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ON THE QUANTIFICATION OVER TIMES IN NATURAL LANGUAGE*

The aim of this paper is to seek the optimal way to represent time in natural language. It discusses whether or not natural language employs a temporal system that explicitly quantifies over times at the level where semantic interpretation takes place. I first argue that a single-index theory is not empirically adequate for natural language. I then propose a system in which times are syntactically represented. The system works in such a way that tense morphemes saturate the time argument slots of the predicates they attach to. Consequently it predicts that only the times of the main tensed predicates of clauses are accessible. Empirical evidence is presented showing such a distinction between tenseless and tensed predicates in terms of the accessibility to the times introduced by them.

1. Priorian Tense Logic and Its Alternative: A Preliminary Comparison

The central question to be addressed in this paper is whether natural language employs a temporal system that has explicit quantification over times at the level where semantic interpretation takes place. In the tradition of tense logic, the answer to this question has been negative. For instance, the semantics of the past tense defined in Prior (1967) and further developed in Montague (1973), as shown below, assumes among other things that tense manipulates times (only) in the meta-language.[1]

(1) Where ϕ is a tenseless sentence,
  a. $[[\textbf{Past}\ \phi]]^{g,t,w} = 1$ iff there is a time t′ such that t′ < t and $[[\phi]]^{g,t',w} = 1$.
  b. $[[\phi]]^{g,t,w} = 1$ iff ϕ is true at t in w.

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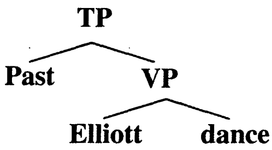
[1] To be consistent with the framework introduced later, sentence denotations are considered to be relative to a variable assignment g and a world index w.

Let us assume that the past tense operator *Past* is realized as the past tense morpheme under the Tense Projection (TP). Then the LF structure for a sentence like *Elliott danced* looks like the following:[2]

(2)



Denotations of verbs are relativized with respect to a temporal index.

(3)a. $[[\textbf{dance}]]^{g,t,w} = \lambda x \in D_e$ [x dances at t in w]

b. $[[\textbf{Elliott}]]^{g,t,w} =$ Elliott

By standard composition principles, we get the following truth conditions:

(4) $[[\textbf{(2)}]]^{g,t,w} = 1$ iff there is a time t′ such that $t' < t$ and Elliott dances at t′ in w.

When uttered at an arbitrary time t in an arbitrary world w, the sentence is true when there is a time t′ that precedes t and Elliott dances at t′ in w. This seems to capture our intuition about past tense sentences.

The system assumes e (for individuals) and t (for truth values) as basic semantic types. Furthermore, sentences are assumed to be evaluated with respect to a single temporal index t (in addition to a variable assignment function g and a world index w).[3]

An alternative to this view is the following: in addition to the basic semantic types e and t, a new basic semantic type i for intervals is introduced, whose domain is the set of intervals. In such a system, what are assumed to be one-place predicates such as intransitive verbs are analyzed as two-place predicates, taking an individual argument and a time argument.[4]

(5) $[[\textbf{dance}]]^{g,w} = \lambda t \in D_i\ [\lambda x \in D_e$ [x dances at t in w]]

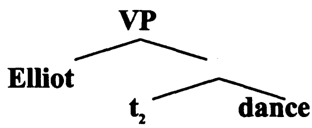
[2] I assume the VP-internal subject hypothesis.

[3] There are other assumptions that this kind of tense semantics makes: tense is a sentential operator and an existential quantifier over times. I do not consider issues concerning the latter. See Partee (1973) and Enç (1987) for a referential view of tense, Ogihara (1989, 1996) for arguments for a quantificational view, and von Stechow (1995) for arguments against tense as an existential quantifier.

[4] There seems no direct evidence showing whether an individual or a time should be the first argument. I make an arbitrary choice here. But see the discussion in section 3.

The verb's time argument may be projected in the syntactic structure as a time variable.[5]

(6)



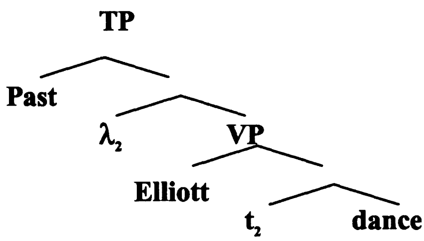
The denotation of the variable is given by an assignment function g in the ordinary way, except that its domain is the set of intervals. The tenseless constituent Elliott dance is true under a given assignment g if and only if Elliott dances at g(2).

The semantic denotation of the past tense now looks like the following:

(7) $[[\textbf{Past}]]^{g,w} = \lambda P \in D_{<i,\, t>}\ [\lambda t \in D_i$ [there is a time t' such that $t' < t$ and that $P(t') = 1$]]

The past tense *Past* takes predicates of times and yields predicates of times. Since VPs denote truth values in our model, the past tense denotation cannot be directly applied to the VP denotation. Hence, let us assume that the syntax contains an abstractor over variables.

(8)



The time variable saturating the time argument position of the verb *dance* (i.e. t_2) is bound by its coindexed lambda abstractor. Its value is determined by an assignment function g, just as with ordinary individual variables. The entire sentence (i.e., the TP) denotes a function from intervals to truth values. When applied to an arbitrary interval t, we get the following truth conditions.

(9) $[[\textbf{(8)}]]^{g,w}(t) = 1$ iff there is a time t' such that $t' < t$ and Elliott dances at t' in w.

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[5] We may choose not to project a time argument in syntax while introducing a semantic type for intervals. In this case, the syntactic structure is the same as the one in (2). I do not consider such a system here since it does not differ from a system like Priorian tense logic in the respects relevant to our discussion below.

These truth conditions are the same as those in (4).

A major difference between the two systems is how tense manipulates times in natural language. The former system employs extension-at-a-time as the basic semantic relation. Tense manipulates times only in the metalanguage. The latter system employs explicit quantification over times in the object language, i.e., at LF in our model. Tense manipulates times through variables ranging over times.

In spite of this seemingly major difference, the two systems yield the same truth conditions for the sentence we examined. Does this mean that they are just notational variants? Many authors have answered this question negatively, pointing out different empirical predictions made by these systems (cf. Kamp 1971, Vlach 1973, Gabbay 1974, van Benthem 1977). Among these authors, Cresswell (1990) concludes that natural language has the same expressive power as a language with explicit quantification over times.[6]

What Cresswell (1990) proposes is a multiple-index system rather than a system with time variables: sentences are evaluated not with respect to a single index but with respect to a sequence of times.[7] The inventory of this system contains two kinds of null operator, one that fits times into the sequence, and one that retrieves a relevant time from the sequence. This system allows us to keep track of infinitely many indices, and therefore its expressive power is the same as that of a system where the time arguments of all predicates are represented as time variables. Put into our context, Cresswell would support a system with time variables in syntax, rather than a single-index system like Priorian tense logic.

This paper argues for a system with explicit quantification, but in a limited way. I argue that all predicates, whether they are verbs, nouns, or adjectives, have a time argument, but not all time arguments are represented in the syntactic structure as time variables. In other words, I argue that a tense system for natural language does not allow us to keep track of all the times introduced. Specifically, I claim that there is a distinction regarding whether or not the relevant predicate is the main predicate of a clause; the time argument of the main predicate of a clause is represented in syntax, but not the time arguments of predicates in argument positions and modifiers. I further claim that this is a straightforward consequence of the natural language tense system.

The rest of the paper is organized as follows: Section 2 reviews two problems of analyses like Priorian tense logic that are relevant to the current

[6] Cresswell proves this using quantification over possible worlds, but the same proof can be made for quantification over times.

[7] Cresswell is mostly concerned with world indices. Kratzer (1995) applies Cresswell's proposal to temporal indices.

discussion. In section 3, I present a tense system that solves these problems. Section 4 discusses consequences of the system presented. A brief comment on the comparison between a multiple-index system and a system with time variables is given in section 5.

2. Problems of Priorian Tense Logic

A number of problems with analyses like Priorian tense logic have been pointed out in the literature (Kamp 1971, Vlach 1973, Partee 1973, Saarinen 1979 Enç 1981, Dowty 1979, 1982, among many others). Among them, I will discuss two issues: sequence-of-tense phenomena, and what I call 'later-than-matrix' interpretations of embedded tenses.

2.1. *Sequence-of-Tense Phenomena*

A first problematic example involves sentences with two or more tenses embedded under one another, as shown below:

(10) Tom said that Karen was dancing

It is well known that sentences like this are ambiguous between the so-called simultaneous interpretation and a (backward) shifted interpretation. That is, the sentence can describe a situation in which either (11a) or (11b) is true.

(11)a. Tom said, "Karen is dancing."
b. Tom said, "Karen was dancing."

The existence of such ambiguity is traditionally referred to as the sequence of tense phenomenon. The phenomenon has received much discussion in the literature of tense since the existence of the simultaneous interpretation is unexpected. Native speakers feel that the present tense in (11a) is somehow "changed" into the past tense. That is, the embedded past tense is semantically vacuous in the sense that it does not contribute to the pastness in the sentence. The unexpectedness of the simultaneous reading can be shown by calculating the truth conditions of the sentence. The structure of sentence (10) is the following:

(12) $[_{TP}$ Past $[_{VP}$ Tom say that $[_{TP}$ Past $[_{VP}$ Karen be dancing$]]]]$

To see what truth conditions this structure yields, we need the semantics of propositional attitude verbs such as *say*. The following denotation suffices to see the prediction of the system regarding the above ambiguity.

(13) $[[\textbf{say}]]^{g,t,w} = \lambda p \in D_{\langle i,\langle s,t\rangle\rangle}$ [$\lambda x \in D_e$ [for all worlds w′ and times t′ that are compatible with what x says at t in w, $p(t')(w') = 1$]]

We derive the truth conditions as follows:[8]

(14) $[[(12)]]^{g,t,w} = 1$ iff there is a time such that $t' < t$ and for all worlds w′ and times t″ that are compatible with what Tom says at t′ in w, there is a time t‴ such that $t''' < t''$ and Karen is dancing at t‴ in w′.

These truth conditions correctly predict the backward shifted reading; the embedded eventuality time, i.e., the time at which Karen is dancing, precedes the matrix eventuality time, the time at which Tom speaks (or more precisely, the time which Tom considers to be 'now′ at the time of his speech). However, they cannot derive the simultaneous reading. Under the truth conditions derived above, the embedded eventuality time is necessarily placed before the matrix time due to the second past tense operator.

Many researchers are convinced that the sequence-of-tense phenomenon is problematic for systems like Priorian tense logic. Some have proposed to introduce a 'sequence of tense' rule to 'delete' the embedded past tense in examples like (10) (Comrie 1985, Ogihara 1989, 1995, 1996), while others argue against analyzing tenses as sentential operators and propose a referential analysis of tenses (Enç 1987; Abusch 1994, 1997; Heim 1994; Kratzer 1998).

