(This could be modified to require the referent be the utterance time where the speaker lacks appropriate referential intentions.) Natural languages provide an array of descriptive indexical devices for referring to times or time intervals related specifically to the present, e.g., 'today', 'tomorrow', 'tonight', 'yesterday', 'last year', 'next year'. A general treatment for descriptive indexical devices is illustrated in [29]-[30].

[29]   For any speaker s, times t, t_1, such that t_1 = the night of t, $\text{ref}_{[s,t]}$('tonight') = t_1.
[30]   For any speaker s, times t, t_1, such that t_1 = the day before t, $\text{ref}_{[s,t]}$('yesterday') = t_1.

Temporal indexicals directly refer.[20] In T-sentences derived from axioms like [29]-[30], the descriptive material does not contribute to truth conditions. The T-sentence for 'Tonight is the night', instantiated to speaker $s\mathbb{N}$ and time $t\mathbb{N}$, would be:

[31]   'Tonight is the night' is $\text{true}_{[s\mathbb{N},t\mathbb{N}]}$ iff $t\mathbb{N}$ is the night.

Treating descriptive indexicals as directly referring terms is required because co-referring descriptive indexicals can be interchanged *salva veritate.* We can report your assertion *yesterday* of 'Today is Sunday' by saying *today* that you said that yesterday was Sunday (note the shift in tense: we will discuss tense sequencing in complement clauses in §10).[21]

We might try to treat structured temporal designators such as '1 January 2000' either as semantically equivalent to definite descriptions, e.g., 'the first day of January of the 2,000th year after N', where 'N' is replaced by a term that picks out an anchor time for the date system, or as having their referents merely fixed by a definite description. We opt for the latter approach. The first approach fails in modal contexts if we substitute for 'N' a description of an anchor event, such as 'the birth of Christ'.[22] Intuitively, 'Necessarily, the birth of Christ was 2,000 years before 1 January 2000' is false. Christ could have been born earlier or later than he was. But if '1 January 2000' were equivalent to '1 January 2000 years after the birth of Christ', it would be true, at least on the narrow scope reading. But there is no true reading of the original. To avoid this objection, we could introduce rigidified definite descriptions such as 'the time of the actual birth of Christ', but our competence with the use of date terms does not seem to be contingent on knowing any particular description of the anchor time. We will settle then for a reference clause for date formats, as in [32],

[32]   For any speaker s, time t, numerals n_1, n_2, month designator 𝟗, *the x such that x = day*
*$ref_{[s,t]}(n_1)$ of month $ref_{[s,t]}($ 𝟗 *) of the year $Ref_{[s,t]}(n_2)$ years after the actual day on*
which Christ was born is such that $ref_{[s,t]}(^+n_1$ 𝟗 $n_2') = x.$

where for speaker s, time t, $ref_{[s,t]}($'January'$) = 1$, and so on.

5   Temporal adverbs and adverbials[23]

In this section we discuss relational temporal adverbials such as 'at midnight', 'before noon', 'two days hence', 'yesterday', 'tonight', 'between 2 and 3 p.m.' Temporal adverbials may be forward looking ('tomorrow', 'next week'), backward looking ('yesterday', 'a month ago', 'last week'), about the present ('now', 'at this moment', 'currently'), or neutral ('on Tuesday', 'in May'). We will call these future, present, past, and unanchored adverbials respectively.[24] A verb's tense restricts what modifiers it can take. The simple past may take past adverbials or unanchored adverbials, but neither present nor

future adverbials. 'John slept last week', and 'John slept through May', are fine, while 'John slept right now', and 'John slept in three days', are not. The future tense may be modified by unanchored, present, or future adverbials, but not past adverbials. 'John will sleep on Tuesday', 'John will sleep now', 'John will sleep tomorrow', are all acceptable, but 'John will sleep last week' is not. An event verb in present tense may be modified by unanchored, or future adverbials, as in 'John leaves on Tuesday', and 'John leaves next week', and perhaps by present adverbials, e.g., 'John leaves now', but it will not accept a past adverb, as in, 'John leaves yesterday'. In contrast, present tense state verbs take only present adverbials. 'I am tired right now' is acceptable, but 'I am tired next week' and 'I am tired last year' are not.

We begin with adverbial modification of sentences in the simple past. We propose a uniform treatment of relational adverbs that will secure entailment relations like those in [35].

[35]   Bill loved Mary yesterday.
         Therefore, Bill loved Mary sometime.
         Therefore, Bill loved Mary.

We are already committed to quantifying over times due to our treatment of simple tenses. 'Bill loved Mary' is equivalent to '[There is a time t_1: $t_1 < t^*$](Bill loves(t_1) Mary)'. Modifying 'Bill loved Mary' with the adverb 'yesterday' has the effect of specifying the time interval in the past relative to the present when Bill loved Mary, i.e., that it is identical with or included in yesterday. This recommends assigning 'Bill loved Mary yesterday' satisfaction conditions equivalent to [36],

[36]   [There is a t_1: $t_1 < t^*$ & t_1 ⨍ yesterday](Bill loves(t_1) Mary).

where '⨍' is read as 'is included in or identical with'. (We include the adjunct in the restriction on the quantifier because the adverb is intuitively modifying the element contributed by the tense.)

Adverbial phrases formed by combining a preposition with a temporal designator receive similar treatment. What varies is the temporal property expressed by the prepositional phrase. 'Bill loved Mary for two hours' is equivalent to '[There is a t_1: $t_1 < t^*$ & the duration of t_1 is two hours](Bill loves Mary(t_1))'. 'Bill loved Mary before midnight' is equivalent to '[There is a t_1: $t_1 < t^*$ & t_1 is before midnight](Bill loves Mary(t_1))'. 'Bill loved Mary in June' is equivalent to '[There is a t_1: $t_1 < t^*$ & t_1 is in

some/this June](Bill loves(t_1) Mary)'. The satisfaction conditions in [36] underwrite the entailments in [35]. Our treatment correctly predicts restrictions on modifiers of verbs in the past tense. Future or present adverbials will require the time of an event to be in the future or the present, but the tense of the verb requires it to be in the past. Unanchored adverbials are treated as existentially quantified or implicitly deictic, where neither requires the times of which they are predicated to be in the future, past or present vis-a-vis the time of utterance.

The future tense receives a parallel treatment (with '>' substituted for '<'). However, we must say something about the use of 'now' with a future tense verb; to avoid incoherence, this should be understood as sentential and not adverbial modification. 'John will sleep now' should be read as 'It is now the case that John will sleep'. Our discussion of tense in complement clauses will cover this case. For present tense state verbs satisfaction conditions are illustrated for 'Bill loves Mary now' in [37].

[37]   Bill loves(t*) Mary & t* ⌐ now.

Our treatment of past and future tense event verbs parallels exactly that of present and past tense state verbs, but the situation is more complex with present tense event verbs, such as 'leaves' or 'speaks'. One can modify a state verb with a present adverbial, but not with future, past, or unanchored adverbials. In contrast, while present tense event verbs, like present tense state verbs, cannot be modified by past adverbials, they can be modified by future adverbials, and, arguably, present adverbials, though in contrast to state verbs it is awkward to do so. [38] is unexceptional, [39] unacceptable, while [40] is awkward.

[38]   John leaves tomorrow.
[39]   John leaves yesterday.
[40]   John leaves now.

We suspect that anyone who finds [40] acceptable is imagining it as a reply to 'When does John leave?', where the reply is expected to indicate a future time, while in fact John's departure is scheduled for the present.

If 'John leaves' is an open sentence, adding a modifier binds the free argument place for time. If [39]-[40] are semantically unacceptable, the quantifier is restricted to future times; if [39] alone is

unacceptable, the restriction is to times contemporaneous with the utterance or later. We tentatively

assume [40] is semantically acceptable. 'John leaves tomorrow' then receives satisfaction conditions as

in [41].

[41]   [There is a t_1: t_1 $\$$ t^* & t_1 ⨍ tomorrow](John leaves(t_1)).

The restriction to present or future times explains the restriction on which adverbials can modify a

present tense verb. Present tense verbs modified by unanchored adverbials, such as 'on Tuesday', are

likewise interpreted as future looking.

This account treats non-quantificational temporal adverbials as predicates of an implicitly quantified

temporal variable. Unacceptable combinations of tense and adverbs is due not to a structural or logical

defect, but rather to semantic incompatibility. Even for unacceptable forms, there is no difficulty in

identifying logical form. What renders them unacceptable is a conflict between the requirement

imposed on the event time by tense and what the meaning of the adverb requires. (Our treatment of

temporal adverbials is reminiscent of Davidson's treatment of event adverbials (Davidson 1980).

However, Davidson treats temporal adverbials as predicates of events as well. We will argue that he is

mistaken in §9.)

6   'Before' and 'after'

'Before' and 'after' can function as sentential connectives, as in 'Brutus hailed Caesar before he killed

him', as components in relational predicates flanked by event or temporal designators when

concatenated with the copula, as in 'Midnight is before noon', and as adverbials, as in 'before

tomorrow', and 'before Mary'. An adequate semantic account of 'before' and 'after' should exhibit

them playing the same semantic role in each of these constructions. A simple unified account is

suggested by our approach. A sentence such as 'Brutus hailed Caesar before he killed him' will be

represented as involving two existential quantifiers over past times relative to the present. 'before'

naturally modifies the verb in its preceding clause by relating its time to that of the verb used in its

succeeding clause. So 'before' is a relational predicate of times. Satisfaction conditions for 'Brutus

hailed Caesar before he killed him' would then be represented as [42].

[42]　　[There is a time t_1: $t_1 < t^*$][there is a time t_2: $t_2 < t^*$ & t_1 is before t_2](Brutus hails(t_1) Caesar and Brutus kills(t_2) Caesar).

This suggestion extends to 'after' and other temporal relational terms, such as 'at the same time as' (or simply 'as'), 'until' ('before but not after') and their modifications, such as 'a few minutes before' ('since', which is used with the perfect tenses, is more complicated, but the same idea applies). Some relational terms are themselves complex. But there appears to be a uniform contribution of the modifiers of simple relational terms. 'x is M before y' can be unpacked as 'x is before y and INT(x,y) = M', where 'INT(x,y)' means 'the interval between x and y'. This licenses general satisfaction conditions for sentences of the form $^+$N M R R$^{\cdot}$, where 'R' is replaced by a simple temporal relational predicate and 'M' by its modifier. This treatment explains why 'before' and 'after' are not truth-functional connectives, for the underlying logical form exhibits 'before' and 'after' as contributing temporal relational predicates.

