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TENSE SELECTION AND THE TEMPORAL INTERPRETATION OF COMPLEMENT CLAUSES*

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Abstract

The problem addressed in this paper is tense selection. Clausal complements of verbs such as *expect* and *predict* appear to select for finite verbs that are future marked and for infinitival complements that have a future interpretation. It is argued that these two facts can (and must) be given a uniform account. To that end I adopt a relational treatment of tenses and argue for a particular architecture of composition in which the free application of abstraction is component of the grammar. The lexical semantics of future-selecting verbs is argued to contain an implicit future operator and these verbs are taken to select for future relations. The resulting framework is one in which untensed clauses are fundamentally distinguished from tensed clauses, and type-shifting is a regular part of the interpretive process.

1 Introduction

Untangling the factors that go into the temporal interpretation of complement clauses has provided work for formal semanticists for a number of years (Ladusaw 1977; Dowty 1982; Enç 1987; Ogihara 1989; Abusch 1994; von Stechow 1995b; Kusumoto 1998). Balancing the considerations of semantic innocence – that meanings be the same in root as in embedded contexts – with those of compositionality – that the meanings of the whole should be composed out of the meanings of the parts – has proved a difficult challenge. Much attention has been focussed on the interpretation of past tensed complements of past tensed verbs – the so-called "sequence of tense" phenomenon. In this paper, however, I will be primarily concerned with the interpretation of infinitival complement clauses and the relationship between infinitival complements and future tensed complements. We will, nevertheless, be unable to avoid saying something about sequence of tense.

The empirical problem I will address in this paper can be presented in puzzle form, and the puzzle is this: Why, if (1b) is an acceptable variant of (1a), is (2b) not an acceptable variant of (2a)?

(1) a. Arnim expects that Monika will write a very long dissertation.
b. Arnim expects Monika to write a very long dissertation.

(2) a. Arnim believes that Monika will write a very long dissertation.
b. *Arnim believes Monika to write a very long dissertation.

Verbs such as *expect, promise* and *predict* – what I will call "future-oriented" verbs – appear to require that their infinitival complements have a future interpretation, while verbs such as

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believe, think, understand and *know* – "present-oriented" verbs – require that their infinitival complements have a present interpretation. So in (1b), Arnim's expectation is that Monika will write a long dissertation at some time in the future, while in (3) – an acceptable variant of (2b) – Arnim's belief is that Monika is presently writing a long dissertation.

(3) Arnim believes Monika to be writing a very long dissertation.

In recent work, Abusch (1999) has noted three properties which distinguish present-oriented verbs from their future-oriented counterparts. The first – illustrated by the contrast between (2b) and (3) – is that infinitival complements of present-oriented verbs must be progressive, stative, or have a habitual interpretation. The second is that infinitival complements of present-oriented verbs cannot be modified by non-present time-frame adverbials such as *tomorrow* or *yesterday*. And the third is that infinitival complements of present-oriented verbs are equivalent with present tense (or sequence-of-tense past tense) finite complements – so (3) has the same meaning as (4).

(4) Arnim believes that Monika is writing a very long dissertation.

Infinitival complements of future-oriented verbs, on the other hand, can be non-stative, can be modified by future time-frame adverbials, and are equivalent with future tense finite complements, as we saw in (1). Put simply, infinitival complements of present-oriented verbs behave as if they are semantically present tensed, and infinitival complements of future-oriented verb behave as if they are semantically future tensed.

Aware of these facts, Ogihara (1989) took infinitival clauses to be ambiguous between a "present tense" interpretation and a "future tense" interpretation. Infinitival complements of future-oriented verbs behave like future tensed clauses, then, simply because they *are* future tensed clauses, and infinitival complements of present-oriented verbs behave like present tensed clauses simply because they *are* present tensed clauses. Unfortunately, in addition to positing an otherwise unmotivated ambiguity, Ogihara had to stipulate which kind of infinitival clause appeared with which kind of verb. Without a stipulation to the effect that infinitival complements of present-oriented verbs may not be future there is no way to account for the fact that (5) is not ambiguous between present – (6a) – reading and a future – (6b) – reading.

(5) Fritz believes Arnim to be in the mountains.
(6) a. Fritz believes that Arnim is in the mountains.
    b. Fritz believes that Arnim will be in the mountains.