Gennari (1999, 2003), however, claims that the problem is only apparent. She argues that the two readings shown in (11) do not show that the sentence is ambiguous; she claims that the sentence is only vague and that therefore the truth conditions in (14) are sufficient to derive both readings. First, Gennari notes that the availability of the simultaneous reading is limited to a certain class of verbs, namely stative verbs.[9,10] Compare (10) with (15):

(15) Tom said that Karen went to Vancouver.

Unlike (10), (15) does not allow a simultaneous interpretation (unless the embedded sentence is considered to be a generic sentence); the time of Karen's going to Vancouver is placed before that of Tom's speech. Gennari claims that the difference is due to the choice of embedded predicates.

[8] I assume that a special functional application rule is used to combine an intentional verb and its complement, following Heim and Kratzer (1998):

(i) If α is a branching node and $\{\beta, \gamma\}$ the set of its daughters, then for any possible world w, time t, and assignment function g, if $[[\beta]]^{g,w,t}$ is a function whose domain contains $\lambda w'\lambda t'[[\gamma]]^{g,w',t'}$, then $[[\alpha]]^{g,w,t} = [[\beta]]^{g,w,t}(\lambda w'\lambda t'[[\gamma]]^{g,w',t'})$

[9] The class, according to Gennari, includes lexical stative verbs such as *be*, *know*, etc., but also derived statives, such as progressives and generics. See the definition in footnote 11.

[10] The observation is not new. Other researchers, such as Enç (1987), Ogihara (1989), and Stowell (1993), have made similar observations.

Be-dancing is a stative predicates, whereas *go-to-Vancouver* is eventive.[11] Stative predicates have a property that Gennari calls a 'super-interval property'. That is, when *Karen be dancing* is true at an interval *t*, it is possible that it is true at another interval *t′* which *t* is a subinterval of. However, when *Karen go to Vancouver* is true at an interval *t*, it is not the case that the same predicate is true of its super-interval. With this in mind, her explanation as to the 'ambiguity' of sentences like (10) goes as follows: The sentence is unambiguous. Its only LF structure is something like (12) and its only truth conditions are the ones in (14). But due to the super-interval property, the truth conditions are compatible with two distinct situations. One is when the time of Karen's dancing entirely precedes Tom's speech, i.e., Karen was not dancing as Tom spoke. The other situation compatible with the truth conditions in (14) is when the time of Karen's dancing overlaps Tom's speech, i.e., Karen was dancing before Tom spoke and continued to be dancing as he spoke. This is possible due to the fact that predicates like *be-dancing* are by definition stative and hence have a super-interval property.

This strategy cannot be used for eventive predicates, however, since they lack a super-interval property. When the interval at which the tenseless predicate *Karen go to Vancouver* is true entirely precedes the time at which Tom spoke, it is not the case that *Karen go to Vancouver* is true at a super-interval that overlaps the time of Tom's speech. This is why the simultaneous reading arises only with stative predicates.

If this analysis on the right track, it should be preferred over an analysis in which what surfaces as the past tense morpheme is claimed to be 'ambiguous' in one sense or another. The one-past-tense thesis is intuitively more appealing. Many researchers have rejected such an idea, however.

Here I point out two empirical problems. One concerns so-called activity or process verbs. They appear to hold a super-interval property. For instance, when *Karen dance* is true at *t*, it is possibly true at its super-interval *t′*. Yet sentences like *Tom said Karen danced* do not allow a simultaneous interpretation (again, unless the embedded sentence is understood as a generic sentence). Second, the generalization that eventive predicates do not allow a simultaneous reading seems to be empirically incorrect. Consider the following example:[12]

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[11] Gennari uses the following definition to define stative predicates:

(i) A sentence *Q* is stative iff it follows from the truth of *Q* at an interval *i* that *Q* is true at all instants within *i*.

[12] See Kusumoto (1999) for more examples of eventive predicates allowing a simultaneous interpretation.

(16) The announcer said that Ichiro struck out.

The sentence contains an eventive verb but is ambiguous between the following readings.

(17)a. The announcer said, "Ichiro strikes out."
b. The announcer said, "Ichiro struck out."

The first reading cannot be derived under an account like the one pursued in Gennari (1999).

Among those who are convinced that sentences like (10) are truly ambiguous, Enç (1987) maintains the one-past-tense thesis. Let us first illustrate with a simple example what her framework is. Enç gives the following syntactic representation for the sentence *Elliott danced*:

(18) [$Comp_0$ [Elliott [$PAST_i$ [dance]]]

Tenses and complementizers are both referential expressions that denote intervals, and complementizers function as an evaluation time for tenses. In simple sentences such as the one above, $Comp_0$ denotes the speech time. The semantics of the past tense is to restrict time intervals it can denote to past intervals with respect to some evaluation time. Hence the interval denoted by $PAST_i$, which corresponds to the eventuality time of the main predicate, is placed before the speech time.

According to Enç, the past tense always locates the relevant eventuality time (i.e., the eventuality time of a predicate it attaches to) at a past time with respect to some evaluation time. But such evaluation time does not have to be a local one. Specifically, she gives the following two structures for the sentence; the former yields a backward shifted interpretation, the latter a simultaneous one.

(19)a. [$Comp_0$ [Tom [$PAST_i$ [say $Comp_i$ [Karen [$PAST_j$ ...]]]]]]
b. [$Comp_0$ [Tom [$PAST_i$ [say Comp [Karen [$PAST_i$ ...]]]]]]

Without going into the details, the idea is this: In (19a), the embedded past tense takes its local complementizer, $Comp_i$, as its evaluation time. This complementizer is coindexed with the matrix past tense. Thus the interval that the embedded past tense denotes is restricted to some past time with respect to the matrix eventuality time. In (19b), on the other hand, the embedded past tense is coindexed with the matrix past tense; therefore, by standard assumption about coindexing, they denote the same interval. In a nutshell, the embedded past tense may be interpreted with respect to two different evaluation times, the matrix eventuality time (which gives rise to a backward shifted reading) and the original evaluation time (which gives rise to a simultaneous reading).

Abusch (1988) convincingly argues that this is not on the right track. Here is her example:[13]

(20) John decided a week ago that in ten days he would say to his mother that they were having their last meal together.

Abusch is concerned with the interpretation of the most embedded past tense (the underlined one). It can be simultaneous with a future time at which John talks to his mother. Since this time is in the future with respect to the speech time of the sentence, there is no time which the underlined past tense can take as its evaluation time with respect to which it is past. Abusch and many other researchers, such as Ogihara (1989, 1996) and Stowell (1993, 1995a, b), are convinced that there are instances of the past tense such as the underlined one in (20) which do not have any meaning related to anteriority. In other words, what surfaces as the past tense morpheme is semantically ambiguous.

2.2. *Later-than-Matrix Interpretations*

Another problem of systems like Priorian tense logic is the existence of what I call 'later-than-matrix' interpretations. This is also pointed out by many authors, such as Kamp (1971), Vlach (1973), Gabbay (1974), and Cresswell (1990), among others.

Consider the following example:

(21) Hillary married a man who became the president of the U.S.

Under the (current version of) Priorian analysis, the example has the following LF structure and truth conditions.[14]

(22)a. $[_{TP}$ Past $[_{VP}$ Hillary marry $[_{NP}$ a $[_{N'}$ man $[_{CP}$ who$_i$ $[_{TP}$ Past $[_{VP}$ e_i become the president of the U.S.]]]]]]][15]

b. $[[$**(30a)**$]]^{g,t,w}$ = 1 iff there is a time t' such that $t' < t$ and there is an individual x such that x is a man at t' in w and Hillary marries x at t' in w, and there is a time t'' such that $\underline{t'' < t'}$ and x becomes the president of the U.S. at t'' in w.

[13] The example is based on a similar example in French discussed in Kamp and Rohrer (1984).

[14] The noun *man* and the relative clause are both of type ⟨e,t⟩. In calculating the N′ node, we use a composition rule called Predicate Modification.

(i) If α is a branching node, $\{\beta, \gamma\}$ are the set of α's daughters, and $[[\beta]]$ and $[[\gamma]]$ are both of type ⟨e,t⟩, then $[[\alpha]] = \lambda x \in D_e. [[\beta]](x) = [[\gamma]](x) = 1$

[15] Traces are represented as *e*, not to be confused with temporal variables.

According to the truth conditions above, one may utter the sentence truthfully at *t* in a situation in which Hillary marries a man at some time before *t* who, at the time of marrying, has already become the president. Though there is nothing wrong with this, we also judge the sentence true in a different situation; it may be uttered truthfully when the man Hillary married had not been a president at the time of marrying, but became one after the marriage. This intuition is not captured in the truth conditions given above. I call this reading 'the later-than-matrix' reading, since the embedded eventuality is understood to take place later than the matrix eventuality.[16]

The problematic part of the truth conditions is the underlined part of (22b). The embedded past tense (which locates the time of marriage) is evaluated with respect to the time introduced by the matrix past tense (i.e., *t′*), not with respect to the original evaluation time (i.e., *t*). This is due to the properties of a system in which sentences are evaluated with respect to only one temporal index, and in which tense introduces a new time which replaces the original index and becomes the new evaluation time.[17]

Some researchers, such as Ladusaw (1977), Ogihara (1989, 1996), and Stowell (1993), however, argue that such data do not show what they are supposed to show. That is, the existence of a later-than-matrix interpretation in examples like (21) is not correctly predicted, not because analyses like Priorian tense logic are inadequate in analyzing natural language tense phenomena, but because the LF structure assumed for the sentence is not right. These authors claim that embedded tenses, like the one in the relative clause in (21), are not necessarily interpreted in the scope of the matrix tense. At the level where semantic interpretation takes place, the embedded tense is outside the scope of the matrix tense due to an operation like quantifier raising (QR) (or quantifying in). Let us call such an analysis a scope analysis. Under such analysis, the LF structure for the sentence looks like the one in (23a), and this yields the right truth conditions, as in (23b).

[16] In the literature, such interpretations are sometimes called 'forward-shifted' interpretations. The term is introduced in analogy to 'backward-shifted' interpretations, which refer to the reading in which the embedded event time is understood to precede the matrix event time. I believe the term 'forward-shifted' is confusing since it gives an impression that the embedded tense takes a time introduced by the matrix tense as its evaluation time and shifts it into the future. As we will see below, there is no forward shifting mechanism involved. Thus I choose to use a theory-independent name. I would like to thank Barbara Partee for suggesting this name.

[17] Specifically, this problem arises due to the property that sentences are evaluated with respect to only one temporal index. That is, it is not a general problem of all systems where tense manipulates times in the meta-language. In the literature, proposals have been made to improve such a single-index system without giving up an index system altogether. Improvement along this line leads to a multiple-index system as proposed in Cresswell (1990). Such a system does not differ from a system with time variables in the relevant respects, so I will not examine this line of improvement here. But see comments in section 5.