　　Occurrences of 'before' and 'after' in adverbials function to relate times as indicated in the previous section. Satisfaction conditions for [43] are given by [44].

[43]　　John will leave before tomorrow.
[44]　　[There is a t_1: $t_1 > t^*$ & t_1 is before tomorrow](John leaves(t_1)).

Sentences of the form $^+$N before $''$ $^{\cdot}$, where N is a sentence and $''$ a noun phrase but not a temporal designator, will be treated as having the underlying form $^+$N before R$^{\cdot}$, where N and R are sentences. If $''$ is a predicate nominalization, e.g., 'being fined', then R = $''$ { UNOM($''$,T), where UNOM(x,y) yields a predicate of which x is a nominalization with the tense marker y, where y will be the tense of the main verb. UNOM('being fined', future) = 'will be fined', while UNOM('being fined', past) = 'was fined'. If $''$ is a singular term or quantified noun phrase, R = $''$ { PRED(N), where PRED(x) is the predicate of x. PRED('John will leave') = 'will leave'. 'John will leave before Mary' has satisfaction conditions represented by [45].

[45]　　[There is a time t_1: $t_1 < t$][there is a time t_2: $t_2 < t$ & t_1 is before t_2](John leaves(t_1) and Mary leaves(t_2)).

7   Temporal quantifiers

Temporal quantifiers include 'everyday', 'always', 'sometimes', 'often', 'frequently', 'whenever', and 'when'. Whereas 'everyday', 'always', and 'sometimes', and the like, function as simple adverbs, 'whenever' and 'when', though adverbs, introduce subordinate clauses, and function syntactically as sentential connectives. In both cases, however, semantically they quantify over times, binding unarticulated argument places in the verb(s).[25] We first treat temporal quantifiers that occur as adverbs, and then as sentential connectives.

The past and future tenses interact with temporal quantifiers differently than the present. We begin with present tense. [46] means roughly that John's hair is a mess at all times, and it can clearly be used on different occasions to express the same proposition.

[46]   John's hair is always a mess.

Although [46] is in the present tense, when modified by a temporal quantifier, it does not function as an indexical. In representing its truth conditions, then, we should treat the unarticulated argument place as bound by the temporal quantifier, rather than functioning indexically. This leads to [47] (*mutatis mutandis* for other temporal quantifiers).

[47]   [For all times t_1](John's hair is(t_1) a mess).

In contrast, utterances of [48] at different times express different propositions.

[48]   John's hair was always a mess.

An utterance of [48] yesterday would be true iff at every time before it John's hair was a mess, but its utterance today would require also that in the intervening time his hair remain unkempt. (Similarly for the future tense.) Thus, whereas by modifying a present tense verb we can transform a context sensitive sentence into a context independent one (other deictic terms aside), past and future tense verbs remain deictic when so modified. (This is one reason not to treat the present tense as involving quantification like the past and future, for it would mean treating it as combining with quantificational adverbs differently from the past and future, although they would share underlying structure.) The effect of the modification is to replace existential quantification over past times with quantification appropriate for the modifier. Satisfaction conditions of [48] then would be represented as those of [49].

[49]   [For all times t_1: $t_1 < t^*$](John's hair is(t_1) a mess).

The adverbs 'when' and 'whenever' are syntactically sentential connectives, but should likewise be treated semantically as quantificational. In [50], 'when' and 'whenever' are interchangeable.

[50]   John blushes whenever/when Mary looks at him.

For this reason, we will treat 'when' in such contexts as abbreviating 'whenever'. They are not interchangeable in [51], which requires a separate treatment.

[51]   I did it when he wasn't looking.

The difference is that between a universal and an existential quantifier. [50] is true iff at *any* time Mary looks at John, John blushes, i.e., [50] is roughly equivalent to a universally quantified conditional with 'whenever' functioning as a quantifier with wide scope binding the unarticulated argument place for time in both verbs. Employing restricted quantifiers, we need not represent [50] counter-intuitively as containing sentential connectives, but may represent its satisfaction conditions as in [52]; treating 'when' as a restricted existential quantifier in [51], yields [53].

[52]   [For all times t_1: Mary looks(t_1) at John](John blushes(t_1)).
[53]   [There is a time t_1: $t_1 < t^*$ & he is(t_1) not looking](I do(t_1) it).

As above, the past and future tenses remain deictic, though the present of state verbs does not. (It may seem natural to treat 'when' in some contexts, e.g., in 'Caesar defied the Roman senate when he crossed the Rubicon', as a definite description, but this is only because we know some things have happened only once. Interpreting 'when' as a definite description cannot be correct, since Caesar's defiance of the senate is consistent with 'Caesar crossed the Rubicon many times'.)

Notice that sentences with mixed simple tenses grammatically conjoined by 'when' or 'whenever', such as, 'John blushes whenever Mary looked at him' or 'John blushed when Mary will look at him', are uninterpretable. This is what we would expect if [52]-[53] were correct, since a single quantifier must bind the argument place for time in each verb, which renders restrictions signaled by different tenses unsatisfiable.

8 Habitual sentences and frequency adverbials

So-called habitual sentences, sentences about events that occur at regular intervals, are most naturally treated, from our standpoint, as harboring verbs whose temporal argument places are bound by a restricted quantifier, or sequence of restricted quantifiers, which may sometimes be suppressed. Frequency adverbials are the usual means of expressing habitual action, adverbials such as 'often', 'seldom', 'two times a week', 'every morning', 'regularly', as well as the quantifier adverbials already discussed. Frequency adverbials often consist of a phrase specifying a frequency, such as 'three times', or 'often', together with a modifier specifying a particular recurring interval, such as 'in the springtime', 'a week', or 'morning'. The modifier says that for every such interval, the event expressed by the verb occurs with the frequency expressed by the frequency adverbial. Significantly, a sentence with mandatory habitual readings invariably has a present tense event verb as its main verb. Consider first the examples in [54]-[55].

[54]   Mary often smokes in her.
[55]   Bill complains frequently.

Under what conditions are these true? We would *say* that Mary often smokes in her office only if she had smoked a fair number of times in the past while in her office. It would not do to announce [54] if Mary had infrequently or never smoked in her office, even if we knew that soon she will be smoking there everyday. [54] also suggests that Mary's smoking in her office is habitual, so that we can expect her to continue. If we wanted not to suggest that, we would use the present perfect: Mary has often smoked in her office. But this is not to say that [54] would be false were these conditions unmet, but rather only that we would not assert it. On the face of it, 'often' is a temporal quantifier in the same family as 'always' or 'sometimes'. It can be used with any tense, and it seems not to be temporally indexed. If we applied to it the same model we have for other quantifier words, we should represent [54] by [56].

[56]   [Often times t_1](Mary smokes(t_1) in her office).[26]

We wish to suggest [56] represents the logical form of [54], and that the special conditions above under which we would assert [54] represent conditions required by a standard conversational

implicature of using [54] (in preference to one of the other forms of reporting something about the pattern of someone's office smoking across time). So construed [54] does not require the times of Mary's smoking to be in the past, though this would be implied by its use, since if we knew that the smoking would begin in the future, we could be expected to be more specific. (Similarly, if we knew it were confined to the past relative to the time of speech, we could be expected to be more specific.) By choosing [54], we would indicate that Mary had been smoking often in her office, and was apt to continue (i.e., since we do not rule out its continuing, but could be expected to do so if we believed it would not, or to indicate some caution if we were unsure, we are supposed to believe it will continue). Interpreting [54] as [56] is compatible with the conditions under which we could be expected to assert [54], and it retains the basic model of applying quantificational temporal modifiers to present tense event verbs we have already deployed with success. (Compare: 'Mary smokes in her office every day'.)

Something similar arises with [55]. In addition, the adverb conveys something about the intervals between the times quantified over. There is no reason, though, not to use the corresponding quantifier word in representing its logical form, as in '[Frequent times t_1](Bill complains(t_1))'. Nonetheless, we may indicate more fully how this is to be understood by paraphrasing it with a plural restricted existential quantifier, '[There are times t: t occurs at frequent intervals]'. The implication that Bill *has* complained frequently and is apt to continue, will be explained pragmatically as already indicated.

We turn now to more complex examples in [57]-[58].

[57]   Mary lectures three times a week.
[58]   John often falls in love in the springtime.

In [57], evidently 'three times' is modified by 'a week'. 'three times' by itself would function as a number quantifier. 'a week', interpreted as 'each week', functions as a restricted universal quantifier with wide scope over 'three times'. This yields [59].

[59]   [For all times t_1: t_1 is a week][three t_2: t_2 f t_1](Mary lectures(t_1)).

[58] is ambiguous between in the springtime John often falls in love (this is more naturally conveyed by 'John falls in love often in the springtime'), and there are many springtimes in which John falls in love. These are represented in [60a]-[60b].

[60]　(a) [For all times t_1: t_1 is springtime][often t_2: $t_2\mathbf{d}t_1$](John falls(t_2) in love).
　　　(b) [Often t_1: t_1 is in the springtime](John falls(t_1) in love).

Not all sentences with habitual interpretations contain explicit frequency adverbials modifying the main verb. In [61]-[62], it is natural to say there is an implicit adverbial, more or less specific, perhaps, depending on context.

[61]　John works for a living.
[62]　Rover barks.

With [61], the adverbial 'for a living' together with the present tense event verb tells us that it is to be understood as quantified. A living cannot be earned from a single event of working, wages being what they are, and the present tense of an event verb typically has no use unless modified by a temporal adverb. Thus, [61] would usually be interpreted roughly as [63].

[63]　John works *regularly* for a living.

The use of present tense in [62] likewise requires a modifier, and since it is not future or past directed, it is naturally taken to be a frequency adverb of some sort, 'often' or 'frequently', or perhaps a vague cardinality quantifier 'a lot [of times]' (the speaker could not be intending to convey that Rover barks all the time). Thus, [62] might be interpreted roughly as [64].

[64]　Rover *often* barks.

These would receive satisfaction conditions appropriate for implicitly understood adverbials on the model exhibited above. (In practice which adverbials are implicit will be no more precise than the context requires.)