With such a stipulation, however, Ogihara's analysis comes close to simply stipulating the facts, since the restriction is limited to non-finite complements. The tense of finite complements of present-oriented verbs is not restricted.

In later work Ogihara (1996) adopted a "lexical" account which avoided this problem. On this account, infinitival clauses are taken to be unambiguously "present tensed", with the lexical semantics of the embedding attitude verb determining the time with respect to which the complement clause is evaluated. Present-oriented verbs specify a relative present evaluation time, and future-oriented verbs specify a relative future evaluation time. In essence, future-oriented verbs are taken to lexically introduce a future tense operator that is applied to the complement clause. Abusch, in fact, argues explicitly that *expect* should be interpreted as

believe-will. This reflects the intuition that a sentence of the form *x expects y to VP* is true exactly when the corresponding sentence of the form *x believes that it will be the case that y VPs* is true. This kind of analysis runs into trouble, however, when it comes to the treatment of finite complements.

We know that in the scope of a future tense operator a present tense clause can have a future-shifted reading, as in (7) – the fish might be alive when it is bought, not when the sentence is uttered.

(7) Arnim will buy a fish that is alive.

That being the case, if the lexical semantics of *expect* were to contain a future tense operator, we would expect (8a) and (8b) to be synonymous, with both the infinitival and the present tense complement having a future-shifted reading.

(8) a. Monika expects Arnim to be in Constance.
b. ??Monika expects that Arnim is in Constance.

But, of course, they are not synonymous, and it is not even clear that (8b) is acceptable.[1] A present tense clause in the complement position of a future-oriented verb cannot be future shifted, but an infinitival clause must be future shifted, and this presents a problem for the lexical account.

This interplay between the interpretation of finite complements on the one hand and the interpretation of infinitival complements on the other is what makes the puzzle presented by the data in (1) and (2) so difficult. Accounting for just one or just the other is relatively straightforward. It is accounting for both in the context of a compositional theory that is problematic. It does not seem possible to give a general mechanism for the temporal interpretation of clausal complements which satisfies the following basic conditions.

- Infinitival clauses have a uniform meaning
- Finite clauses have a uniform meaning.
- Attitude verbs have a uniform meaning.
- Attitude verbs combine with their complements uniformly.

In what follows I will review more thoroughly the problems just sketched, and then give an account of complement interpretation that does satisfy these conditions. We will apply a standard Lewis-style *de se* analysis of attitude verbs to the problem of temporal interpretation, but will then have to significantly alter the standard anaphoric analysis of tenses that usually accompanies such a treatment. We will propose a dynamic analysis that allows tenses to act as predicates on the one hand and variables on the other, depending on their context of use. This would appear to be a radical departure from standard analyses, but, in fact, is in keeping with

[1] I am aware of dialects of English in which there is a sense of *expect* meaning strongly believe which can appear with present tense (and past tense) complements. In my own dialect, however, *expect* requires that its finite complements he future tensed. It is this strict sense of *expect* that we are investigating here.

some of the most interesting recent accounts of the semantics of tense interpretation (Kusumoto 1998, von Stechow 1995a).

2 Tenses and Tensed Complements

The meaning of tensed sentence is usually factored into two components: the tense and the remainder of the sentence. This remainder has been called variously a "tenseless sentence" (Enç 1986), a "sentence radical" (Galton 1984), or a "basic proposition" (Katz 1995). Intuitively, the tenseless remainder is what the sentences (9a–c) all have in common.

(9) a. Ede lived in Germany.
b. Ede lives in Germany.
c. Ede will live in Germany.

This remainder is invariably interpreted as an intensionalized property of times – this being also the interpretation typically assigned to infinitival clauses, i.e., that which must be combined with a tense to give a tensed clause meaning.

But what are the tenses? Are they sentential operators which "shift" the evaluation time of a sentence, as the traditional Montagovian analysis would have it (Montague 1974)? Or are they referential elements that fill verbal argument positions, as argued by Enç (1986) – perhaps with anaphoric properties (Partee 1973; Partee 1984)?