(23)a. [a man who_i [$_{TP}$ Past [$_{VP}$ e_i become president of the U.S.]]]$_j$ [$_{TP}$ Past Hillary marry e_j]

b. $[[(\mathbf{23a})]]^{g,t,w}$ = 1 iff there is a man x at t in w and there is a time t″ such that <u>t″ < t</u> and x becomes president at t″ in w, and there is a time t′ such that t′ < t and Hillary marries x at t′ in w.[18]

Under this LF, neither of the past tenses is in the scope of the other, and therefore both are interpreted relative to the original evaluation time, which allows the possibility of the relative tense eventuality time following the matrix eventuality time.

In what follows, I will show on empirical grounds that a scope analysis is untenable. Recall that movement of relevant noun phrases is necessary in order to derive the later-than-matrix interpretation under a scope analysis. First, this means that the analysis has to assume that constraints on movement may be violated, since the relevant element can be further embedded in an island and still be able to get the later-than-matrix interpretation. Second, it predicts a correlation between the interpretation of relative clause tense and the scope interpretation of relevant noun phrases. I will argue that this runs into a scope paradox. I will show that the interpretation of tense in relative clauses and the scope of the NPs that head those relative clauses do not correlate in the way that traditional tense logic requires.

First, let us look at examples containing negative polarity items (NPIs).

(24)a. I tried not to hire anybody who put on a terrible performance.[19]

b. She failed to talk to any prospective student who (later) decided to come to UMass.

Suppose we are watching a play with a casting director. Some of the cast members are very bad and the play is a failure. The casting director can truthfully say something like (24a), claiming no responsibility for the failure of the play. The relative clause eventuality time is understood to take place after the matrix eventuality time. Similarly, suppose that ten prospective students showed up at the UMass open house, all of whom had not decided whether to come to UMass yet. A faculty number talked to only five of them, and none of them decided to come. Among those who she failed to talk to, four decided to come to UMass. In this situation, sentence (24b) is

[18] These truth conditions predict that the relevant man has to exist at the original evaluation time. In other words, they predict that the sentence, under the later-than-matrix interpretation, cannot be truthfully uttered if the man is already dead. This is another potential argument against the scope analysis. I will come back to this in section 4.

[19] I thank Danny Fox for suggesting the use of *try not to*.

judged true. This means that both sentences should be able to have a later-than-matrix interpretation. Recall that a scope analysis says that the later-than-matrix interpretation is obtained by moving the relevant noun phrase outside the scope of the matrix tense. In these cases, the relevant noun phrases contain an NPI, which has to be in the scope of a licensor. The movement, which is necessary to yield the later-than-matrix interpretation, takes the NPI outside the scope of its licensor. Thus, the scope analysis falsely predicts that sentences like these cannot have a later-than-matrix interpretation, lest they be ungrammatical.

Our second type of example involves quantifier scope. To illustrate the point, consider the following example first.

(25) Every faculty member failed to talk to a prospective student.

The sentence is three-ways ambiguous. On the first interpretation, which corresponds to the wide scope reading of the indefinite noun phrase, a *prospective student*, it means that there is a particular prospective student that no faculty member talked to. The second interpretation says that for each faculty member, there is a possibly different prospective student that she or he did not talk to. The indefinite takes an intermediate scope on this interpretation, i.e., between the universal quantifier and the verb *fail*. Lastly, under the narrow scope reading of the indefinite NP, the sentence means that no faculty member talked to any prospective student. With this in mind, consider the following scenario: The UMass linguistics department holds an open house for prospective students. Faculty members talk to them and try to convince them to come to UMass. The faculty member who recruits the most students gets a prize.[20]

(26) Every faculty member failed to talk to a prospective student who decided to come to UMass. So nobody got a prize this year.

In order for the continuation *So nobody* ... to make sense, the first sentence has to be understood to have a narrow scope interpretation for the indefinite. But at the same time the sentence is understood to have a later-than-matrix interpretation for the relative clause tense. The scope analysis predicts that this is not possible.[21]

[20] I thank Mike Terry for suggesting this scenario.

[21] This argument only goes through with the assumption that traces left behind by quantified expressions are not of the same type as those expressions, as a *NALS* reviewer suggests. That is, I assume in the above discussion that quantified NPs are of type ⟨⟨e,t⟩⟩ but the traces they leave are of type e. We may alternatively allow higher-type traces, i.e. traces of type ⟨⟨e,t⟩,t⟩ here, and assume the following structure, where X represents a variable of type ⟨⟨e,t⟩,t⟩, and λX correspondingly represents lambda abstraction over the variable of the same type.

Lastly, I will give evidence against a scope analysis regarding a bound variable interpretation of a (null) pronoun. It has been observed that expressions like *later*, *local*, etc. can have a pronoun-like interpretation. (See Mitchell 1986 and Partee 1989.) For instance, *later* in example (27a) roughly means 'later than the time at which Mary left the message'. This corresponds to a referential usage of a pronoun. It can also have a bound variable-like interpretation as exemplified in (27b). Imagine that the pronoun *them* in the subject position denotes a set of women consisting of Nancy, Barbara, and Hillary. The sentence is true when for each woman x, the man x married became president at a time later than x's marrying time to the relevant man. Both referential and bound variable interpretations may be derived by assuming that an expression like *later* has an implicit time variable that can be either bound or free.

(27)a. Mary left a message. John later called her back.
b. Every one of them married a man who later became president.

In the case of (27a), the implicit time variable associated with *later* is free and receives its value from the context. In the case of (27b), it is bound by the time variable that represents the marrying time (or more precisely, the lambda operator that binds the relevant time variable).

(*Footnote continued*)

(i) [a student who decided to come to UMass] λX [every faculty member failed to talk to X]

This structure correctly yields the narrowest scope interpretation for the indefinite NP and a later-than-matrix reading for the tense in the relative clause. In order to show that the introduction of higher-type traces is not a solution to all quantifier scope problems, a more complicated example has to be examined.

(ii) I failed to introduce [any faculty member]$_i$ to a student of her$_i$ research field who decided to come to Umass.

We are still interested in the narrowest scope of the indefinite NP *a student* .... We are also interested in a bound variable interpretation for the pronoun *her* contained in that NP. Since the NPI phrase has to stay below the licensing verb, it in turn stays below the matrix tense. Thus, the bound status of the pronoun *her* makes sure that the indefinite NP necessarily stays under the scope of the NPI phrase, which in turn means that it is below the matrix tense.

A scope analysis together with higher-type traces would have to assume the following structure for the relevant reading for the relative clause tense.

(iii) [a student of her$_i$ research field who decided to come to UMass] λX I failed to introduce [any faculty member]$_i$ to X

Due to the trace X of type $\langle\langle e,t\rangle,t\rangle$, the indefinite NP semantically reconstructs into the original position where it left the trace X, yielding the narrowest scope reading for the NP. The pronoun *her*, however, cannot be bound by the NPI phrase as a result of semantic reconstruction. A scope analysis thus incorrectly predicts that the sentence does not have a bound variable interpretation for *her* and a later-than-matrix interpretation for the relative clause tense at the same time.

If this is the correct analysis of the relevant interpretation we are after, it should be incompatible with a later-than-matrix interpretation of the relative clause tense under a scope analysis. Here is why: On the one hand, the entire object noun phrase has to be above the matrix tense in order to yield the later-than-matrix interpretation. On the other hand, the implicit time variable in the relative clause has to be in the scope of the matrix tense. These two requirements cannot be met at the same time.[22]

This last evidence also shows that another possible scope analysis, namely to let the relative clause scope out, is untenable.[23] A relative clause scope analysis avoids the first two problems by not moving relevant noun phrases, but cannot avoid the last one. If we move the relative clause above the matrix past tense operator, it necessarily brings the implicit time argument of later outside the scope of its binder, making the bound variable interpretation impossible. Besides, such an analysis has to stipulate movement of adjuncts out of a noun phrase which, in general, is prohibited.

So far, I have shown that the temporal interpretation of relative clauses and the scope of relevant noun phrases do not correlate in the way a scope analysis predicts that they do. But other researchers have observed cases where such a correlation does exist. Consider the following example (slightly modified from an example discussed in Abusch 1988):[24]

(28) John looked for a woman who married a millionaire.

The sentence is ambiguous between a *de re* reading and a *de dicto* reading. Under a *de re* interpretation, there is a particular woman that John looked for, and under a *de dicto* interpretation, it means that John looked for a woman who married a millionaire, but not a particular one. Abusch claims

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22 Another possibility suggested by the *NALS* editors is to analyze the implicit pronoun in *later* as an E-type pronoun, equivalent to the description 'the time at which she married him'. Suppose that an E-type pronoun is represented as f(x), where x is an individual variable bound by the subject NP, and f is a contextual function variable, which, when applied to an individual, yields the unique time at which x married. Under this analysis, we do not run into a scope problem of the sort mentioned above. We can have a hierarchical structure, *every one of them* > *a man who ...* > *PAST*, where the E-type pronoun contained in the relative clause is bound by the subject NP. However, this analysis faces a different kind of scope problem. Since the E-type pronoun contains a variable that has to be bound by the subject NP to yield the temporal reading we are after, the object NP has to be under the scope of the subject NP. This means that the bound variable reading of *later* is only compatible with the narrow scope interpretation of the object NP, which is not the case.

23 In Kusumoto (1999), I argued that in order for the moved constituent to be interpretable, the trace has to be of the same type as the moved constituent and that semantic reconstruction ruins what is aimed for in the first place. This is wrong. Such movement does give us the correct result in a framework like Priorian tense logic.

24 The original example is *John looked for a woman who married him*. Due to the choice of the embedded predicate, it is hard to get a *de dicto* interpretation of the noun phrase.

that when the object gets a *de dicto* interpretation, the later-than-matrix interpretation is not available. This observation, if correct, follows directly from a scope analysis, assuming that the *de re* vs. *de dicto* distinction is a matter of scope, i.e., if a *de re* interpretation is derived by scoping the relevant noun phrase outside the scope of the intensional verb. Such an analysis is proposed in Stowell (1993) and Uribe-Etxebarria (1994).

Before I analyze data like this in the current framework, let me clarify the terminology. Compare, first, the following examples:

(29)a. John was looking for a book written by me.
b. John was looking for a book written by Chomsky.

Given that I have never written a book, and hence there is no book written by me in the actual world, sentence (29a) can only be truthfully uttered (by people who know the facts) in a situation where John mistakenly believed that I had written a book and looked for it. That is, the event of John's looking for some object takes place in the actual world but the object itself does not exist in that world. We may call this an opaque reading. Sentence (29b) has two other true readings since Chomsky has written books in the actual world. One is that there is a particular book which is actually written by Chomsky, say LGB, and John was looking for that book. The other is that John was looking for any one of the books actually written by Chomsky. These two readings are similar in that the speaker of the sentence is committed to the existence of Chomsky's book(s) in the actual world. We may call these readings transparent readings, among which the former is a specific one and the latter is a non-specific one.