Although [63]-[64] employ present tense verbs, it is clear that their future and past analogs may be interpreted habitually as well: in these cases, however, there is an alternative reading of the sentences as existentially quantified, compatible with their modifiers. Discussing Rover's laryngitis, you may remark, 'Don't worry, Rover will bark again'. This would receive the habitual reading. However, if A, after

remarking to B that Rover always barks three times before going to sleep, continues, 'I've counted two barks only so far. Rover will bark again', this does not receive an habitual reading. Sometimes an adverbial will force an habitual reading, since it is incompatible with the existential reading, given what we know about how things work. This is so for 'will work for a living' and 'worked for a living'. Both would receive the habitual reading, because making a living by working requires, for most, regular application.[27]

9 Relation to the event analysis

In this section, we consider how our account interacts with the Davidsonian event analysis of adverbial modification. The event analysis assigns [66] satisfaction conditions as in [67].

[66] John walked up the hill at midnight in his dressing gown.

[67] For any function f, speaker s, time t, f satisfies$_{[s,t]}$ 'John walked up the hill at midnight in his dressing gown' iff there is an 'e'-variant f𝑁 of f such that f𝑁 satisfies$_{[s,t]}$ 'e is a walking by John and e is a going up the hill and e occurs at midnight and e occurs with John in his dressing gown'.

On the Davidsonian account, the temporal adjunct is a predicate of an event, not a time.

[67] does not really avoid treating adjuncts as introducing a predicate of times, because 'e is a walking by John and e is a going up the hill and e is at midnight and e occurs with John in his dressing gown' is tensed, so its satisfaction conditions must be unpacked by tenseless verbs in the metalanguage. (One might insist that these predicates are tenseless, but then they cannot be in English; in any case, reference must be secured to the time of utterance (or its equivalent) to accommodate the sensitivity of tense to time of utterance. See note 27 for further discussion.) Once done, we see that 'at midnight' introduces a predicate of times, as in [68].

[68] For any function f, speaker s, time t, f satisfies$_{[s,t]}$ 'John walked up the hill at midnight in his dressing gown' iff there is an 'e'-variant f𝑁 of f such that f𝑁 satisfies$_{[s,t]}$ '[There is a t_1: $t_1 < t^*$](e is(t_1) a walking by John) and [there is a t_1: $t_1 < t^*$](e is(t_1) a going up the hill) and [there is a t_1: $t_1 < t^*$ & t_1= midnight](e occurs(t_1)) and [there is a t_1: $t_1 < t^*$](e occurs(t_1) with John in his dressing gown)'.

[68], however, is inadequate, because it does not require each conjunct to be made true by the same time. For any event in which more than one agent could participate at different times, e.g., building a house, satisfaction conditions modeled on [68] would be incorrect. We need a single quantifier over temporal argument places for every modifier introduced by an adverbial phrase. So we should treat the main verb as introducing an existential quantifier over times which binds the temporal variable in the main verb and in any other verb introduced by its adverbials. This has an unexpected benefit. Because two quantifiers bind the adjuncts to the main verb (represented as having three places), it becomes possible to treat some adjuncts as modifiers of the agent of the act and not the event he performs. Thus, the awkwardness of treating an adverb such as 'in his dressing gown' as a modifier of an event can be dispensed with. The result is illustrated in [69].

[69] For any speaker s, time t, function f, f satisfies$_{[s,t]}$ 'John walked up the hill at midnight in his dressing gown' iff there is an 'e'-variant f̃ of f such that f̃ satisfies$_{[s,t]}$ '[There is a t_1: $t_1 < t^*$ & $t_1 =$ midnight](walks(John,e,t_1) & e is(t_1) a going up the hill & John is(t_1) in his dressing gown)'.

Similarly, we are now able to treat what are intuitively adverbials of place, e.g., 'on a mountain top', or of condition, e.g., 'in top form', as modifying objects rather than events (or states). This pleasing result is available only if we treat tense as introducing a quantifier binding argument places in each adjunct introduced by an adverbial.[28]

10 Thought and Tense

Sentences we use to describe particulars are indexed to the time of their utterance, and the contents of thoughts we express using them are determined by what they express. Consequently, our thoughts about particulars are invariably thoughts directly about the times of the thoughts themselves. Since sentences we use to express thoughts express them only once, when we want to attribute thoughts or speech acts to others or to ourselves at times other than the time of attribution, which sentences we use to articulate their contents must be indexed to the time of the reported thought or speech act. In this section, we consider how this is reflected in the interpretation of tense in complement clauses of indirect discourse and attitude sentences.

We will approach the topic of tense in attitude sentences and indirect discourse as a design problem for constructing reports of attitudes and speech acts, given a straightforward semantics for unembedded tensed sentences. Consider John's potential assertions at t_0 of [70a]-[72a], and their corresponding representations in English* interpreted relative to t_0 in [70b]-[72b].

[70]   (a) Mary was tired.   (b) [There is a $t_1 < t_0$](Mary is at t_1 tired).

[71]   (a) Mary is tired.   (b) Mary is at t_0 tired.

[72]   (a) Mary will be tired.   (b) [There is a $t_1 > t_0$](Mary is at t_1 tired).

We may report John's assertion (or the belief he thereby expresses) either before or after it occurs, or even simultaneous with it. Our temporal position with respect to John's utterance determines the tense of the main verb in our report; the tense of the complement clause, however, must be sensitive to the tense John used to express his belief. Let us consider first a report of what John said from the perspective of a time later than his assertion. The main verb will be in the past tense, but how do we report, given available resources, the content of John's assertion?

Deictic elements in complement clauses are usually interpreted relative to the speaker's context. Thus, although in direct speech we would report that John said 'I am tired', in indirect discourse we would report the same act by 'John said that *he was* tired'. However, unlike demonstrative pronouns and indexicals, such as 'I' and 'now', which are always interpreted relative to speaker context, just as they are when not embedded in a complement clause, tense is more complex. In reporting an assertion by John of any of [70a]-[72a] at t_0 from the perspective of a later time, it would be inappropriate to interpret a tense in the complement clause relative to speaker context, for that would attribute to the subject an assertion about the speaker's time and not his own. Thus, the tense in the complement clause must have its reference time, the time with respect to which tense of the complement clause verb indicates the time of the occurrence of the event it expresses, fixed by the tense of the main verb, that is, the argument place that functions indexically when the sentence is unembedded must be bound by the quantifier introduced by the main verb when embedded in an indirect discourse. Then the verb in the complement clause must indicate that the event expressed occurred before, at, or after the time of the reported utterance.

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From the design standpoint, it would be simplest to re-use in the complement the tense used by the subject. If the argument place that usually functions indexically were bound by the quantifier the main verb introduces, this would capture the relative present, past, or future directedness of the content of the original assertion. However, while some languages work like this (e.g., Russian, and, though without verb inflection, Chinese and Japanese[29]), English does not: in indirect speech if the main verb is in the past, the tense of the complement clause *must* shift to the past perfect, past, or past future respectively, as the tense of the main verb in the reported utterance is past, present or future.[30] This tense sequencing rule[31] is illustrated in Table 1.

Sentence uttered by John	Tense shift in complement clause with past tense main verb
Mary was tired.	John said that Mary had been tired.
Mary is tired.	John said that Mary was tired.
Mary will be tired.	John said that Mary would be tired.

TABLE 1

These would be interpreted respectively as [73]-[75].[32]

[73]   [There is a $t_1 < t^*$](John says(t_1) that [there is a $t_2 < t_1$](Mary is(t_2) tired)).
[74]   [There is a $t_1 < t^*$](John says(t_1) that Mary is(t_1) tired).
[75]   [There is a $t_1 < t^*$](John says(t_1) that [there is a $t_2 > t_1$](Mary is(t_2) tired)).

The tense of the main verb controls the temporal argument place of the verb in the complement clause which functions indexically when unembedded. For in order to articulate what John said using [70a], we must represent him as saying at some past time that at some prior time Mary was then tired; this is represented by [73]. This has been identified traditionally as the function of the past perfect, i.e., to pick out a time prior to some past time indicated by a verb in the sentence. Were the verb in the complement clause to be interpreted relative to the speaker's time, the report would be false of John, since he said nothing about the time of the speaker's utterance. Likewise, to capture what John said using [71a] we must say that there is some time such that John said at that time that Mary was then tired, which is what [74] expresses. To report that in the past John said that in the future relative to the time of his utterance Mary would be tired, the reference time of the embedded verb must be fixed by

the time of John's utterance, as shown in [75].[33] If we are right, most indirect discourse and attitude sentences quantify into the complement clause.

The tense sequencing phenomenon occurs only with the main verb in the past. So reports of John's future speech act will use the tense John would use, as in Table 2.

The sentence that will be used by John	Complement clause tense with future tense main verb
Mary was tired.	John will say that Mary was tired.
Mary is tired.	John will say that Mary is tired.
Mary will be tired.	John will say that Mary will be tired.

TABLE 2

Their interpretations would then be represented as in [76]-[78].

[76] [There is a $t_1 > t^*$](John says(t_1) that [there is a $t_2 < t_1$](Mary is(t_2) tired)).

[77] [There is a $t_1 > t^*$](John says (t_1) that Mary is(t_1) tired).

[78] [There is a $t_1 > t^*$](John says (t_1) that [there is a $t_2 > t_1$](Mary is(t_2) tired)).

The tense of the main verb, again, controls the temporal argument places of the verb(s) in the complement clause which, when unembedded, index to the time of utterance.[34]

Reports of present sayings use the same tense as used by the person whose speech act is being reported, but employ the present progressive for the main verb, as is illustrated in Table 3.

Sentence used by John	Complement clause tense with present tense main verb
Mary was tired.	John is saying that Mary was tired.
Mary is tired.	John is saying that Mary is tired.
Mary will be tired.	John is saying that Mary will be tired.

TABLE 3

Here the main verb does not express quantification over times, and, hence, in complement clauses verbs are simply interpreted relative to the utterance time, which gives correctly the content of John's assertions if he uses those or synonymous sentences. The interpretations are [79]-[81].

[79] John is saying(t^*) that [there is a $t_1 < t^*$](Mary is(t_1) tired).

[80]   John is saying(t^*) that Mary is(t^*) tired.
[81]   John is saying(t^*) that [there is a $t_1 > t^*$](Mary is(t_1) tired).

(This provides further support for rejecting the treatment of the present tense in [12].)