This referential-anaphoric account of tenses has become increasingly popular (Abusch 1994; Heim 1994; Kratzer 1998; Kusumoto 1998). On this account, tenses refer to times, and may be "bound" by other time-denoting elements in the sentence or discourse. For example, the embedded tense in (10) may either be bound by the higher tense, as indicated in (11a), or interpreted freely (potentially to be bound by another time in the discourse), as in (11b).

(10) Monika believed that Arnim was in Constance.

(11) a. Monika PAST_1 believe that Arnim PAST_1 be in Constance.
b. Monika PAST_1 believe that Arnim PAST_2 be in Constance.

The logical form (11a) is taken to correspond to the prominent "same time" reading of (10) – on which Monika's belief was that Arnim was in Constance at the time she had her belief – while (11b) corresponds to the less-prominent "back shifted" reading – on which Monika's belief is that Arnim was in Constance at some previous time. The pastness associated with the past tense here is taken to be a presuppositional requirement on the times that can felicitously bind the tense, much like the gender presuppositions associated with third-person pronouns.

As Arnim von Stechow (1984, 1995a, 1995b) has been careful to point out, it is a fundamental semantic error to bind variables in the complement of attitude verbs, however, as such binding improperly smuggles information into the content of the attitude that should not be there. In the case of temporal information, the problematic consequences of such illicit binding are quite clear. For example, if the coindexation in (11a) is interpreted as true coreference, then the sentence attributes to Monika the belief (at some past time) that Arnim was in Constance at that time. The problem is that Monika may have had no idea what time it was. For example, to take an unlikely context, if Monika's watch was running so slowly that when Arnim called from Constance at noon, she thought it was only eleven in the morning, (12a) might be true, but (12b) false.

(12) a. At noon, Monika believed that Arnim was in Constance.
b. At noon, Monika believed that Arnim was in Constance at noon.

One way of dealing with this problem is to adopt a temporal analog of Lewis' (1979) treatment of *de se* attitudes (von Stechow 1984; Ogihara 1989; Abusch 1994; Heim 1994; von Stechow 1995a; von Stechow 1995b).

Lewis considers the problem of how to distinguish beliefs about the facts from indexical belief. In Kaplan's famous sentence (13), for example, we need to distinguish the propositional belief that Jones' pants are on fire from the indexical belief – what Lewis calls the *de se* belief – that the believer has burning pants.

(13) Jones thinks his pants are on fire.

If Jones is confused about his own identity, these two beliefs do not coincide. If he thinks that he is Smith, for example, we might want to deny that Jones has the belief that Jones' pants are on fire while affirming his belief that his own pants are on fire.

Lewis gives a clever account of the distinction by suggesting that the objects of attitudes are not normal propositions – sets of possible worlds – but rather properties, or "centered" propositions – functions from individuals to sets of possible worlds. The embedded expression *his pants are on fire* is not simply interpreted as the set of possible worlds in which Jones' pants are on fire, but rather as the function from (male) individuals to the set of worlds in which that individual's pants are on fire. The verb *believe*, then, is translated as a predicate of type <<<*e*<*st*>><*e*<*st*>>>> with the following (atemporal) interpretation (the function *Dox* returns, for each individual x and world w the world-individual pairs that x entertains in w as possible alternatives for who he might be and what world he might be in, i.e., the set of doxastic alternatives).

(14) $[\![\textbf{believe}_{\textbf{atemporal}}]\!](w,x,P) = 1$ iff $\forall \langle x',w' \rangle \in \textbf{Dox}(w,x)\ P(w',x') = 1$

(13) is true, then, (on the *de se* reading) if for all Jones thinks, he is in a world in which his own pants are on fire.

To derive the relevant interpretations from the syntactic structure, the index on the "bound" pronoun in the complement clause must be abstracted over at the level of Logical Form, as in (15).[2]

(15) Jones_1 believes λ 1 [his_1 pants are on fire]

After abstraction, the complement clause in (15) has the right semantic type to appear as the object of *believe,* since it is interpreted as a function from individuals to propositions. The truth conditions for (15), then, can be read off the structure: (15) is true if and only if in worlds compatible with Jones' beliefs, the individual Jones thinks he is has burning pants.

To maintain semantic uniformity in Lewis' system, in the case of propositional belief we must abstracted vacuously as in (16).[3]

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[2] The syntactic and semantic mechanisms associated with this kind of abstraction have been discussed by Chierchia (1989) and, more generally, by Heim & Kratzer (1998).