Now, if the *de re* vs. *de dicto* distinction in the discussion of (28) is somewhat synonymous to the specific vs. non-specific distinction, as Abusch describes the two interpretations of the above sentence, then the claim is simply false. Consider the following scenario: John was looking for a particular book in a library. He found that the library had three copies, which were checked out by three women, Jen, Eva, and Elisabeth. So in order to borrow the book, he looked for one of the women. For his purpose, it did not have to be any particular one among them. When he finds any one of them, his search is over. Unbeknownst to John, all three women later married millionaires. Under a scenario like this, we judge sentence (28) to be true.

So if the term *de dicto* is understood in this way – i.e., non-specific,– and if the *de re* vs. *de dicto* distinction is a matter of scope, the fact that the later-than-matrix interpretation is available with sentences like (28) with the *de dicto* interpretation rather goes against a scope analysis of tense in relative clauses.

This would have been the end of the story had there not been another distinction that seems relevant, namely, the transparent vs. opaque interpretations of noun phrases. Suppose that John was thinking, "I want to find a woman who will marry a millionaire", and was looking for such a woman. We do not seem to be able to describe such a situation by uttering a sentence like (28). Rather, we would want to say *John looked for a woman who would marry a millionaire*. That is, sentence (28), when its object NP receives an opaque interpretation, does not seem to have the later-than-matrix interpretation. It looks as if there is a correlation between the availability of an opaque interpretation of the object noun phrase and that of the later-than-matrix interpretation of the relative clause tense. And this seems to be correctly predicted under a scope analysis.

To spell it out, we need the semantics of intensional transitive verbs. I follow Zimmermann (1993) and assume that intensional verbs may take properties or individuals as their object, i.e., they are ambiguous between type ⟨⟨e,t⟩,⟨e,t⟩⟩ and type ⟨e,⟨e,t⟩⟩.[25] Correspondingly, indefinite noun phrases way ambiguously denote properties of type ⟨e,t⟩ on generalized quantifiers of type ⟨⟨e,t⟩,t⟩. In order to be interpretable, the object NP of a property-taking intensional verb has to be of type ⟨e,t⟩. In the case of an individual-taking intensional verb, when a quantified expression sits in the object position, the only way for the sentence to be interpretable is to let the object scope out, leaving an individual type trace. Under a theory like this, the correlation is captured. The object noun phrase has to stay *in situ* to receive an opaque interpretation. If a noun phrase necessarily scopes out for the relative clause that modifies it to receive a later-than-matrix interpretation, then it would be incompatible with an opaque interpretation.

The above fact seems to support a scope analysis. I would like to point out, however, that this is not a phenomenon unique to verbs like *look for*. Similar phenomena have already been observed for propositional attitude verbs and other types of clause taking intensional verbs (Ogihara 1996 and Abusch 1997). When a past tense is embedded under another past tense on a propositional attitude verb, a later-than-matrix interpretation is not possible.

(30) John believed that Mary was sick.

[25] The two denotations of *look-for* are given below:

(i) a. $[[\textbf{look-for}_{\textbf{opaque}}]]^{g,w,t} = \lambda P \in D_{\langle e,t\rangle} [\lambda x \in D_e$ [for all worlds w′ and times t′ such that x's attempts in w at t succeed in w′ at t′, there is an individual y such that P(y)(t′)(w′) and x finds y in w′ at t′]]

b. $[[\textbf{look-for}_{\textbf{transparent}}]]^{g,w,t} = \lambda y \in D_e [\lambda x \in D_e$ [for all worlds w′ and times t′ such that x's attempts in w at t succeed in w′ at t′, x finds y in w′ at t′]]

The sentence can be used to report a situation where what John believed is "Mary is sick" (simultaneous reading) or "Mary was sick" (backward shifted reading), but not "Mary will be sick." It seems that the unavailability of the later-than-matrix interpretation has to do with the interaction of the intensionality introduced by certain verbs and the semantics of past-under-past sentences.

Abusch (1997) proposes a constraint called the Upper Limit Constraint that says, "The local evaluation time is an upper limit for the denotation of tenses" (p.25). Applying this to example (28), the local evaluation time delimits the times introduced by the verb *look-for*; the constraint says that the time of marrying may not be later than them. Although it is not clear whether this constraint can be derived from independently motivated syntactic and/or semantic principles, it certainly explains the lack of later-than-matrix readings in both (28) and (30). If we want to treat these two types of examples alike, then a scope analysis would not be of much help.

To conclude, I have presented three cases where a scope analysis makes wrong predictions. The case of intensional transitive verbs, by contrast seems to dare better with a scope analysis, but I have suggested a different way of looking at this case. The discussion is inconclusive here; further research is needed to investigate tense interpretation in intensional contexts. However, the first three cases are sufficient, I hope, to show that a scope analysis alone cannot save a single-index system.

3. Toward a Solution

In the previous section, we have seen two arguments against Priorian tense logic. In this section, I propose a system that overcomes such problems, a system in which times are represented in syntax.

3.1. *Sequence-of-Tense Phenomena*

We have seen in section 2.1. that we cannot maintain the one-past-tense hypothesis for English; some occurrences of past tense morphology in English are semantically vacuous. A number of solutions have been proposed to account for this phenomenon, the observation of which traces back to traditional grammarians such as Jespersen (1931). More recently, authors such as Abusch, Ogihara, and Stowell have contributed to a better understanding of the phenomenan, all arguing in some way or other that in languages like English, there are two kinds of past tenses (at least at a descriptive level), a true past tense and a vacuous one. I would like to follow Stowell's proposal.

Abstracting away from the details, Stowell's proposal may be summarized as follows: All occurrences of what we see as the past tense morphology in English are semantically vacuous. They do not carry the meaning of anteriority at all. What carries the meaning of anteriority is a phonetically null element in English. There is a licensing condition on occurrences of the past tense morphology. Every occurrence of past tense morphology has to be licensed by the phonetically null element by being c-commanded by it.

Here is one implementation of Stowell's idea: (i) predicates have an argument slot for a time. (We assume that they also have a slot for a world. That is, we introduce another semantic type s for worlds, whose domain is the set of possible worlds.) Hence the following denotation for intransitive verbs such as *dance*:

(31) $[[\textbf{dance}]]^g = \lambda x \in D_e\ [\lambda t \in D_i\ [\lambda w \in D_s\ [\text{x dances at t in w}]]]$

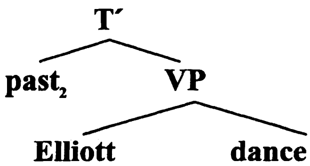
Thus VPs such as the tenseless predicate *Elliott dance* denote properties of times (i.e., of type ⟨i, ⟨s,t⟩⟩). (ii) The past tense morphology–the morphology that turns *dance* into *danced* and *go* into *went*–is a time variable of type i. Following Stowell, we represent it in small letters, as $past_2$. As with ordinary individual variables, its denotation is given by a variable assignment.

(32) $[[\textbf{past}_2]]^g = g(2)$

In this sense, it is not semantically vacuous; it has a value determined by g. It does not, however, have the meaning of anteriority.

Syntactically, it is generated right above VPs, perhaps as the head of T. By functional application, it saturates the time argument position of the VP that it takes as a complement.[26]

(33)



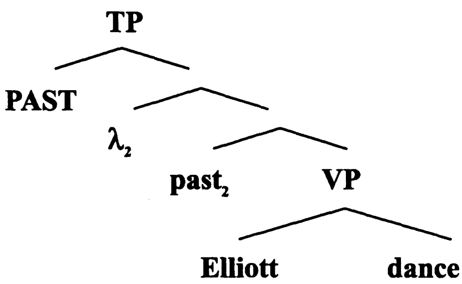
The meaning of anteriority is introduced by the phonetically null operator, which is called *PAST*. Its denotation is given below:

(34) $[[\textbf{PAST}]]^g = \lambda P \in D_{\langle i,\langle s,t\rangle\rangle}\ [\lambda t \in D_i\ [\lambda w \in D_s\ [\text{there is a time } t' \text{ such that } t' < t \text{ and that } P(t')(w) = 1]]]$

[26] The idea that tense morphemes are time variables that saturate a time argument slot has been suggested in the literature by Partee (1973), Enç (1987), and Abusch (1994, 1997).

This null element has to be introduced whenever there is a morphological realization of the past tense. Borrowing Stowell's analogy, the past tense morphology, i.e., *past*$_2$, is like a polarity item. It needs to be licensed by an appropriate licensor by being c-commanded by it. The appropriate licensor for *past*$_2$ is *PAST*. The entire TP now looks like the following. Again, we assume the insertion of an abstractor over variables.

(33)



The TP denotes a property of times, and when applied to an arbitrary time t and world w, it yields the following truth conditions:

(36) $[[(35)]]^g(t)(w) = 1$ iff there is a time t' such that $t' < t$ and Elliott dances at t' in w.

Although this does not look much like progress, the system quite naturally accounts for the ambiguity of sentences like *Tom said that Karen was dancing*. The current account says that the sentence is ambiguous because it has two different syntactic representations; one contains two occurrences of *PAST* as in (37a) and the other contains just one occurrence of *PAST* as in (37b).

(37)a. [$_{TP}$ PAST λ_2 past$_2$ [$_{VP}$ Tom say that [$_{TP}$ PAST λ_3 past$_3$ [$_{VP}$ Karen be dancing]]]]

b. [$_{TP}$ PAST λ_2 past$_2$ [$_{VP}$ Tom say that [$_{TP}$ λ_3 past$_3$ [$_{VP}$ Karen be dancing]]]]

Both structures are legitimate regarding the licensing of the past tense morphology. The licensing condition says that the morphemes *past*$_2$ and *past*$_3$ have to be c-commanded by *PAST*. The occurrences of *past*$_2$ in (37a,b) and *past*$_3$ in (37a) satisfy the condition locally. The embedded *past*$_3$ in (37b) is also licensed, but non-locally, by the *PAST* in the higher clause.

Now let us calculate the truth conditions for the two structures. Under the current framework, the denotation of propositional verbs such as *say* looks as follows:

(38) $[[\textbf{say}]]^g = \lambda p \in D_{\langle i,\langle s,t\rangle\rangle}\, [\lambda x \in D_e\, [\lambda t \in D_i\, [\lambda w \in D_s$ [for all worlds w′ and times t′ that are compatible with what x says at t in w, $p(t')(w') = 1$]]]]

In (37a), the result of applying the PAST operator yields just the right type for the verb, namely type ⟨i,⟨s,t⟩⟩. In (37b), however, there is no tense operator. The past tense morpheme *past₃* saturates the time argument position of the lower VP and hence yields a constituent of type ⟨s,t⟩. Here again we introduce an abstractor over the time variable, making the embedded clause the right type for the matrix verb.

(39)a. $[[\textbf{(37a)}]]^g(t)(w) = 1$ iff there is a time such that $t' < t$ and for all worlds w′ and times t″ that are compatible with what Tom says at t′ in w, there is a time t‴ such that $t''' < t''$ and Karen is dancing at t‴ in w′.

b. $[[\textbf{(37b)}]]^g(t)(w) = 1$ iff there is a time such that $t' < t$ and for all worlds w′ and times t″ that are compatible with what Tom says at t′ in w, Karen is dancing at t″ in w′.