So far as we can see, there is no deep reason why English must employ a tense sequencing rule for indirect discourse and attitude sentences when the main verb is in the past tense. Not all natural languages do. Furthermore, the tense sequencing rule appears to prevent unambiguous reports of certain past speech acts. If a speaker uses a sentence in the past perfect, e.g., 'Mary had been tired', or in the present perfect, e.g., 'Mary has been tired', no tense can be used unambiguously to report him indirectly, since the past perfect has already been allocated to reporting utterances of sentences in the simple past. Our practice is to use the past perfect to report speech in the past perfect and the present perfect as well as the simple past, and to rely on context for disambiguation. This limitation can be got around to some extent by employing adverbial modifiers. We can say, 'John said then that Mary had been tired before some previous time'. This fails to assign content correctly, even if the quantifiers take wide scope, since the modifier is still represented as a conjunct. But such peculiarities of English cannot be philosophically significant, since languages can plainly to be designed so as to avoid them.

A brief remark on adverbial modifiers in complement clauses is in order. We take indirect discourse again as our model. By and large, we use the same modifiers as those in the reported utterance. John's assertion of 'Mary left before Jim' would be reported as 'John said that Mary had left before Jim'. This would be represented as '[There is a time t_1: $t_1 < t^*$](John says(t_1) that [there is a t_2: $t_2 < t_1$][there is a t_3: $t_3 < t_1$ & $t_2 < t_3$](Mary leaves(t_2) and Jim leaves(t_3))'. Adverbials that contain deictic referring terms such as 'now' and 'today', however, are evaluated relative to the time of utterance, which forces a shift from the adverbial originally used. Thus, if John said yesterday, 'Mary will leave before the day after tomorrow', he would be reported indirectly today as in [82], which is interpreted as [83].

[82]   John said that Mary would leave before tomorrow.
[83]   [There is a time $t_1 < t^*$](John says(t_1) that [there is a $t_2 > t_1$ & $t_2 <$ the day after t^*](Mary leaves(t_2)).

Unanchored adverbials, which seem to function deictically when unembedded, such as 'at midnight', and 'by noon', are an exception. In [84] the referent of 'midnight' is determined relative to the time of John's saying, not the time of utterance. Similarly, for other expressions which pick out times relative to a day or other standard unit. [84] would be interpreted as [85].

[84]   John said that Mary had left before midnight.
[85]   [There is a time $t_1 < t^*$](John says(t_1) that [there is a time $t_2 < t_1$ & $t_2 <$ the midnight of t_1](Mary leaves(t_2)).

This fits in with our earlier suggestion that unembedded uses of unanchored adverbials are implicitly deictic or quantified.

The account generalizes straightforwardly to iterated attitude and discourse sentences. In [86], the tense of 'said' governs 'had told', which in turn governs 'was leaving'.

[86]   John said last week that Mary had told him 3 days earlier she would be leaving tonight.

'last week' indexes to the present, as does 'tonight', but '3 days earlier' expresses a relation whose second term is suppressed yet is evidently the time of John's report. [86] is represented as [87].

[87]   [There is a $t_1 < t^*$ & t_1 **d** the week before t^*](John says(t_1) that [there is a $t_2 < t_1$ & t_2 **d** the day 3 days earlier than t_1](Mary tells(t_2) him that [there is a $t_3 > t_2$ & $t_3 =$ tonight](Mary is(t_3) leaving)).

If 'would say' is embedded in a report with a main verb in the past, the verbs it governs are also governed by the sequencing rule. In [88], the tense of 'would tell' governs 'loved', but 'loved' indexes to the time of the telling, not to a prior time. [88] would be represented as in [89].

[88]   John said that he would tell Mary that he loved her by next week.
[89]   [There is a $t_1 < t^*$](John says(t_1) that [there is a $t_2 > t_1$ & $t_2 <$ next week](he tells(t_2) Mary that he loves(t_2) her)).

Earlier we noted that present tense event verbs true of speech acts may be used performatively, as in, 'I promise I won't be late', or 'I promise to be there'. We suggested that these are understood to be modified implicitly by 'hereby', which refers to the utterance act itself, and that this modifier provides a quantifier to bind what would otherwise be a free variable in the main verb. We can now suggest a representation of the logical form of such sentences in light of our discussion of indirect discourse. We will take 'I promise I won't be late' as our example, which we represent as in [90].

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[90] [There is time t_1: $t_1=t^*$](I promise(t_1) by this act that it is not the case that [there is a t_2: $t_2>t_1$](I am(t_2) late)).

We likewise suggested that sometimes 'now' modifies a sentence, not a verb, as in 'Now he will resign for sure', which equivalent to 'It is now the case that he will resign', and might be represented as in [91].

[91] [There is a t_1: $t_1=t^*$ and $t_1=$now](it is(t_1) the case that [there is a t_2: $t_2<t_1$](he resigns(t_2)).

The chief moral here is that our reports of others' attitudes at times other than the present do not completely report the content of their attitudes, since they involve quantifying into the complement clause. What we learn is that some completion of the complement clause gives the content of the speaker's assertion (belief, etc.). There appears to be no way in English to be more precise, since even adding an adjunct does not eliminate quantifying into the complement clause, because the main verb's tense must control verb(s) in the complement clause.[35,36]

11 Semantics and the Metaphysics of Time

What light does our account of tense shed on traditional issues in the philosophy of time? A semantic theory for a language by itself has only conditional implications for what there is. It reveals the commitments of the sentences of a language, but nothing follows about what there is independently of which of them are true. Likewise, nothing follows about our commitments independently of our commitment to the truth of some sentences. However, since we are all committed to the truth of what we say using tensed sentences, we can confidently say that we are committed to whatever must be true if most of what we thereby say is true.

A first obvious, though not insignificant, point is that we are committed to times or, time intervals, if our semantics for tense and tense devices is correct. Not only do we refer to times using temporal referring devices, but we quantify over times as well. So there are times, if most of what we say is true. Moreover, if most of what we say is true, presentism, the view that only the present time is real, must be false, since we quantify over times before and after the present time.

Our account also takes sides in the debate over whether time is an A-series or a B-series, in McTaggart's terminology. Time is a B-series if temporal moments or intervals do not themselves have

changing properties, and talk about the present, past, and future is always relativized to some time or other as a reference point. Time is an A-series if times have changing properties of being present, past or future, where the property of being present is one which each time has in succession. Our semantics for tense is not committed to time's being an A-series in virtue of commitments to what we ordinarily say; indeed it is not clear that talk of being the present, past, or future time makes sense. Talk about times undergoing change appears to be a category error: if change involves an object having a property at one time and lacking it at another, for times to change, we would have to treat times as persisting through time! This would confuse times with objects, as one might confuse places with objects located at them and talk of places changing places.

Appeal to our use of a predicate such as 'is the present time' is illusory. This predicate is an indexical, since its component verb is tensed. To correctly capture its use, it must be exhibited as being used in accordance with a rule that makes its utterance true of a time iff that time is the time of utterance. Its satisfaction clause then can be represented as [92].

[92]   For any function f, time t, speaker s, f satisfies$_{[s,t]}$ 'x is the present time' iff f('x') = t.
No property is attributed using the predicate. It would be a mistake to object that 'is the present time' employs the identity sign plus a definite description, for in this case 'present' has no life independent of its use in 'the present time'. (While 'is present' has a use, it is used to mean the same thing as 'is here', and it is not used as a simple predicate of times.) 'The present time' does not function as a complex expression, but functions like 'now'. (Similar remarks apply to 'is in the past' and 'is in the future'.) Likewise, simply using tense inflected verbs does not commit us to properties of being present, past, or future.[37]

So if we are right about tense, the metaphysics of English, and, presumably, other natural languages, treats time as a B-series (the alternative not only being uncountenanced by compositional semantics, but of doubtful intelligibility: an example of the 'bewitchment of our intelligence by language'). We are left with a variety of puzzles: why we experience times as a succession of instants with a single direction, and why we cannot, as it were, travel through time in either direction in the way we can travel in any direction through space. Such puzzles, however, can yield only to conceptual analysis. The project of a

compositional semantics is complete after the logical form of the sentences we use to express our thoughts about times has been revealed.

12 Conclusion

This paper sketches a truth-theoretical approach to the phenomenon of tense and temporal modification in English. By treating tense as a device of restricted indexical quantification, we can account for the simple tenses and their modifiers in a way that conforms to our intuitive sense of what we say when we use tensed sentences, and we can show how understanding tensed sentences rests on a finite number of semantic rules. Tense is not very systematic, and we have seen that no simple compositional story can be told about how tenses interact with modifiers and how they behave when embedded. On the other hand, the number of rules required to understand these interactions is small, and we should not expect natural languages to be logically prefect.

While we lack a proof, we still think it would be difficult, compatibly with our methodological requirement that an interpretive truth theory be context insensitive, to give an account of the truth conditions of tensed sentences without treating tense as a quantificational device of some kind. We are aware of only two ways in which to do this: our approach and one which involves quantifying over events or states, as discussed in note 27, in which we also explain why we prefer our approach.

If our approach is correct, then, as we noted, we can draw a number of conditional consequences about the philosophy of mind, language, and metaphysics. First, many of our sentences and thoughts are directly about the present. Second, giving an account of the semantics of propositional attitudes which countenances quantification into their complement clauses is necessary for an adequate semantics for propositional attitudes, for virtually all attitude reports turn out to quantify into the complement clause. Contra Quine, quantifying-in cannot be incoherent on pain of making most of what we wish to say about the attitudes of another incoherent. Third, if much of what we say in ordinary speech is true, times or time intervals are real, and there are past as well as future times. On this condition, irrealism about time, and presentism (irrealism about past and future times) are both false. Fourth, our semantics for tense and temporal referring devices gives no comfort to anyone who views time as an A-series, i.e., who views times as undergoing change themselves. The quantificational approach does not treat

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tense as attributing properties to times at all, but as quantifying over, and indicating relations among, them by means of indexical reference to the time of utterance. Anyone who wishes to maintain that tensed sentences attribute properties to times owes us a semantics for tense that achieves as least as much as we have shown is possible with our quantificational approach.

Appendix
Present Perfect, Past Perfect, Future Perfect

In this appendix, we discuss the prefect tenses (or the perfective aspect, as it is often called), and how they differ from simple tenses.[38] Table 4 gives the forms of the perfect tenses.

Tense	Form	Example
Future Perfect	'will'/'shall' + 'have' + past participle	John will have seen it.
Present Perfect	present of 'have' + past participle	John has seen it.
Past Perfect	past of 'have' + past participle	John had seen it.