(16) Jones$_1$ believes λ 2 [his$_1$ pants are on fire]

Although the complement clause is interpreted as a function from individuals to propositions, the object of belief is effectively the proposition that Jones' pants are on fire, since in this case the function is a constant function.

As von Stechow, Ogihara, Abusch and Heim have all shown, a Lewis-style *de se* analysis can be applied to the temporal interpretation of complement clauses. Consider the following example:

(17) At midnight Fritz believed it was raining.

According to the anaphoric analysis of tense, this sentence is provided with the following LF for the same time interpretation.

(18) At midnight$_1$ Fritz PAST$_1$ believe [it PAST$_1$ be raining]

We don't, however, want to say that this sentence is only true if Fritz believed it was raining at midnight, as the LF in (18) would suggest, because Fritz might not have known at midnight that it was midnight. We would prefer to say that Fritz' belief was that it was raining at whatever time he thought it was at midnight. To account for this kind of temporal uncertainty we need to interpret the objects of belief as "temporally centered" propositions. We will, then, translate the verb *believe* as the predicate *believe* of type <<<*e*<*i*<*st*>>><*e*<*i*<*st*>>>>, which has following interpretation:

(19) [[**believe**]](w,t,x,P) = 1 iff $\forall$<w',t',x'> $\in$ **Dox**(w,t,x) $P(w',t',x')$ = 1

The doxastic alternatives returned by the function *Dox* are now triples of worlds and times and individuals which are taken to be viable alternatives for the identity of actual world, the present time, and the attitude holder. Intuitively, this says that to believe *P* is to believe that you are in a world at a time at which *P* holds.

For a concrete illustration, assume that there are three worlds – w_1, w_2, and w_3 – and three times – 11:30pm, midnight, and 12:30am. (In order to keep things relatively simple, from now on we will ignore the individual parameter in the discussion.) Let us assume that in w_1 it is raining at 11:30 and 12:30 but not at midnight, in w_2 it is raining only at midnight, and in w_3 it is raining only at 11:30. We can display this state of affairs graphically:

	11:30pm	midnight	12:30am
w_1	rain	no rain	rain
w_2	no rain	rain	no rain
w_3	rain	no rain	no rain

[3] We have, of course, simplified the treatment greatly, in that we have assumed simple coreference in the propositional case, although there should, in fact, he a *de re* treatment.

So if in the above scenario Fritz' only belief is that it is raining, and he is not sure what time it is, then his doxastic alternatives are $\langle w_1,11:30pm\rangle$, $\langle w_2,12:30am\rangle$, $\langle w_1,midnight\rangle$, and $\langle w_3,11:30pm\rangle$. If, in addition, he thinks it is sometime before midnight, his doxastic alternatives are $\langle w_1,11:30pm\rangle$ and $\langle w_3,11:30pm\rangle$. If, on the other hand, his only belief is that it is exactly midnight, and he has no idea if it is raining or not, then his doxastic alternatives are $\langle w_1,midnight\rangle$, $\langle w_2,midnight\rangle$, and $\langle w_3,midnight\rangle$.

Returning to the analysis of (17), to generate an interpretable structure – one whose arguments are of the right semantic type to combine with their predicates – we need to abstract over the "bound" tense, just as we abstracted over the bound pronoun in (13). This yields the structure in (20).[4]

(20) At midnight$_1$ Fritz PAST$_1$ believe λ 1 [it PAST$_1$ be raining]

(17) is true, then, if at midnight Fritz located himself at a time in a world in which it was raining. In our the situation just described that would mean that Fritz' doxastic alternatives at midnight must be a subset of the set $\{\langle w_1,11:30pm\rangle, \langle w_1,12:30am\rangle, \langle w_2,midnight\rangle, \langle w_3,11:30pm\rangle\}$. Note that if Fritz isn't confused about the time at all, then he locates himself in world w_2.

The *de se* analysis of embedded tenses has become a standard accompaniment to the anaphoric treatment of tense, and the parallel it presents between pronouns on the one hand and tenses on the other is quite appealing, particularly in the context of "sequence of tense" interpretation (Heim 1994; Kratzer 1998). For us, however, the appeal lies in the straightforward way it can be applied to the treatment of infinitival complements; they can literally be interpreted as "tenseless" clauses.