According to (37b), the time of Karen's dancing is simultaneous with the time of Tom's 'now' at the time he spoke.

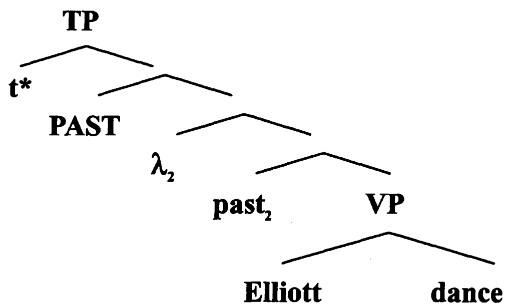
3.2. *Later-than-Matrix Interpretations*

In this section, I introduce a new lexical item *t**. This is an indexical item like *I* and *here*, except that it is not pronounced. Like other indexical items, its denotation is dependent on the context.

(40) $[[\textbf{t*}]]^{g_c}$, = the speech time provided by the context, s*

Syntactically, it appears above tense operators. Semantically, it serves as the evaluation time for tenses by saturating the time argument slot of tense operators. Simple sentences such as *Elliott danced* now look like the following:

(41)



By functional application, we get the following truth conditions:

(42) $[[(41)]]^{g_c}(w)$ = iff there is a time t′ such that t < s* and Elliott dances at t in w.

Now let us come back to the example we discussed in section 2.3, repeated here.

(43) Hillary married a man who became the president of the U.S.

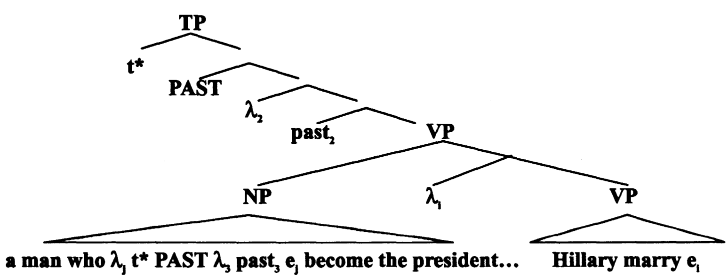
The example is compatible with two different situations. In one situation, the marrying time follows the time of the man becoming president. In the other (which is our real world situation), the marrying time precedes the time of the presidency. Recall that the latter, the later-than-matrix interpretation, is problematic for Priorian tense logic; Priorian tense logic only provides the earlier-than-matrix interpretation, and the scope analysis leads us to a scope paradox.

Under the current proposal the S-structure of the relevant sentence looks like (44a):

(44)a. $[_{TP}$ t* PAST λ_2 $past_2$ $[_{VP}$ Hillary marry $[_{NP}$ a $[_{N'}$ man $[_{CP}$ who_i $[_{TP}$ t* PAST λ_3 $past_3$ $[_{VP}$ e_i become the president of the U.S.]]]]]

Since we assume that the determiner *a* is of generalized quantifier type, it is not interpretable at the VP complement position. I assume that the object NP is raised to a VP adjoined position, yielding the following structure.

b.



Note that each past tense operator *PAST* is accompanied by an indexical element *t** and thus is evaluated independently. The truth conditions of the sentence are the following:[27]

(45) $[[(\mathbf{44b})]]^{g_c}(w) = 1$ iff there is a time t′ such that t′ < s* and there is an individual x such that x is a man at t′ in w and Hillary marries x at t′ in w, and there is a time t″ such that t″ < s* and x becomes the president of the U.S. at t″ in w.

According to these truth conditions, the time of marrying and that of the man's becoming the president both precede the time at which the sentence is evaluated, i.e. the speech time. But they say nothing about the order of the two eventuality times. That is, the two times are only ordered with respect to the speech time but not with respect to each other. The analysis correctly captures the fact that the sentence is compatible with both possible orders.

Finally, let us come back to the example of intensional verbs.

(46) John looked for a woman who married a millionaire.

This sentence cannot be used to report a situation in which at some time in the past John wants to find a woman who will later marry a millionaire. That is, when the object NP receives an opaque interpretation, the later-than-matrix interpretation for the embedded verb is not available. The current system does not predict this fact, however. Consider the following structure for the above sentence.

(47) John looked for $[_{NP}$ a [woman $[_{CP}$ who_j t* PAST λ_2 $past_2$ $[_{VP}$ e_j married a millionaire]]]]

The verb *look-for* is an intensional one and the object NP is of type ⟨e,⟨i,⟨s,t⟩⟩⟩. The embedded past tense can be understood as a real past tense with its own evaluation time, *t**, just as in the previous example. However, this structure should yield an unavailable reading, namely, an opaque reading for the NP and a later-than-matrix interpretation for the embedded verb.[28]

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[27] The noun *man* is of type ⟨e,⟨i,⟨s,t⟩⟩⟩ and the relative clause is of type ⟨e,⟨s,t⟩⟩. Hence these two denotations cannot simply be intersected by the rule of Predicate Modification. We need a rule like the following to get the denotation of the N' node (cf. Kratzer 1994).

(i) If α is a branching node and β and γ its daughters, and β denotes a function f of type ⟨e,⟨i,⟨s,t⟩⟩⟩, and γ a function g of type ⟨e,⟨s,t⟩⟩, then α denotes a function h of type ⟨e,⟨i,⟨s,t⟩⟩⟩ such that for all $x \in D_e$, $t \in D_i$, and $w \in D_s$, $h(x)(t)(s) = 1$ iff $f(x)(t)(s) = 1$ and $g(x)(s) = 1$.

[28] The truth conditions are the following, when applied to an arbitrary world w; there is a time t such that t < s* and for all worlds w′ and times t′ such that John's attempts in w at t succeed in w′ and t′, there are individuals x and y such that x is a woman at t′ in w′ and y is a millionaire at t′ in w′ and there is a time t″ such that t″ < s* and x marries y at t″.

Is it possible to prevent this structure? One possibility is to appeal to an independent constraint such as Abusch's (1997) Upper Limit Constraint, as mentioned in section 2.2. Another is along the line of Percus (2000), who claims that there is a "binding theory" for unpronounced variables (such as variables ranging over possible worlds). One environment Percus examines is propositional attitude contexts; he argues that a verb directly embedded under a propositional attitude verb has to be evaluated with respect to those worlds introduced by that attitude verb. If world variables and time variables behave similarly, then Percus's "binding theory" can be generalized so that it prevents t^* from occurring in embedded sentences like the one in (47).

4. Tenseless vs. Tensed Predicates

The tense system proposed in the previous section is summarized below:

(i) Predicates have an extra argument slot for a time.
(ii) Tense morphemes are time variables that saturate the time argument slots of predicates. This means that tense morphemes themselves do not contribute to the meanings of anteriority or simultaneity.
(iii) The meanings of anteriority and simultaneity derive from phonologically null elements that stand in a certain relation with tense morphemes. These elements give the ordering between eventuality times and evaluation times.
(iv) The evaluation times are also represented in the object language with a phonologically null time variable, represented as t^*.

In the lexical inventory of this system, there are only two types of time variables, two tense morphemes $past_2$ and $pres_1$. One consequence of this system is that it distinguishes tenseless and tensed predicates in terms of the representation of times. Consider the sentence *Every man danced.* There are two predicates in the sentence, *man* and *dance*. The former is tenseless whereas the latter is tensed. One structure of the sentence looks like the following:[29]

(48) $[_{TP}$ t* PAST λ_2 $past_2$ $[_{VP}$ $[_{NP}$ every man] dance]]

On the one hand, the time argument slot of the tensed predicate *dance* is saturated by the tense morpheme $past_2$ in the object language. That is, whatever the value of $past_2$, it denotes the time of dancing. On the other

[29] This structure yields the interpretation in which every man danced at the same past time. The NP *every man* may move and take scope over the past tense, which yields the interpretation in which different men dance at (possibly) different times.

hand, the time argument slot of the noun *man* is not saturated in the object language; its interpretation is determined in the meta-language.

To see the consequence of this distinction, I will first review two important contributions to the temporal interpretation of noun phrases in section 4.1. Then two pieces of evidence will be presented to support the distinction.

4.1. *Temporal Interpretation of Noun Phrases*

Enç (1981, 1986) has brought much attention to the temporal interpretation of noun phrases. Enç's contribution starts with a criticism of Priorian tense logic based on examination of noun phrase interpretations.

In Priorian tense logic, not only the denotation of verbs but also that of nouns, adjectives, etc. is considered to be relative to a temporal index. Hence the denotation of the noun *student* looks like the following:

(49) $[[\textbf{student}]]^{g,t,w} = \lambda x \in D_e$ [x is a student at t in w]

Now consider the sentence *A student danced.* When the NP *a student* stays in situ, the LF for the sentence looks like (50a), in which the past tense scopes over the NP. The NP may, however, scope out, in which case the LF looks like (50b).

(50)a. $[_{TP}$ Past $[_{VP}$ a student dance]]
b. [a student]$_j$ $[_{TP}$ Past $[_{VP}$ e_j dance]]

Since the denotation of nouns like student is dependent on a temporal index, whether it stays within the scope of the past tense operator or not makes a truth conditional difference. Let us calculate the truth conditions of the relevant sentence under the two structures.[30]

(51)a. $[[\textbf{(50a)}]]^{g,t,w} = 1$ iff there is a time t′ such that t′ < t and there is an individual x such that x is a student at t′ in w and x dances at t′ in w.
b. $[[\textbf{(50b)}]]^{g,t,w} = 1$ iff there is an individual x such that x is a student at t in w and there is a time t′ such that t′ < t and x dances at t′ in w.

A major difference between the two is that the truth of (50a) requires that the relevant individual has to be a student at the time she danced while (50b) does not. The relevant individual might not have been a student at the time of dancing but has become one later. This example itself may not be evi-

[30] I assume that *a* is an existential quantifier with the following denotation:

(i) $[[\textbf{a}]]^{g,t,w} = \lambda P \in D_{\langle e,t\rangle}$ $[\lambda Q \in D_{\langle e,t\rangle}$ [there is an individual $x \in D_e$ such that P(x) = 1 and Q(x) = 1]] dence against Priorian tense logic since the sentence may be judged true in either situation. Enç, however, presents several examples whose intuitive interpretations cannot be derived by Priorian tense logic. Consider first the following example:

(52) Every fugitive is in jail.

Since there are two scope taking elements in the sentence, the tense and the quantified subject noun phrase, the sentence has two LFs:

(53)a. $[_{TP}$ Pres $[_{VP}$ every fugitive be in jail]]
b. [every fugitive]$_j$ $[_{TP}$ Pres $[_{VP}$ e_j be in jail]]

Priorian tense logic treats the present tense as semantically vacuous. Hence the following semantics:

(54) $[[\textbf{Pres}\ \phi]]^{g,t,w} = 1$ iff $[[\phi]]^{g,t,w} = 1$

With this meaning, both (53a) and (53b) yield the same truth conditions.