TABLE 3

The perfect expresses a completed event. The present perfect is used to indicate that an event has been completed as of the present. It differs from the simple past in allowing that the event's terminal point coincides with the time of utterance. One can say, 'John has finished swimming now', but not 'John finished swimming now'. Likewise, one can say, 'John has worked here since 1980', which means that from 1980 to the present John has worked here, but not 'John worked here since 1980', because the simple past requires the time of the event expressed by the verb to be in the past. (Adverbials of the form 'since'$\{$ *, where * is a temporal designator, are acceptable only with perfect tenses, though there is the idiomatic, 'It is a year since we left'.) However, contrary to what some philosophers and linguists claim,[39] the event need not extend into the present, as is shown by the acceptability of 'John has been a lifeguard, but isn't any longer'. The future perfect is used to indicate something has been completed as of some future time. The past relative to the future reference time may be past relative to the speaker's time of utterance, or it may be completed at any time up to and including the future reference time. If it is true now to say John sat down yesterday, it is true to say John will have sat down by tomorrow. Likewise, if tomorrow one says truly, 'John has finished swimming now' at 3 o'clock, it would be correct to say today, 'John will have finished swimming by 3 o'clock tomorrow'. The past perfect is used to say something has been completed by some past time. So if John finished swimming

at 3 o'clock yesterday, it would be correct to say today, 'John had finished swimming by 4 o'clock yesterday'.

The effect of projecting these future, present, or past reference times relative to which an event is said to have been completed can be accommodated within our framework by introducing another quantifier and a relation restricting the relations among the bound temporal variables. The past perfect pf [93a] is illustrated in [93b], and the future perfect of [94a] in [94b].

[93] (a) John had seen it.
   (b) [There is a t_1: $t_1 < t^*$][there is a t_2: $t_2 \# t_1$](John sees(t_2) it).
[94] (a) John will have seen it.
   (b) [There is a t_1: $t_1 > t^*$][there is a t_2: $t_2 \# t_1$](John sees(t_2) it).

For convenience, we will adopt Reichenbach's terminology[40] to distinguish among the times represented by 't_1', 't^*', and 't_2', the *reference* time, the *speaker* time, and the *event* time, respectively. The event time is the time of the action expressed by the main verb, the speaker time is the time of utterance, and the reference time is the time relative to which the event time is located. In [93]-[94] 'have' contributes a restricted existential quantifier that relates its temporal variable, the reference time, to the speaker time as before or after it, depending on whether the tense of 'have' is past or future, and the past participle contributes likewise a restricted existential quantifier binding the variable associated with event time, which is related to the reference time as before or simultaneous with it. The present perfect of [95a] receives a parallel treatment, as in [95b].

[95] (a) John has seen it.
   (b) [There is a t_1: $t_1 = t^*$][there is a t_2: $t_2 \# t_1$](John sees(t_2) it).

Though we could simplify [95], it is plausible that the function of combining a tense of 'have' with the past participle is the same in every perfect tense but for the contribution of the tense of 'have'.[41] This leads to a pleasing symmetry in the interaction of perfect tenses with various adverbials.[42]

The utility of the perfect becomes apparent when we consider its interaction with certain adverbial modifiers which (partially) fix the reference time. In 'John will have seen it by tomorrow', 'by tomorrow' modifies the reference time, i.e., the future time in the past relative to which the event is said

to occur. Similarly for the past perfect and the present perfect. Thus, for 'John will have finished swimming by tomorrow', we have [96].

[96]   [There is a time t_1: $t_1 > t^*$ & t_1 = tomorrow][there is a t_2: t_2 # t_1](John finishes swimming(t_2)).

This explains why 'John will have finished swimming by yesterday' is ill-formed, since it would require the reference time, which the quantifier restriction requires to be in the future relative to the utterance time, to be also in the past relative to the time of utterance. Similar remarks apply to the past perfect. One cannot say, 'John had seen it by tomorrow'. The perfect tenses are useful, particularly the past and future perfect, because they allow us to set time boundaries other than the present for events. This is accomplished by adverbial modification on the past or future reference time with respect to which another event is to have occurred in the past relative to it. This explains why unembedded and unmodified uses, or context free uses, of the perfect can seem odd, e.g., an unadorned use of 'John had been there'. The perfect tenses are almost never used without adverbial modification, or without an appropriate context in which there is an implicit adverbial modification provided by the surrounding discourse.

Not all adverbials modifying verbs in a perfect tense modify the reference time; some modify the event time. In 'John had arrived on Tuesday', 'on Tuesday' modifies only the event time. Generally, it appears that adverbials introduced by limiting prepositions, like 'by', 'before', and 'after', modify the reference time. Adverbials that indicate a specific date are used to specify the event time. Often, such modifications will sound odd, as in, 'John will have arrived Tuesday next week'. They sound odd because using the perfect tense when the adverbial modifies the event time is usually pointless. 'John had arrived on Tuesday' seems less strange because it is easy to imagine a narrative in which the use of the past perfect would have a point, e.g., 'Mary, who arrived on Wednesday, thought she had arrived before John. But John had arrived on Tuesday.'[43]

An interesting test of our proposal is whether it can explain the interaction of adverbials introduced using 'since' followed by a temporal designator with the various tenses, which seem acceptable only with perfect tenses. While we can say, 'John has/had/will have worked since 1980', we cannot say

felicitously 'John worked/works/will work since 1980'. With the past perfect and the future perfect, 'since 1980' adds that the activity expressed by the verb has taken place in the period from 1980 to the *reference* time; with the present perfect, 'since 1980' adds that the activity expressed by the main verb has taken place in a period from 1980 to the present,[44] but since this is the reference time, we can represent 'since 1980' requiring for all three that the activity take place between 1980 and the reference time, as illustrated in [97]-[99] (where 't - x' means 'the time interval from x to t').

[97]   [There is a t_1: $t_1 = t^*$][there is a t_2: $t_2 \# t_1$ & $t_2 = t_1 !$ 1980](John works(t_2) here).
[98]   [There is a t_1, t_2: $t_1 < t^*$][there is a t_2: $t_2 \# t_1$ & $t_2 = t_1 !$ 1980](John works(t_2) here).
[99]   [There is a t_1, t_2: $t_1 > t^*$][there is a t_2: $t_2 \# t_1$ & $t_2 = t_1 !$ 1980](John works(t_2) here).

So modifying a verb in a perfect tense with 'since 1980' is to say that the *event* time is equal to the time interval between 1980 and the *reference* time. We can see why 'since 1980' does not sit comfortably with the simple tenses. It designates a time interval identified with the event time. But for the simple tenses, the anchor time for determining the time interval would be the time of utterance (i.e., the event time would be identified with $t^* !$ 1980), but the requirements imposed on the event time by the simple tenses are incompatible with this. Notice how nicely the account adapts to the embedding of 'since' in other modifiers, e.g., 'several times since 1980'. 'since 1980' modifies 'several times', which quantifies over the event time. So 'John has worked several times since 1980' is represented as '[There is a t_1: $t_1 < t^*$][several t_2: t_2 d $t_1 !$ 1980](John works(t_2))'.

Adverbs of quantification, and 'before' and 'after' used as sentential connectives, likewise modify the event times. Consider [100] and [101].

[100]   John had loved Mary long before he said it.
[101]   John had never been to Arizona.

'Before' relates event (or state) times, i.e., it relates the argument places in the main verbs of the sentences flanking it. In [100], 'long' modifies the state time. [100] is paraphrasable as [102].

[102]   [There is a t_1: $t_1 < t^*$][there is a t_2: $t_2 \# t_1$][there is a t_3: $t_3 < t^*$ & t_2 is long before t_3](John loves(t_2) Mary and John says(t_3) it).

The extra quantifier effectively is innert, which explains why [100] and [103] express the same thing.

[103]   John loved Mary long before he said it.

The past perfect in [100] serves mostly as a way of emphasizing John's love was past relative to a relevant time also in the past. The quantifier 'never' in [101] binds the temporal argument place in its main verb. [101] conveys that at no time prior to some former time had John been to Arizona, which does not entail John has never been to Arizona. [101] is paraphrased as [104].

[104]   [There is a t_1: $t_1 < t^*$][for no t_2: $t_2 < t_1$](John is(t_2) in Arizona).

'when' may be used with the past perfect, but apparently only if the 'when'-clause is in the simple past. [105] is acceptable, [106] is not.

[105]   He had gone when Bill arrived.
[106]   He had gone when Bill had arrived.

In [105], 'when' binds the event time for the restricting clause, and the reference time for [105] is in the past perfect, as shown in [107].

[107]   [There is a time t_1: $t_1 < t^*$ & Bill arrives t_1][there is a time t_2: $t_2 < t_1$](he goes(t_2)).

When we assigned satisfaction conditions to sentences of the form $^+$N when R$^\cdot$, when N and R were in the past tense, we saw that semantically N shifts to present tense. Now we see that when N is in past perfect, it effectively functions like the past with the argument place which usually functions indexically being bound by 'when'.[45] The problem with [106] is that for 'when' to bind across both sentences, it must bind the reference time in 'Bill had arrived' and what would be the indexical reference to speaker time in 'He had gone' when unembedded. This yields [108],

[108]   [There is a time t_1: $t_1 < t^*$ & $t_2 < t_1$ & Bill arrives t_2][there is a time t_3: $t_3 < t_1$](he goes(t_3))

which conveys no useful information about the temporal relations between the two event times. 'whenever', like 'when', is comfortable with the past perfect only when the restricting clause is in the simple past, as in [109], which would be paraphrased as in [110].

[109]   He had tried to buy it whenever he had money.
[110]   [For any time t_1: $t_1 < t^*$ & he has(t_1) money][for a time t_2: $t_2 < t_1$](he tries(t_2) to buy it).

These examples illustrate how to combine our account of adverbial modification with perfect tenses. There is some interest in looking at the possible combinations of tenses, with 'when' and 'whenever', but that would be too involved a task for the present context. Depending on its kind, a modifier will

modify either the reference or event time. Quantificational adverbs which are not sentential connectives invariably modify event time. Limiting adverbs invariably modify reference time. Temporal sentential connectives like 'before' and 'after' invariably connect event times. 'when' and 'whenever' bind event time in the first clause and speaker time in the second.[46]

References

Abusch, D. 1997. Sequence of Tense and Temporal De Re. *Linguistics and Philosophy* 20:1-50.

Burge, Tyler. 1974. Demonstrative Constructions, Reference and Truth. *The Journal of Philosophy* 71:205-223.