3 Infinitival Complements

As we mentioned above, infinitival clauses are typically interpreted as that which must be combined with a tense to yield a tensed clause meaning. On the approach described above this means that infinitivals must be interpreted as intensionalized properties of times. And, as such, they are intrinsically of the right semantic type to appear as the complement of *believe,* without their having to undergo any sort of type-raising abstraction. This means that we can apply our analysis to infinitival complements directly. According the semantics we just gave, the truth conditions for (21a), when uttered at t_0 in w_0, are as in (21b).[5]

(21) a. Fritz believes it to be raining

b. $\forall\langle w',t'\rangle \in$ **Dox**$(w_0,t_0,$Fritz$)$ **be-raining**$(w',t') = 1$

[4] It is an open question whether it is possible to have a de re interpretation of such bound tenses as well as a de se interpretation. We will not consider this question here.

[5] We have, as promised, ignored the individual variable. This involves two simplifications. First, the **Dox** function is taken to return sets of world-time pairs and not world-time-individual triples. And second, the complement clause has been interpreted as a function from times and worlds to truth values, rather than from individuals, times and worlds to truth values. These simplifications, are of course, of no consequence. To be absolutely precise, however, the real truth conditions for (21a) are given by the formula: $\forall\langle w',t',x'\rangle \in$ **Dox**$(w_0,t_0,$Fritz$)$ λ x[**be-raining**](x')(w',t') = 1. This additional complexity is required for the *de se* analysis of sentences such as *Peter believes himself to be sick*, for which abstraction over the embedded reflexive becomes necessary.

In other words, (21a) is true only if all the worlds and times in Fritz' doxastic alternatives are worlds and times at which it is raining. In the state of affairs we just sketched, (21a) would be true if and only if Fritz' doxastic alternatives in the real world at the time of speech are a subset of the set {<w_1,11:30pm>, <w_1,12:30am>, <w_2,midnight>, <w_3,11:30pm>}. The content of the belief attributed to Fritz in (21a) and that attributed to him in (17) are, then, identical.

The fact that one sentence contains a *de se* interpreted past tense and another an infinitive clause doesn't play a role, since infinitive complements of *believe* are, in effect, always interpreted as temporally *de se*;[6] they are always predicated of the temporal doxastic alternative. This, in turn, accounts for the present-tense-like interpretation of the infinitival complements of present-oriented verbs, since the temporal doxastic alternative is defined as the time (or set of times) that the believer takes to be (candidates for) his present time.

In the case of future-oriented verbs such as *expect*, however, we know that infinitival complements have a future-tense-like interpretation. A sentence such as (22) is true if Fritz thinks it will be raining at some time after the time at which he locates himself.

(22) Fritz expects it to be raining.

The intuitive difference interpretation of *believe* and *expect*, then, can be stated as follows: To believe it to be the case that *P* is to locate oneself at a world and time at which *P* holds, whereas to expect it to be the case that *P* is to locate oneself at a world and a time at which at some later time, *P* holds. Let us incorporate this intuition into our analysis by translating *expect* provisionally as a predicate of type <<<*e*<*i*<*st*>>><*e*<*i*<*st*>>>> with the following interpretation:[7]

(23) $[\![\textbf{expect}_{\textbf{prov}}]\!](w,t,x,P) = 1$ iff $\forall \langle w',t',x' \rangle \in \text{Dox}(w,t,x)\ \exists\ t'' >_{w'} t'\ P(w',t'',x') = 1$

Applying this analysis to (22) when uttered at t_0 in w_0, then, gives us the truth conditions in (24).

(24) $\forall \langle w', t' \rangle \in \textbf{Dox}(w_0, t_0, \text{Fritz})\ \exists\ t'' >_{w'} t'$ **be-raining**$(w', t'') = 1$

In the state of affairs described above, then, (22) is true if Fritz' doxastic alternatives at t_0 in w_0 are a subset of the set{<w_1, 11:30>, <w_1, midnight>, <w_3, 11:30>}.

This, of course, is essentially a formalization of the lexical account proposed by Ogihara. As we noted above, however, such an analysis runs into trouble when it is applied to tensed complements. Consider, for example, sentence (25):

(25) ??Fritz expects that it is raining.