(55) $[[\textbf{(53a)}]]^{g,t,w} = [[\textbf{(53b)}]]^{g,t,w} = 1$ iff for all x such that x is a fugitive at t in w, x is in jail at t in w.

Given the intuitive meaning of *fugitive*, these truth conditions are contradictory; an individual cannot be both a fugitive and in jail at the same time. However, suppose that five inmates escaped from a jail but all were arrested later by the angry police. The sentence does have a legitimate interpretation in which *every fugitive* is understood as *every* (*contextually salient*) *past fugitive*. This interpretation, though more prominent than the contradictory one, is not captured in analyses like Priorian tense logic as shown above.

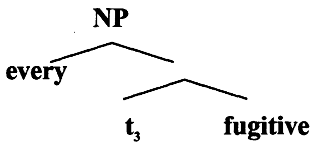
Enç further presents an example that gives rise to a scope paradox.

(56) Every congressman who remembers a president will be at the party.

Suppose that the presidency is abolished at some future time. At some point after that time, a party is given for congressmen who are old enough to remember a president. The sentence can be truthfully uttered in that situation to mean something like this: There is a future time *t* at which a party will be given, and every individual who is a congressman at *t* who remembers any individual who is a president before *t* will be at the party at *t*. To obtain such an interpretation under a scope analysis, we want the future operator to scope over every congressman, a president to be in the scope of every congressman (since different congressmen may potentially remember different presidents), and a president to be outside the scope of the future operator (since there are no future presidents). This is, of course, impossible.

Based on the above examples and more, Enç (1981, 1986) concludes that treating tenses as operators and taking nouns and verbs as index sensitive elements is not the right way to analyze temporal phenomena in natural language. Enç (1986) proposes to introduce temporal variables in the object language–that is, to assume structures like the following for the noun phrase *every fugitive:*

(57)



The variable t_3 is a free variable, whose domain is determined by the relativized assignment function in much the same way as with free pronouns.

(58) $[[\mathbf{t_3}]]^{g_c} = g_c(3)$

This explains that the temporal interpretation of nouns often depends on the pragmatic situation. For instance, the sentence *Every fugitive is in jail* is assigned the following structure and truth conditions.[31]

(59)a. $[_{TP}$ t* PRES λ_2 $pres_2$ $[_{VP}$ $[_{NP}$ Every [t_3 fugitive]] be in jail]]

b. $[[(\mathbf{59a})]]^{g_c}(w) = 1$ iff there is a time t′ overlapping s* such that for every (contextually salient) individual x such that x is a fugitive at $g_c(3)$ in w, x is in jail at t′ in w.

Under the given scenario, the sentence is correctly judged true with these truth conditions.

However, there is another situation in which the sentence is judged true but is not compatible with these truth conditions. Suppose that there is a group of five people who were fugitives at different times in the past but are currently in jail. Under this scenario the sentence can still be truthfully uttered. If the time argument of a noun is represented as a free time variable whose value is contextually determined, the value assigned cannot vary from one fugitive to another.

Musan (1995), while acknowledging the contribution made by Enç (1981, 1986), argues that not all temporal interpretations of nouns are context dependent. Compare the following examples:

31 The denotation of *every* should look like this:

(i) $[[\mathbf{every}]]^g = \lambda P \in D_{\langle e,\langle s,t\rangle\rangle}.\ [\lambda Q \in D_{\langle e,\langle i,\langle s,t\rangle\rangle\rangle}.\ [\lambda t \in D_t.\ [\lambda w \in D_s.$ [for every individual such that $P(x)(w) = 1$, $Q(x)(t)(w) = 1$]]]

(60)a. Every fugitive is in jail.
b. There is a fugitive in jail.

Sentence (60a) is Enç's example; it allows the temporal interpretation of the noun *fugitive* to be independent of the tense of the sentence. (60b), on the other hand, does not allow such an interpretation. Its only possible interpretation is a contradictory one in which the relevant individual is both a fugitive and in jail at the same time (i.e., at the time at which the sentence is evaluated). Musan claims that the difference in the temporal interpretation lies in the interpretation of noun phrases; presuppositional NPs allow independent temporal interpretations whereas cardinal NPs do not. Since the presuppositionality/cardinality distinction stems from the choice of determiners, Musan concludes that determiners are responsible for the temporal interpretation of nouns. Specifically, Musan argues that presuppositional determiners such as *every* introduce an existential quantifier over times which binds the temporal variable introduced by its restrictive clause. Incorporating her proposal into our current framework gives the following denotation for *every*.

(61) $[[\mathbf{every}]]^g = \lambda P \in D_{\langle e,\langle i,\langle s,t\rangle\rangle\rangle}$ $[\lambda Q \in D_{\langle e,\langle i,\langle s,t\rangle\rangle\rangle}$ $[\lambda t \in D_i$ $[\lambda w \in D_s$ [for every individual x such that there is a time t′ such that $P(x)(t')(w) = 1$, $Q(x)(t)(w) = 1$]]]]

With this denotation, Enç's example should have the following truth conditions:

(62)a. $[_{TP}$ t* PRES λ_2 $pres_2$ $[_{VP}$ every fugitive be in jail]]
b. $[[\mathbf{(62a)}]]^{g_c}(w) = 1$ iff there is a time t′ overlapping s* such that for every individual x such that there is a time t″ such that x is a fugitive at t″ in w, x is in jail at t′ in w.

The truth conditions say that the time of the relevant individual's being a fugitive and that of being in jail may be different, and therefore the sentence is compatible with the given scenario.

The denotations of cardinal determiners are different from those of presuppositional ones in that they do not introduce an extra existential quantifier over times. Here is the denotation of the determiner *a*.

(63) $[[\mathbf{a}]]^g = \lambda P \in D_{\langle e,\langle i,\langle s,t\rangle\rangle\rangle}$ $[\lambda Q \in D_{\langle e,\langle i,\langle s,t\rangle\rangle\rangle}$ $[\lambda t \in D_i$ $[\lambda w \in D_s$ [there is an individual x such that $P(x)(t)(w) = 1$ and $Q(x)(t)(w) = 1$]]]]

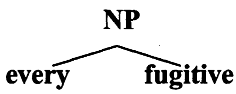
The denotation correctly predicts that the sentence *There is a fugitive in jail* does not have a temporally independent interpretation.

(64)a. $[_{TP}$ t* There PRES λ_2 $pres_2$ $[_{VP}$ a fugitive be in jail]]

b. $[[$**(64a)**$]]^{g_c}(w) = 1$ iff there is a time t′ overlapping s* such that there is an individual x such that x is a fugitive at t′ in w and x is in jail at t′ in w.

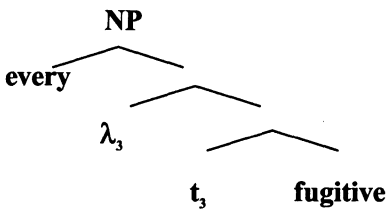
If Musan's analysis of determiners is on the right track, we are left with two conceivable structures for NPs like *every fugitive*. Since *every* requires an element of type ⟨e,⟨i,⟨s,t⟩⟩⟩ and the noun *fugitive* is just the right type, we may simply assume that they are the only elements that constitute the NP, as in (65).

(65)



Alternatively, we may represent a variable for the time argument position of the noun in syntax. In this case, however, we need a lambda abstractor over this variable, for two reasons. First, as shown above, temporal free variables do not always yield the right interpretation. Second, the constituent $[t_3$ fugitive] is not the right semantic type for *every.*

(66)



Note that only the first structure is compatible with our tense system. Our inventory contains just two time variables. Since the two variables are tense morphemes, they may not combine with nouns in English.

In the following two subsections, I present two sets of data that are given a straightforward account under the current system.

4.2. *Temporal Donkey Sentences*

In English, nouns and adjectives do not accompany any tense morpheme, and thus their time argument slots are usually not saturated in the object language. There are cases, however, where nouns and adjectives behave like tensed predicates. These are cases in which nouns and adjectives are used in predicative positions, as in the following example:

(67)a. George was a president

b. $[_{TP}$ t* PAST λ_2 $past_2$ $[_{VP}$ George be a president]]

Let us assume that the verb *be* and the determiner *a* in a predicative position are semantically vacuous. The denotation of the VP is $\lambda t \in D_i$. [$\lambda w \in D_s$. [be-a-president(George)(t)(w)]]. The tense morpheme $past_2$ when combined with this VP saturates the time argument slot of the noun *president*. As a consequence, the time of George's presidency is represented in the object language. This difference leads to a crucial contrast in intuitively synonymous phrases. Consider first the following sentences.

(68)a. I like every person who was a president.
b. I like every former president.

Intuitively, these sentences are judged true under the same circumstances. The sentences differ in a crucial respect under the current system, however. The time argument position of the noun *president* is saturated by the tense past morpheme in the relative clause in (68a), and thus the time of presidency is represented in syntax. In (68b), on the other hand, nothing saturates the time argument position of *president* in the object language. The relevant part of the sentences is represented below:[32]

(69)a. $[_{N'}$ person $[_{CP}$ who λ_i $[_{TP}$ t* PAST λ_3 $past_3$ $[_{VP}$ e_i be a president$]]]]$
b. $[_{N'}$ former president$]$

With this in mind, consider the contrast between the following sentences:

(70)a. Every person who was a president believes (now) that he did a good job then.
b. ?? Every former president believes (now) that he did a good job then.

Example (70b) does not allow as readily as (70a) the interpretation in which every former president believes that he did a good job at the time of his presidency. The contrast is reminiscent of nominal donkey sentences, discussed in Heim (1982, 1990).

(71)a. Every man who has a wife sits next to her.
b. ?? Every married man sits next to her.

The example in (71a) allows a reading in which the pronoun *her* is understood as the so-called E-type pronoun. That is, the sentence says that for each man x who has a wife, x sits next to x's wife. The same reading is not readily obtained

[32] The two structures yield the following semantics.

(i) a. $\lambda x \in D_e$. [$\lambda t \in D_i$. [$\lambda w \in D_s$. x is a person at t in w and there is a time t′ such that $t' < t^*$ and x is a president at t′ in w]]
b. $\lambda x \in D_e$. [$\lambda t \in D_i$. [$\lambda w \in D_s$. there is a time t′ such that $t' < t$ and x is a president at t′ in w]]

in (71b). The contrast is presented in Heim (1982) as a challenge against a pragmatic approach to donkey anaphora, such as the one proposed in Cooper (1979). According to that pragmatic approach, an E-type pronoun is represented as a complex of a free function variable applied to a bound individual variable. The LF of sentence (71a) looks like the following:[33]

(72) $[_S [_{NP}$ every$_x$ $[_{N'}$ man(x) $[_{CP}$ who $[_{NP}$ a$_y$ wife(y)] [x has y]]]] $[_S$ x sits next to f(x)]]

In this representation, the free function variable *f* refers to a contextually salient function from individuals to individuals. Its domain is the set of men who have a wife. When applied to a particular individual in the domain, it yields the unique wife that the individual has. One problem of this type of analysis is that it cannot distinguish the two sentences in (71). Both subject NPs, *every man who has a wife* and *every married man* in (71), intuitively mean the same, and if so, they should equally make the relevant function contextually salient.