Comrie, Bernard. 1985. *Tense*. New York: Cambridge University Press.

Dähl, Bernard. 1985. *Tense and Aspect Systems*. Cambridge: Cambridge University Press.

Davidson, Donald. 1980. The Logical Form of Action Sentences. In *Essays on Actions and Events*. New York: Clarendon Press.

Dowty, David. 1977. Toward a Semantic Analysis of Verb Aspect and the English 'Imperfective' Progressive'. *Linguistics and Philosophy* 1 (45-77).

Dowty, David. 1982. Tenses, Time Adverbs, and Compositional Semantic Theory. *Linguistics and Philosophy* 5:23-58.

Evans, Gareth. 1985. Does Tense Logic Rest on a Mistake? In *Collected Papers*. Oxford: Clarendon Press.

Frege, Gottlob. 1977. The Thought. In *Logical Investigations*, edited by P. T. Geach. New Haven: Yale University Press.

Gabbay, Dov, and Christian Rohrer. 1979. Do We Really Need Tenses Other Than Future and Past? In *Semantics from Different Points of View*, edited by R. Bauerle, U. Egli and A. Von Stechow. New York: Springer-Verlag.

Higginbotham, James. 1995. Tensed Thoughts. *Mind and Language* 10 (3):226-249.

Hinrichs, Erhard. 1986. Temporal Anaphora in Discourses in English. *Linguistics and Philosophy* 9:63-82.

Kamp, J. 1971. Formal Properties of 'Now'. *Theoria* 37:227-273.

Lewis, David. 1975. Adverbs of Quantification. In *Formal Semantics of Natural Language*, edited by E. Keenan. Cambridge: Cambridge University Press.

Ludwig, Kirk. 1996. Singular Thought and the Cartesian Theory of Mind. *Nous* 30 (4):434.

Ludwig, Kirk. 1997. The Truth about Moods. *Protosociology, Cognitive Semantics I - Conceptions of Meaning* 10:19-66.

Ludwig, Kirk, and Greg Ray. 1998. Semantics for Opaque Contexts. *Philosophical Perspectives* 12.

Mittwoch, Anita. 1988. Aspects of English Aspect: On the Interaction of Perfect, Progressive and Durational Phrases. *Linguistics and Philosophy* 2:203-254.

Ogihara, Toshiyuki. 1996. *Tense, Attitudes, and Scope*, *Studies in Linguistics and Philosophy*. Boston: Kluwer.

Palmer, F. R. 1974. *The English Verb*. London: Longman.

Parsons, Terence. 1990. *Events in the Semantics of English: A Study in Subatomic Semantics*, *Current Studies in Linguistics*. Cambridge: MIT Press.

Partee, Barbara. 1973. Some Structural Analogies Between Tenses and Pronouns in English. *Journal of Philosophy* LXX (18):601-609.

Reichenbach, Hans. 1947. *Elements of Symbolic Logic*. New York: Macmillan.

Richard, Mark. 1981. Temporalism and eternalism. *Philosophical Studies* 39:1-13.

Russell, Bertrand. 1903. *The Principles of Mathematics*. Cambridge: Cambridge University Press.

Smith, Carlota. 1978. The Syntax and Interpretation of Temporal Expressions in English. *Linguistics and Philosophy* 2:43-99.

Taylor, Barry. 1977. Tense and Continuity. *Linguistics and Philosophy* 1:199-220.

Vendler, Zeno. 1967. Verbs and Times. In *Linguistics and Philosophy*. Ithaca: Cornell University Press.

Visser, F. Th. 1972. *An Historical Syntax of the English Language*. Vol. 5. Leiden: E. J. Brill.

Vlach, Frank. 1993. Temporal Adverbials, Tenses and the Perfect. *Linguistics and Philosophy* 16 (3):231-283.

Notes

1. An extensive study of the categories of tense and aspect across languages can be found in (Dähl 1985). See also (Gabbay and Rohrer 1979) for a comparison of the expressive resources of English and Hebrew.

2. See (Ludwig 1997) for an account of how to extend the truth-theoretic approach to non-declaratives.

3. Though we will not argue for it here, we believe these are the only contextual parameters we need in order to devise an adequate semantics for tense. Throughout quantifiers over times will range over time intervals, and 'is a time' will be true of time intervals. We will include as a limiting case of a time interval temporal instants.

4. [5] is sometimes said to be untensed (see, e.g., (Palmer 1974, p. 33, pp. 36-38)), since its verb is constructed from a modal auxiliary 'will' and an infinitive verb stem, and does not involve inflection. As we noted above, our classification is guided not by syntactic but semantic considerations, and the semantic function of 'will' + infinite verb stem is to indicate that the action or state expressed by the verb occurs or obtains at a time later than the time of utterance, and thus it semantically functions like the present and past tenses.

5. The future tense is also expressed by using 'is' + 'going' + the infinitive, as in 'Mary is going to love Bill'. Since these are equivalent, what we say about the modal + bare infinitive applies equally to the alternative form.

6. Nonfinite verbs, infinitives, participles, and gerunds, are said to lack tense. However, they do not function as main verbs, but rather nominally, adjectivally, or adverbially.

7. 'ref$_{[s,t]}$(y) = x' is read as 'the referent of y as potentially used by s at t = x'.

8. The truth conditions we offer, in broad outline, we believe underlie most thinking about tense in other frameworks. As far as truth-theoretic accounts go, we draw attention to the formulation using restricted quantifier notation, which we think better captures the semantic structure of the past and future tenses. While we will identify some salient differences with other approaches, we will not try to provide a systematic comparison, which would be a book-length task.

9. The recursive clause for restricted quantifiers has the form,
    For any speaker s, time t, function f, f satisfies$_{[s,t]}$ $^{+}$[Qx: Fx](Gx)' iff Q 'Fx'-variants f' of f satisfies$_{[s,t]}$ 'Gx'.
where 'Q' is a place-holder for a quantifier, and the metalanguage embeds the object language. 'Fx-variant f' of f' is defined as follows: f' is an 'Fx'-variant of f iff f' differs from f at most in that f' satisfies$_{[s,t]}$ 'Fx'.

10. See (Ludwig 1996) for a general argument for this view.

11. This neatly handles the need for a potentially arbitrarily large number of independent reference times for events in subordinate clauses, e.g., 'John saw the man who kissed Mary, who bought a farm from the woman Bill divorced'.

12. As we remarked earlier, metalanguage verbs are tenseless. Object language quantifiers range over every extant object, taken tenselessly, i.e., not relativized to any time. If natural language quantifiers were evaluated relative to the time of utterance, so that their domains were restricted to what existed at that time, this would have to be represented in our semantics by restricting the domain to objects existing at the time of utterance. This is not, however, how quantifiers are used in English: 'Everyone who lived in the 19th century suffered from gout' is not vacuously true but rather factually false. As we note below (note 32), for restricted quantifiers we can interpret the restriction as in a tense other than that of the predicate to which it is attached. We anticipate some discomfort due to the reflection that a sentence such as 'Everyone was at the party' will be false on this view because the quantifier will range over

people at all times. But this is no more puzzling than that the quantifier is used with an implicit restriction on the domain of people at the present time.

    The interaction of negation with tense is more complicated. 'John did not rest for two days' receives one of two readings, depending on whether 'not' takes wide or narrow scope. Our account can represent this by treating negation univocally as a sentential operator, and representing it as either taking wide scope over the sentence, or as letting the tense take wide scope over it. In a truth theory, such sentences would first have to be disambiguated. For the narrow scope reading, 'not' would be treated as internal to the verb, so that it is not treated recursively but in the satisfaction clause for 'did not rest': f satisfies$_{[s,t]}$ 'John did not rest' iff f satisfies$_{[s,t]}$ '[There is a t$_1$: t$_1$<t*](it is not the case that John rests(t$_1$))'. The difference only surfaces when negation interacts with adverbials.

13. Some authors (e.g., (Burge 1974; Partee 1973)) suggest that simple tenses are implicitly demonstrative. An utterance of 'I didn't turn off the stove' is usually understood to involve a specific past time interval, and not just any past time. Space constraints prevent us from discussing this suggestion fully. While a truth theoretic approach can easily incorporate devices that worked this way, we believe these phenomena are pragmatic and not semantic.

14. There are two exceptions. First, there is the so-called narrative or historical present (or, sometimes, 'vividly reporting present'), as in live broadcasts of a sporting event, in which the announcer attempts to convey a sense of immediacy by reporting events in the simple present: He hits a terrific serve, approaches the net, and hits a winner down the line to win the game. (See (Visser 1972, p.724), for a wealth of other examples.) We can also use the naked present in chronological tables, '579 B.C. Nebuchadnezzar takes Tyre'. These are so specialized that we are unsure what weight to grant them. Their aim is clearly to achieve a kind of vividness in reporting that a past tense report would fail to convey. The present tense of event verbs, so oddly used in the present, lies ready to hand: it is no wonder it is pressed into use for such an effect, even if there is something odd about it. But it does seem to be a kind of play with words recognized as a bit odd or out of place, and partly effective for that reason. We are inclined to say this is an *extended* and not a *core* use of the present, despite its appearing throughout the history of English.

    The second case is the use of the present tense of event verbs in issuing performatives, as in 'I promise to meet you there', or 'I warn you not to do that'. It is unclear what to say about such uses. It would be odd to interpret them as anything other than promises or warnings, though it is tempting to say that one promises or warns, etc., by way of asserting one is doing so. But contrast 'I promise to meet you there' with 'I am promising to meet you there'. The latter is not ordinarily useable to make a promise. So no performative is accomplished by asserting one is perform*ing* the act in question as one speaks. It seems, rather, that utterances of 'I promise to meet you there' intended as promises are implicitly self-referential, i.e., are interpreted as 'I hereby promise to meet you there', where 'hereby' makes implicit reference to the utterance; we may treat this modification as introducing a reference to the time of utterance. We will discuss these cases in the section on indirect discourse below.

15. Though denying that the progressive is a tense is not novel, it is not universally accepted. See (Comrie 1985).

16. For discussion, see (Dowty 1977; Parsons 1990, chapter 9). It is called the 'imperfective paradox' because 'imperfect' in grammatical usage means 'uncompleted'. The puzzle is how a verb which expresses essentially a complete event can have an imperfect tense, i.e., a tense which implies that the event has not been completed.

17. See (Vendler 1967) for a classic discussion of verb classification. According to (Vlach 1993, pp. 241-243), progressives are state verbs. so to say that John is leaving is to say that John is in the state of a process of his leaving being in progress. We see no reason to force fit the progressive into any category of this dichotomy.