In her 1990 paper, Heim defends such an analysis and proposes that pronouns like *her* in (71) need a linguistic antecedent. In (71a), the indefinite NP a *wife* may be the appropriate antecedent of the pronoun, whereas in (71b) no element can serve as the antecedent. Hence a donkey anaphora interpretation is not readily available.

Suppose that this is the right analysis for the contrast in (71). That is, suppose that an E-type pronoun is represented as f(x) where f is a free function variable and x is an individual variable, and that an E-type pronoun is subject to a syntactic constraint requiring an E-type pronoun to have a linguistic antecedent.[34] Moreover, let us assume that temporal donkey sentences are treated on a par. That is, the adverb *then* needs a linguistic antecedent to be construed as an E-type pronoun. The proposed system provides a straightforward explanation for the contrast in (70). For the donkey anaphora interpretation, the adverb *then* needs to pick up the time of each relevant individual's being president. Thus, its antecedent has to be the time variable that represents it. In (70a), whose LF is given below, the time variable is the past tense morpheme in the relative clause (i.e., *past*$_2$).

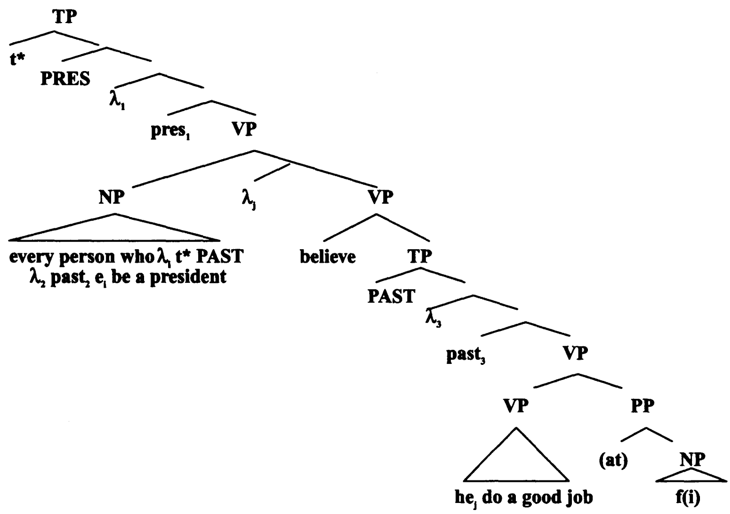
(*Footnote continued*)
The denotion of *former* used in (69b) is given below.

(ii) [[**former**]] = $\lambda P \in D_{\langle e,\langle i,\langle s,t\rangle\rangle\rangle}$ [$\lambda x \in D_e$ [$\lambda t \in D_i$ [$\lambda w \in D_s$ [there is a time t′ such that $t' < t$ and $P(x)(t')(w) = 1$]]]]

[33] This particular version of a pragmatic approach is due to Heim (1990).

[34] Heim's (1990) implementation of this idea introduces a new transformational rule and the representation of E-type pronouns is rather different from that in (72).

(73)



I assume that the adverb *then* is analyzed as a PP with a null preposition preceding it. *Then* itself is an E-type pronoun represented as f(i). The domain of the function f is the set of people who were presidents in the past. When applied to a particular individual in the domain, it yields the unique time at which that individual was a president. Since the time of presidency for each person is represented as $past_2$ in the structure, f(i) = $past_2$. The denotation of the null preposition at is $\lambda t \in Dt\ [\lambda t' \in Dt\ [\lambda w \in Ds\ t'$ is at t in w]]. When applied to the E-type pronoun, this yields $\lambda t' \in Dt\ [\lambda w \in Ds\ t'$ is at f(i) in w]. The PP denotation is then intersected with the lowest VP denotation.[35]

The structure above receives the following interpretation:

(74) $[[(73)]]^{g_c}(w) = 1$ iff there is a time t′ such that t′ overlaps s* and for every x such that x is a person at t′ in w and there is a time t″ such that t″ is before t′ and x is a president at t″ in w, and for all worlds w′ and times t‴ that are compatible with what x believes at t′ in w, there is a time t⁗ such that t⁗ is before t‴ and x does a good job at t⁗ in w′ and t⁗ is at t″ in w′.

In (70b), however, there is no linguistic material that can serve as an antecedent of the E-type pronoun *then*. The current system does not allow

[35] Here is a rule for intersecting two constituents denoting properties of times.

(i) If α is a branching node, $\{\beta, \gamma\}$ are the set of α's daughters, and $[[\beta]]$ and $[[\gamma]]$ are both of type $\langle i,\langle s,t\rangle\rangle$, then $[[\alpha]] = \lambda t \in D_i.\ \lambda w \in D_s.\ [[\beta]](t)(w) = [[\gamma]](t)(w) = 1$.

structures like [$_{NP}$ every [former [$past_3$ president]]] or [$_{NP}$ every [former [$\lambda 3$ $past_3$ president]]].

Further support for the current analysis comes from the fact that the contrast disappears when *then* is dropped.[36] That is, (70b) is good without *then*. This is expected under our analysis, since I attribute the unacceptability of (70b) to the licensing condition of E-type pronouns, according to which an E-type pronoun has to have a linguistic antecedent. I argued furthermore that (70b) violates the condition because there is no element that can serve as an antecedent of the E-type pronoun *then*. When *then* is dropped, the violation of course disappears. What does the resulting sentence mean then? Let us calculate the truth conditions.

(75)a. [$_{TP}$ t* PRES λ_1 $pres_1$ [$_{NP}$ Every former president] [$_{VP}$ believes (now) that [$_{TP}$ PAST λ_3 $past_3$ [$_{VP}$ he do a good job]]];

b. $[[(\mathbf{75a})]]^{g_c}(w) = 1$ iff there is a time t′ such that t′ overlaps s* and for every x such that there is a time t″ such that t″ is before t′ and x is a president at t″ in w, and for all worlds w′ and times t‴ that are compatible with what x believes at t′ in w, there is a time t⁗ such that t⁗ is before t‴ and x does a good job at t⁗ in w′.

Without *then*, the embedded sentence *he did a good job* merely asserts the existence of some past time at which the relevant man does a good job in his belief worlds. The truth conditions by themselves do not guarantee that in each relevant man's belief world, he does a good job at the time of his presidency. According to the truth conditions above, the sentence may be true when each former president believes that he did a good job at a time different from the time of his presidency. The sentence certainly is true under such a circumstance. (Suppose that every former president painted his house and believes that he did a good job doing so.) Uttered out of the blue, however, the sentence *Every former president believes that he did a good job* is most naturally understood to mean that in each former president's belief world, he did a good job at the time of his presidency. This does not follow from the truth conditions we derive. I argue that we understand the sentence in this way due to pragmatic considerations. Consider the following sentences.

(76)a. Bill was a president. He did a good job then.

b. Bill was a president. He did a good job.

The second sentence in the first example contains *then*, which is most naturally understood to be anaphoric to the time of Bill's presidency introduced

[36] I owe this judgment to a reviewer of *NALS*.

in the first sentence. The second example does not have any overt anaphoric temporal element. Nevertheless, the most salient interpretation we get is the same as for the first example. That is, the sentence is understood to mean that Bill did a good job at the time of his presidency.

As observed in the literature (Partee 1973, Hinrichs 1986, for instance), tenses may be used 'anaphorically'. The second past tense in (76b) does not merely assert the existence of a past time at which Bill did a good job, but is used to be anaphoric to the time introduced in the first sentence. Whatever mechanism accounts for such temporal anaphoricity should also explain the anaphoric reading observed in our example.[37]

To sum up, our tense system does not allow a time argument slot of tenseless predicates such as nouns in the argument position to be saturated in syntax, while that of tensed predicates is saturated with a time variable that morphologically realizes as a tense morpheme on those predicates. We have seen that temporal donkey anaphora is a case that is sensitive to such a distinction. The unacceptability of sentences like (70b) should be attributed to the existence of *then* which, when construed as an E-type pronoun to receive a donkey anaphora interpretation, is subject to a syntactic constraint that requires that its antecedent be syntactically represented.

4.2. *Temporal Interpretation of Participle Clauses*

The comparison between the temporal interpretation of participles on the one hand and that of relative clauses on the other provides further support. Let us start with the examples below:

(77)a. Eva talked to a boy who was standing in font of the gate.
b. Eva talked to a boy standing in front of the gate.

Both sentences are compatible with more than one situation regarding the time of the boy's standing in front of the gate. There is one situation under which both are judged true. That is when Eva talks to the boy some time in the past and the boy was standing in front of the gate at the time she talks to him. Let us call this reading a "simultaneous interpretation." We may derive this interpretation for (77a) by interpreting the relative clause tense as a

[37] One way to incorporate such intuitions into the semantics of tense is to introduce a context variable C. A tense operator such as *PAST* takes C as its first argument, whose value is determined by the utterance context.

(i) $[[\mathbf{PAST}]]^g = \lambda P \in D_{\langle i, \langle s, t \rangle\rangle} [\lambda Q \in D_{\langle i, \langle s, t \rangle\rangle} [\lambda t \in D_i [\lambda w \in D_s$ there is a time t' such that $t' < t$ and that $P(t')(w) = 1$ & $Q(t')(w) = 1]]]$

Such contextual variables have been proposed to account for contextual restrictions of determiner quantifiers (cf. Westerstål 1984, von Fintel 1994) and the analysis has also been used in the semantics of tense (cf. Musan 1995).

vacuous tense. Under our tense system, the structure of the object noun phrase looks as follows:

(78) $[_{NP}$ a $[_{N'}$ boy $[_{CP}$ who λ_j $[_{TP}$ $past_2$ $[_{VP}$ e_j be-standing-in-front-of-the-gate]]]]]

(79)a. $[[\mathbf{VP}]]^g = \lambda t \in D_i. [\lambda w \in D_s\ e_j$ is standing in front of the gate at t in w]

b. $[[\mathbf{TP}]]^g = \lambda w \in D_s\ e_j$ is standing in front of the gate at $past_2$ in w]

c. $[[\mathbf{CP}]]^g = \lambda x \in D_e\ [\lambda w \in D_s$ x is standing in front of the gate at $past_2$ in w]

d. $[[\mathbf{boy}]]^g = \lambda x \in D_e\ [\lambda t \in D_t\ [\lambda w \in D_s$ x is a boy at t in w]]

e. $[[\mathbf{N'}]]^g = \lambda x \in D_e\ [\lambda t \in D_t\ [\lambda w \in D_s$ x is a boy at t in w and x is standing in front of the gate at $past_2$ in w]]

f. $[[\mathbf{NP}]]^g = \lambda P \in D_{\langle e,\langle i,\langle s,t\rangle\rangle\rangle}\ [\lambda t \in D_t\ [\lambda w \in D_s$ there is an individual x such that x is a boy at t in w and x is standing in front of the gate at $past_2$ in w and $P(x)(t)(w) = 1$]]

The temporal argument slot of the predicate *be-standing-in-front-of-the-gate* is saturated by the past variable *past₂* and its value is determined by the assignment function. The temporal argument of the predicate *boy* is unsaturated.

When the past tense morpheme *past₂* is bound by the past tense operator in the matrix clause (which also binds the matrix past variable that represents the matrix eventuality time), the sentence receives the simultaneous interpretation.

(80)a. $[_{TP}$ t* PAST λ_2 $past_2$ λ_i $[[_{NP}$ a $[_{N'}$ boy $[_{CP}$ who λ_j $[_{TP}$ $past_2$ $[_{VP}$ e_j be-standing-in-front-of-the-gate]]]]] $[_{VP}$ Eva talk-to e_i]]]

b. $[[\mathbf{(80a)}]]^{g_c}(w) = 1$ iff there is a time t such that $t < s^*$ and there is an individual x such that x is a boy at t in w and x is standing in front of the gate at t in w, and Eva talks to x at t in w.

Example (77b) also has a simultaneous interpretation. Does that mean that the temporal interpretation of participles is obtained in the same manner as that of relative clauses? Our tense system says that this is not so. The absence of tense in participle constructions means that the temporal argument of the predicate *standing-in-front-of-the-gate* in (77b) is unsaturated. The LF for the object noun phrase looks like this:[38]

(81) $[_{NP}$ a $[_{N'}$ boy $[_{PartP}$ standing-in-front-of-the-gate]]]

[38] I assume that the participial morpheme *-ing* projects its own projection PartP.

The noun *boy* and the PartP are both of type ⟨e,⟨i,⟨s,t⟩⟩⟩. Thus the standard predicate modification rule applies to yield the denotation of the N′ node.

(82)a. $[[\textbf{PartP}]]^g = \lambda x \in D_e\ [\lambda t \in D_t\ [\lambda w \in D_s$ x is standing in front of the gate at t in w]]

b. $[[\text{N}']]^g = \lambda x \in D_e\ [\lambda t \in D_t\ [\lambda w \in D_s$ [x is a boy at t in w and x is standing in front of the gate at t in w]]]

c. $[[\textbf{NP}]]^g = \lambda P \in D_{\langle e,\langle i,\langle s,t\rangle\rangle\rangle}\ [\lambda t \in D_t\ [\lambda w \in D_s$ [there is an individual x such that x is a boy at t in w and x is standing in front of the gate at t in w and $P(x)(t)(w) = 1$]]]

The temporal interpretation of the participle (and that of the noun) is not determined at the N′ level or at the NP level. It is determined by an affecting element that immediately dominates them.[39] In this particular case, the matrix past tense is the nearest element that affects the temporal interpretation. That is, the matrix past tense morpheme *past₂* saturates the time argument slots for the noun and the participle as well as the time slot for the matrix predicate.

(83)a. $[_{TP}$ t* PAST λ_2 $past_2$ $[[_{NP}$ a $[_{N'}$ boy $[_{ParP}$ standing-in-front-of-the-gate]]] λ_i $[_{VP}$ Eva talk-to e_i]]]

b. $[[\textbf{(83a)}]]^{g_c}(w) = 1$ iff there is a time t such that $t < s^*$ and there is an individual x such that x is a boy at t in w and x is standing in front of the gate at t in w, and Eva talks to x at t in w.

So far, I have presented how the temporal interpretations of relative clauses and participles differ in the proposed system. Although both of the above sentences have the simultaneous interpretation, it is not derived from the same LF structure. On the one hand, the relative clause tense morpheme and the matrix tense morpheme are coindexed and are bound by the matrix tense operator. Hence, the binding is responsible for the relevant interpretation. On the other hand, one way in which the temporal interpretation of participles is determined is by saturating the time argument slot with the tense morpheme, and this takes place in the course of standard semantic composition.[40]

Another predicted difference between the two is the interaction between the temporal interpretation of nouns and that of modifiers. When a modifier is a relative clause, its temporal interpretation is only dependent on the assignment function. The temporal interpretation of nouns and that of

[39] This includes tenses and presuppositional determiners.

[40] When a presuppositional determiner is used, this is not the case. The existential quantifier over times in the denotation of presuppositional determiners binds a time argument of participles (together with that of nouns they modify).

relative clauses may be independent of each other. When a modifier is a participle, its temporal interpretation has to coincide with that of the noun it modifies. This is because both nouns and participles denote functions from individuals to properties of times, and their denotations are intersected. This difference explains the contrast exhibited by the following examples:

(84) [There are 20 fugitives in the state of Massachusetts now. Half of them were doing time in a prison in Concord and the other half were in a prison in Framingham.]
a. Most of the fugitives who were doing time in Concord are on the loose in Springfield now.
b. # Most of the fugitives doing time in Concord are on the loose in Springfield now.

The context given above provides the information that the relevant individuals are currently fugitives who were in jail before they escaped. The (a) continuation with a relative clause is fine, and the sentence has a sensible interpretation in which the relevant individuals under discussion are the individuals who are currently fugitives but were doing time before. The (b) sentence sounds strange, however, indicating that the same sensible interpretation is not available for it. Here is another pair:

(85) [Last year the US economy went down considerably and many people lost their jobs and even their places to live. They became homeless.]
a. Most of the homeless people who lived in apartment complexes in Amherst are now living on the main street of Northampton.
b. # Most of the homeless people living in apartment complexes in Amherst are now living on the main street of Northampton.

Let us see how the proposed system accounts for the difference. Below are the LF structures of the relevant parts of the sentences in (84):

(86)a. $[_{N'}$ fugitive $[_{CP}$ who λ_j $[_{TP}$ t* PAST λ_2 $past_2$ $[_{VP}$ e_j be-doing-time-in-jail]]]]
b. $[_{N'}$ fugitive $[_{PartP}$ doing-time-in-jail]]

(87)a. [[(**86a**)]] = $\lambda x \in D_e\, [\lambda t \in D_t\, [\lambda w \in D_s$ [x is a fugitive at t in w and there is a time t′ before t* such that x is doing time in jail at t′ in w]]]
b. [[(**86b**)]] = $\lambda x \in D_e\, [\lambda t \in D_t\, [\lambda w \in D_s$ [x is a fugitive at t in w and x is doing time in jail at t in w]]]

In the relative clause, there is no unsaturated temporal variable. Its temporal interpretation is determined by the past tense inside it. Therefore, the temporal interpretation of the relative clause and that of the noun may be independent of each other. The relevant individuals may be fugitives and doing time in jail at different times. On the other hand, the time argument slot of the noun is unsaturated, and thus its temporal interpretation is sensitive to a higher affecting element. The temporal argument slot of the participle predicate is not saturated, and therefore it is intersected with that of the noun. Thus, the relevant individuals have to be fugitives and be doing time in jail at the same time. This is contradictory since the context indicates that what is meant by the expression *fugitives* is individuals those who were once in jail but escaped from it, and are not currently in jail. The anomaly of the (b) continuation is attributed to this semantic incompatibility.

Our explanation crucially replies on the assumption that a structure like the following is not legitimate for participial phrases, where t_3 is a phonologically null time variable that saturates a time slot for the participial.

(88) $[_{N'}$ fugitive $[_{PartP}$ t_3 doing-time-in-jail]]

Alternatively, one might argue that a structure like the one above is in fact available and that the relevant contrast here is not whether time variables are overtly represented in syntax or not. The (a) examples in (84) and (85) are not a sequence-of-tense environment. This means that the relative clauses not only contain a past tense morpheme but also a past tense operator that binds it. That is, the time variables in the (a) examples are not left free. On the other hand, if there were a time variable that saturates the time slot for participles, as in (88), it would have to be left free and get a value from the context to yield the intended interpretation. An alternative account for the contrast is then to say that there is a condition that prohibits free time variables. This story explains the observed difference between relative clauses and participles without resorting to the overt representation of times in syntax.

The following examples show, however, that this line of explaining the difference is untenable. The temporal interpretation of relative clauses, but not that of participles, may be dependent on the tense in matrix clauses.

(89) [There are 20 fugitives in the state of Massachusetts now. Half of them were doing time in Massachusetts and the other half were from Connecticut.]

a. The fugitives who were doing time in Massachusetts were all in the Concord jail.

b. # The fugitives doing time in Massachusetts were all in the Concord jail.

The first sentence has a sensible interpretation where the individuals that are now fugitives but were doing time earlier were in the Concord jail when they were doing time. This interpretation is not available to the (b) example. If the eventuality time of the predicate *doing time* in the (b) example is overtly realized in the syntax and gets bound by the matrix tense, we should not expect any difference between the two examples in the relevant respect.

5. Concluding Remarks

Like many linguists working on tense, I have argued that a single-index tense system, like Priorian tense logic, is not empirically adequate for natural language. In reexamining problems that have been pointed out for Priorian tense logic, I have shown that they are truly problematic; sequence-of-tense phenomena cannot be attributed to the semantic vagueness of the past tense; the availability of a later-than-matrix interpretation does not depends on a syntactic operation such as QR.

Acknowledging empirical inadequacy of such systems like Priorian tense logic, many authors have concluded that the semantics should keep track of all times that are introduced in an evaluation. In our context, this amounts to saying that the eventuality times of all predicates are syntactically represented as time variables. The main thesis of this paper is that this is not right. I have argued that only the time variable of the main predicate of a clause is represented in syntax and that this follows from the semantics of tense morphemes and the way they interact with the predicates they are attached to. I then presented two pieces of evidence that support such a distinction between tensed and tenseless predicates in terms of the accessibility to the times introduced by them.

One issue I have not addressed in detail is the comparison between a system with explicit quantification over times and a multiple-index system. In the literature, it is often claimed that these two types of systems are equivalent in expressive power. In making this claim, the comparison has been made between a system with variables where time arguments of all predicates are represented as time variables, and a multiple-index system where sentences are evaluated not with respect to a finite number of temporal indices but to an infinite sequence of times. However, I have argued that a tense system for natural language should only be able to keep track of times in a limited way. Evidence presented in sections 4.2. and 4.3. showed that the eventuality times of nouns in the argument position and of noun-modifying participles should not be accessible in the same way as those of the main predicate of clauses. A multiple-index system can be made compatible with these data by saying that the occurrences of the two null operators (one to store times and the other to retrieve them) are restricted in such a way that they cannot be generated within noun and participial phrases.

One conceptual problem I want to mention is that there does not seem to be a natural story as to why this is so; given that these null operators are applied to tenseless predicates such as bare VPs, there seems no obvious reason why they should not be applied to other tenseless predicate as well. On the other hand, in our system the relevant distinction follows naturally from the way tense morphemes apply to VPs but not to nouns and participles. A more careful examination is needed for a definite conclusion, however.

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