18. See [LePore, Manuscript #2143, appendix] for detailed discussion of the semantics for demonstratives.

19.[26]-[27] are indexed to the use of the demonstrative because someone can perform more than one demonstration at a time, e.g., pointing to a calendar to benefit one interlocutor, while using 'then' to pick out a different time.

Further modifications would be required to get it just right, but we omit them here to avoid the distraction an adequate discussion would require. See [LePore, Manuscript #2143, appendix] for discussion.

20. This explains why temporal indexicals always index to the time of the speaker even when embedded in sentences which otherwise are interpreted relative to a time distinct from the present, as in 'John said that Mary had believed that Bill would be here by now'. Difficulties introduced by such terms (and similar phenomena -- see note 34) led to two dimensional tense logics (see (Kamp 1971)). In the truth conditional approach, we can provide a simple and natural explanation of this behavior by treating such terms as singular referring terms and assigning them reference axioms which determine referents relative to the time of a speaker's use. This cuts through the difficulties (Dowty 1982, see esp. §4.4.5-6) encounters working in another framework.

21. Multiple temporal demonstratives and indexicals present an additional complexity, which space constraints force us to touch on only briefly. See [Lepore, Manuscript #2143]. Sentences such as 'Now isn't now' and 'Now you see it, and now you don't', in which each use of 'now' indexes to a different time, require satisfaction axioms that quantify over times for each occurrence of 'now' as well as for the utterance as a whole, and each contained sentence (form) in molecular sentences. To accommodate this need, we define a family of relational predicates:

Def. $)(s,t,t_1,...,t_n, "_1, ..., "_n)$ iff $t_1 < t_2 < .. < t_n$, and $t_1...t_n$ occur in t, and s uses $"_1$ at t_1, s uses $"_2$ at t_2,.,s uses $"_n$ at t_n. The six-place predicate so defined holds between a speaker s, three times t, t_1, t_2, and two temporal designators, $"_1, "_2$ iff t_1, t_2 ƒ t, $t_1 < t_2$, and the speaker uses $"_1$ at t_1, $"_2$ at t_2. We give satisfaction conditions for a two-place predicate, R, expressing a temporal relation as follows: For any speaker s, function f, temporal designators $"_1, "_2$, and *times t, t_1, t_2, such that* $)(s,t,t_1,t_2, "_1, "_2)$, f satisfies$_{[s,t]}$ $+"_1$ R $"_2$, iff ref$_{[s,t1]}("_1)$ R(t) ref$_{[s,t2]}("_2)$. This can be extended to predicates with an arbitrary number of temporal argument places. For molecular sentences, we index the utterance time of the contained sentences; for conjunction: For any speaker s, function f, formulas N, R, and *times t, t_1, t_2, such that* $)(s,t,t_1,t_2,N,R)$, f satisfies$_{[s,t]}$ $+N$ and R, iff f satisfies$_{[s,t1]}$ N and f satisfies$_{[s,t2]}$ R. This allows for the possibility of saying truly 'Though John has not smiled yet, he is smiling now, and now has smiled'.

22. We use this for illustrative purposes only. In fact, the year of the birth of Christ is not thought to be the anchor point for our calendar.

23. There is a class of adverbials whose members are used routinely to connect sentences in narratives which we will not discuss. These are exemplified by 'three hours later' in the following passage, borrowed from (Hinrichs 1986): 'They wheeled me into the operating room and put me under sedation. Three hours later I woke up.' The reference time for 'later' here is understood to be the time the narrator was put under sedation. Examples of this sort, as well as the conventions of narrative more generally, in which times of narrated events are understood to occur in an order indicated by the order of narrative, have suggested to many that the proper unit for semantical analysis is larger than the sentence, and that the traditional focus on sentential semantics distorts the semantic structures of natural languages. We will sidestep this debate. Although we think our understanding of narrative can be accommodated by a sentence level semantics, nothing in our approach prevents our incorporating semantic level cross-sentential anaphoric reference.

24. We borrow this terminology and classification scheme from (Smith 1978).

25. Some uses of temporal adverbs suggest that they are not always used to quantify over times, as, for example, in the sentence, 'Even numbers are always divisible by 2'. On such grounds (Lewis 1975) argues that they should be treated as quantifying over "cases". This desperate expedient should be resisted. Given that forms of 'to be' in English will have a suppressed temporal argument place, there can be no difficulty in including a temporal quantifier even in sentences which are about abstract objects. Indeed, not supplying a universal quantifier for a sentence such as 'Even numbers are divisible by 2' might be thought to be misleading when a speaker intends to be conveying that this is so necessarily or by definition. The effect of introducing 'always' is to emphasize the non-contingency of the

claim, although what is said strictly speaking falls short of what is intended.

26. We've not analyzed the modifier 'in her office' here. There are two ways of taking it. One can read it as modifying 'often' or as modifying the event introduced by the verb 'smokes'. On the first reading, we get: [Often t: Mary is(t) in her office](Mary smokes(t)). On the second, adopting the approach we introduce below, we get: [Often t][there is an e](e is(t) a smoking by Mary and e is(t) in Mary's office). The second entails Mary is often in her office, the first does not.

27. (Vlach 1993) claims that '[n]o existing framework for temporal semantics provides a general treatment of durative ...and frequency...adverbials' (p.231), and that, in particular, none can deal with a sentence such as:

    (i)   Allen worked out regularly for two weeks last month.

Our account handles this straightforwardly. The frequency adverb is a quantifier that replaces the existential quantifier of the tense of 'worked out', keeping the past time restriction. The duration adverbial 'for two weeks last month' (where 'last month' modifies 'two weeks') modifies the time so bound, which is understood to be within the time so designated, represented as:

    (ii)   [Regular t_1: $t_1 < t^*$ & t_1 **d** two weeks last month](Allen works(t_1)).

Vlach's account of tense (or more properly, tense inflection) is that it makes no truth functional contribution to sentences in which it occurs, but is like the gender of pronouns, which, he assumes, does not contribute to truth conditions. English users are supposed to follow the convention to use 'he' when talking about a male and 'she' when talking about a female, but one may, he asserts, say truly of a woman, 'He is tall'. Similarly, one is supposed to obey a convention to use present and past when talking about the present and the past, but this is no part of the truth conditions of the utterance, taken literally. All the work of semantic temporal reference, Vlach says, is really done by adverbial modification. This is an interesting suggestion, but certainly swims against the tide! It hardly comports with our intuitive judgements about the truth of utterances using tensed verbs. If one asserts, 'John was elected to the Senate', but John has not acceded to that august body, one offends not just against usage, but against the truth.

28. Can we account for tense using a quantifier over events and not times? The difficulty is to anchor reference to events to the time of utterance. The only way we can see how to do this is to force every utterance to refer to itself, since each utterance is guaranteed to occur at the time of speech. (Such an approach is sketched in (Higginbotham 1995).) For the past tense, we might treat, e.g., 'John kissed Mary' as equivalent to '[There is an event e: $e < u^*$](Kisses(e,John,Mary)'. Then 'u*' would receive the reference axiom: For any speaker s, time t, utterance u by s at t, $ref_{[s,t]}$('u*') = u. It seems counterintuitive, however, to treat every utterance as self-referential. Furthermore, it seems intuitively clear that what one says in uttering, e.g., 'It will rain this afternoon', could have been true even if there had been no utterances. It could not have been true, however, if there had been no times. For these reasons, we reject this alternative approach.

29. See (Comrie 1985, p. 109) for Russian and see (Ogihara 1996).

30. There are apparent exceptions to this rule, e.g., reports of certain states which continue into the present, as in 'I heard last night that Mary is sick', or the 'The Egyptians knew that the earth is round' (borrowed from (Smith 1978, p. 66)). In this case, the present tense is interpreted relative to the speaker's context rather than that of the event or state being reported. This seems acceptable only when the verb is factive or a verb of indirect discourse. One cannot say, e.g., 'I thought that the earth is round'. We suspect that in this case the present tense is used to indicate that what is being reported was not something the content of which was relativized simply to the time of the reported event or state, but rather intended to express a state that would extend into some future indefinite time that at least includes the time of utterance. ((Abusch 1997) gives a different account which makes the appropriateness hinge on what the speaker believes, but if we wish the reports to be possibly true, the right account should focus on what the reportee knows, hears, says, etc.; one of Abusch's examples, 'John believed that Mary is pregnant', we find hard to

interpret!) A related case is, 'I asked him who that lady in the tiara is'. Here there is the pull of the demonstrative construction, interpreted relative to the speaker's time, as well as the assumption, forced by the use of the expression in the nominal modifying the demonstrative, that the lady in question is still wearing a tiara. (The example is borrowed from (Visser 1972, p. 779), a rich source of examples from Old to Modern English. Visser notes that the use of the present in the complement has been common in all periods of the language, though more recently neglected by grammarians (p. 827). The examples all seem, however, to fit the diagnosis here given. An event or process definitely located only in the past relative to the time of speech is quite unhappily reported in the present in the complement, e.g., 'He said that he is tired yesterday'.)

31. This terminology is not used consistently in the literature. Sometimes it is used for the semantic phenomenon of the tense in one clause controlling that in another; sometimes to refer to the syntactic phenomenon of back shifting of tense markers. We use it here in the latter sense.

32. We are following traditional rules for sequence of tense in reporting indirect discourse and attitude sentences. No doubt many speakers of English are not so systematic, and tend to use the simple past for both the simultaneous reading [74] and the past relative to the time of uttering [73]. (Higginbotham 1995) assumes this, as does (Abusch 1997), who offers examples in which reading [73] would be forced by the narrative context: 'John mostly slept through the sixties. But Joan later claimed that he was active in the anti-war movement' (our example). Locating the saying in the discourse at a time later than the time the mentioned speaker intends to comment on forces an auditor to interpret indirect the discourse as in [73]. Our usage seems to track the tradition, but, in any case, tense sequencing rules are not a deep feature of natural languages, though the underlying semantic structures are.

33. Tense sequencing shows up even without an explicit tense marker governing it, as in (Abusch 1997, p. 29): 'Mary's desire to marry a man who resembled her is bizarre'. The past shifting of 'resemble' indicates that the desire is located prior to the time of utterance. This tells us that in its canonical paraphrase, '[The x: x was Mary's desire to marry a man who resembled her](x is bizarre)', the appropriate tense for the copula in the restriction on the quantifier is the simple past. This also points to an account of the acceptability of 'The fugitives are all in jail now' (borrowed from (Vlach 1993, p. 259)), which, while perfectly acceptable, might seem odd because prisoners are not fugitives. By understanding the predicate introduced by 'fugitives' in the past tense, this unwelcome conflict is resolved.

34. As we remarked earlier, there is a clear reason not to interpret the tense in these sentences relative to the speaker's context: this would guarantee that the report is false since the reportee will not say anything in the future directly about the present time (that has the right structure). We are treating indirect speech as a model for attitude sentences. But with attitude sentences, there appears to be a counterexample to our analysis, in a sentence noticed by Parsons (reported in (Dowty 1982), p. 50):
    (i)   One day John will regret that he is treating me like this.
In (i) the tense of the complement verb 'is treating' is independent of that of the main verb, i.e., it indexes to speaker time. Loose talk or counterexample? If what one intends to say by (i) is true, John will one day be disposed to report himself by, 'I regret that I treated him like that'. But interpreted relative to their respective contexts, sentences in the complement clauses do not express the same proposition, being directly about different times. How then could (i), interpreted as intended, be true? What one intends to convey could have been reported by (ii).
    (ii)   One day John will regret that he (has) treated me like this.
This gets it just right. We suggest the following account of the use of (i). A speaker, resentful of John, wishes to emphasize John is mistreating him, and to emphasize its objective wrongness by asserting that John will regret (someday) his mistreatment of him (his treating him like this). Our speaker could say, 'John is treating me like this and one day he will regret his treating me like this', but this is a mouthful, and in the heat of the moment, out comes a fusion of the two, natural enough, given that 'his treating me like this' is the nominalization of 'he is treating me like this'. We so interpret him because 'this' is used to pick out a current activity of John's, which requires the tense of 'is treating' to index to the present and not to the time of John's regret. We understand what he intends well enough

though he issues an inaccurate report and violates some (well-grounded) rules of usage.

35. Similar binding phenomena occur between the tense of verbs generally in superordinate and subordinate clauses, where we find the past shifting of tense as a marker of this binding as well. Consider the contrast between (i) and (ii),

    (i)   A child was born who would be king.
    (ii)   A child was born who will be king.

discussed in (Kamp 1971), in which they form part of his motivation for a two-dimensional tense logic. The effect of the past shifting is to introduce the same kind of binding relation between the tense of the main verb and the subordinate clause we find in complement clauses of indirect discourse. Whereas in (ii) the tense of the verb in the subordinate clause is interpreted relative to the speaker's context, in (i) it is interpreted relative to the time bound by the past tense of the main verb. This can be represented as, '[There is a time t_1: $t_1 < t^*$][there is a time t_2: $t_2 > t_1$](a child is(t_1) born who is(t_2) king)'. ((i) is true even if a child was born who at some time after the speech act is king, although, given the availability of (ii), it would be pragmatically misleading to use (i) except when the time of the child's being king precedes the time of speech.) Similarly, the use of the simple past in the superordinate and the past perfect in the subordinate signals that the tense of the main verb controls that of the subordinate. In 'A president was elected who had been jailed', the natural interpretation requires that the event expressed in the subordinate clause occur prior to the event expressed in the superordinate. It is not clear that we find the same effect with the simple past in the subordinate clause, however, which, if it followed the pattern of indirect discourse would index to the same time as the event expressed by the main verb. 'A president was elected who was jailed' does not suggest that the jailing and the election occurred simultaneously; rather, the restriction seems to be that both occurred prior to the time of utterance. The phenomenon occurs with other tenses. Consider, 'John will meet a man who has been/is/will be/ king'. In appropriate contexts, we can force readings in which either the tense in the subordinate clause is independent of the main clause, and indexes to speaker time, or which is controlled by that of the main clause. It is clearly useful to have both readings, but lamentable that English, in this as in many other cases, provides no means of systematic disambiguation. Using back shifting of tense for verbs in subordinate clauses whose main verbs are in the past can be seen as a half-hearted attempt to disambiguate, which when employed in discourse and attitude sentences leads regrettably to the difficulties we noted with reporting unambiguously past speech acts employing the past and present perfect. But this lack of systematicity should not be too surprising. Natural languages are feral shrubs, untrimmed to the shapes of a logically perfect language.

36. A word may be in order about the implications of our treatment of tense in complement clauses for certain argument forms given in natural language. So, consider the argument: John thought that Mary loved him, and he still thinks that; therefore, John thinks that Mary loved him. (The genre we treat here was brought to our attention by (Richard 1981).) The argument is intuitively valid (relativizing both sentences to a set of contextual variables), but what is the function of 'that' in the second conjunct of the first sentence? If it is a referring term, then it cannot be taken to pick out a proposition referred to in the first conjunct, since the only proposition expressed there is that expressed by the full sentence, since the complement clause semantically contains variables bound from outside it. Thus, we must treat it either as something like a pro-sentence, which is to replace by 'Mary loved him', or, if we treat it as a referring term, it looks as if it must refer to the sentence 'Mary loved him'. In favor of the first alternative, perhaps, is the naturalness of replacing 'that' with 'so'. The second alternative, however, could be made to work as well in a sophisticated sententialist account (see (Ludwig and Ray 1998)).

37. This shows also that modifying our proposal by introducing predicates such as 'Past(t)', 'Present(t)' and 'Future(t)', fails to avoid the result. These must be interpreted indexically, and their analysis treats them as equivalent to '$< t^*$', '$= t^*$' and '$> t^*$'. It might be objected that our account rules out the past and future tensed predicates 'was the present time' and 'will be the present time'. But these are handled by imposing our account of past and present tense onto our analysis of the present tense predicate. So, for the past tense predicate:

    For any speaker s, time t, function f, f satisfies$_{[s,t]}$ 'x was the present time' iff [there is a $t_1 < t$](f('x') = t_1). Similarly for the future tense version. No property is attributed in this clause.

38. The reader may wish to compare our account with (Parsons 1990, chapter 10), who does not analyze the perfect as a tense. Rather, more in the vein of our account of the progressive, Parsons's treats what we call the perfect tenses as perfect *forms* of verbs, which are state verbs that express being in the state of having done or been something (analogous to the structure, subject + tense + have + adjective + noun, as in 'John has red hair'), and which can be in the past, present, or future ('had', 'has', 'will have'). This has the same effect as our suggestion below. It is not clear that anything we say rules decisively against this alternative, which could be adopted in the framework we pursue. On the other hand, we are unpersuaded that etymological considerations show that our analysis is incorrect: English users employ these constructions perfectly ignorant of their history, and there is nothing in their dispositions which would suggest they see a strong analogy with the use of 'have' in state attributing sentences such as 'John has red hair'. Furthermore, the double quantifier approach interacts in an intuitively compelling way with adverbial modification of perfectives.

39. See (Dowty 1982, p. 27), who also provides references.

40. See (Reichenbach 1947, pp. 287-298).

41. In this we differ from (Taylor 1977), who treats the present perfect as semantically equivalent to the simple past. We already noted it cannot be equivalent to the simple past, which requires the event expressed occur strictly in the past, while the past perfect does not. We also depart from Taylor in taking syntactic structure as a guide to the semantic structure of the present perfect. Taylor's paraphrases of the perfect tenses employ demonstratives for reference times, for which there is no sanction in the original, i.e., to say that, e.g., John had been a major in the army, one does not *need* to have any specific past time in mind relative to which John before that time had been a major in the army, although, of course, one may. Taylor also errs in his treatment of the future perfect in supposing that the event time must lie strictly in the future. This isn't so, as our example in the text shows.

42. An oddity about which adverbials the present perfect will take comfortably is that it does not happily accept adverbials that specify precisely event time when the time is clearly in the past, though this is not so for the past or future perfect. Although one can say felicitously 'I have seen her today', one cannot say, 'I have seen her yesterday'. (This data is discussed in the useful (Mittwoch 1988, p. 218).) Our account presents no semantic barrier to this, though it would be pragmatically odd, since given the difference between the present perfect and the past, when an adverbial definitely locates the event time in the past, using the present perfect will seem pointless.

43. (Reichenbach 1947, p. 294) incorrectly suggests that such modifiers modify the reference time. In 'John had arrived on Tuesday, a day before Mary', it is not reference time but event time that is in question. Likewise in Reichenbach's example, 'I had met him yesterday', 'yesterday' does not modify the reference time, but rather the event time. For we can likewise say, 'I had met him yesterday, but Mary did not meet him until this morning'. So when Reichenbach claims that modifiers modify the event time only when the event and reference time coincide, he is mistaken. Rather, different modifiers should be taken to modify different times, according to their character.

44. Another, though less natural, reading, according to which to say that 'John has worked here since 1980' is to say that at some time between 1980 and now, John has worked here. It may be that 'since' is ambiguous. On the other hand, it may be that there is a univocal reading that in standard contexts generates the reading we offered in the text. Three possibilities suggest themselves. First, the sense of 'since' is univocally 'between now and 1980', and it is usually understood as elliptical for 'ever since'. Second, '=' should be replaced 'f', in [101]-[103] and the implication that the period is equal to the whole is pragmatically generated as the most salient period in the conversational context. Third, the latent sense is generated by the possibility of using 'since' in a context in which an implied numerical quantifier modifies it, as in answer to, 'Has John worked here at any time since 1980', by saying, 'Yes, he has worked here since 1980'. Nothing fundamental hinges on resolving this.

45. This analysis, together with our treatment of the tenses unembedded, helps explain the peculiar behavior of an adverb that seems happiest with perfect tenses, namely, 'already'. 'He has already arrived' is felicitous enough, but 'He arrived already' is odd. This is explained by combining the plausible reading of 'already' as conveying that the event time is before the reference time with our analysis. (We cannot treat it as 'before now' because it does not always relate event time to the present, as in, 'By the time he had arrived, we had already finished dinner'.) We represent 'John has already arrived' as '[There is a t_1: t_1=t*][there is a t_2: t_2#t_1 & t_2<t_1](John arrives(t_2))'.

46. We regret that space constraints prevent us from comparing our account with Reichenbach's celebrated discussion (Reichenbach 1947, pp. 287-298). Reichenbach postulates a speaker, reference, and event time for all tenses, not just the perfect tenses. While we think Reichenbach's basic picture is correct for the perfect tenses, he has not given adequate reasons to postulate a reference time for the simple tenses.