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[6] Chierchia (1989) has noted that the PRO subjects of infinitival complements also have only a *de se* interpretation

[7] In order to capture the fact that one can have misconceptions about the temporal relationships that hold between times, the temporal ordering relation must he parameterized with respect to the world of evaluation.

If (25) can be interpreted at all it means something like *Fritz strongly believes that it is raining*. Following the analysis of tensed complements we presented in the last section, however, (25) would be assigned the LF in (26).

(26) Fritz $PRES_1$ expect λ 1 [it $PRES_1$ be raining].

Here the tense is abstracted over, and so the clausal complement of *expect* is interpreted as a property of times. The truth conditions for (25) would be as in (27).

(27) $\forall$<w',t'> $\in$ **Dox**(w_0,t_0,Fritz) $\exists$ t'' $>_{w'}$ t' **be-raining**(w',t'') = 1

That is, it should mean that Fritz thinks it will rain. This, of course, is not what (25) means.

The problem is that abstracting over a bound tense makes the finite and infinitival clausal complements synonymous, and while in the case of *believe* this leads to the correct truth conditions, in the case of *expect* it does not. The lexical semantics of *believe* specifies alternatives for the present, whereas *expect* specifies alternatives for the future. In the analysis of tense interpretation we just sketched, and in all treatments I am aware of, it is only possible to specify alternatives for one or the other of these. To give a compositional analysis of the temporal interpretation of the clausal complements of attitude verbs, however, we need a semantics that also allows us to specify alternatives for both. This we will provide in the next section.

4 A New Semantics for Tensed Complements

In our earlier discussion we made a slight omission. We suggested that the back shifted reading of a sentence such as (28) is a case of a "free" tense in the complement clause.

(28) Fritz believed that Arnim climbed Monta Rosa.

This is not, strictly speaking, correct. There is no such thing as a free tense in such a context. As Ogihara (1989,1996) has show, all tenses embedded under an attitude verb, even non-bound tenses, are interpreted with respect to the "local now". On the backshifted reading of (28), for example, the embedded past tense is interpreted with respect to the time Fritz thought it was when he had his belief. The sentence is interpretated to mean that Fritz located himself at a time after a time at which Arnim climbed Monta Rosa. While the embedded tense is not, strictly speaking, bound by the higher tense, it isn't entirely free either. It is interpreted with respect to it. This has the effect that sometimes an embedded past tense doesn't end up referring to a past time at all. In (29), for example, the embedded past tense is interpreted with respect to Wolfgang's future doxastic alternatives and, therefore, might refer to a future time.

(29) Wolfgang will believe that the students turned in their papers on time.

The point here is that tenses often have a relative interpretation. This relative interpretation presents well-known problems for anaphoric treatments of tenses, since it shows that tenses do behave (at least sometimes) like "shifting" operators. In what follows, I would like to develop on a suggestion made by von Stechow (1995a) for how to treat relative tenses in the context of an anaphoric theory and show how this new account of tenses will help us address the problems we raised above.

Von Stechow suggested that tenses be treated as relational operators. A tense takes three arguments: two times – the perspective time and the event time – and a temporal predicate. Typically the perspective time is bound by the "local now" – the temporal parameter of the doxastic alternative or the speech time – and event time is the time which satisfies the open temporal argument of the predicate. Formally, the perspective time will appear as a left index on the tense and the event time will appear as a right index. Semantically, thetenses require that a particular temporal relation hold between the perspective time and the event time. This is indicated by the interpretations in (30).[8]

(30) a. $[\![_i\text{PRES}_j]\!]^g(P)(w) = 1$ iff $g(j) =_w g(i)$ and $P(g(j))(w) = 1$
b. $[\![_i\text{PAST}_j]\!]^g(P)(w) = 1$ iff $g(j) <_w g(i)$ and $P(g(j))(w) = 1$
c. $[\![_i\text{FUTR}_j]\!]^g(P)(w) = 1$ iff $g(j) >_w g(i)$ and $P(g(j))(w) = 1$

Under this view of tense interpretation, tensed clauses are treated as formulae with possibly free variables. The indices on a tenses may be bound by other time-denoting elements in the sentence or discourse, and may themselves act as binders. Although highly non-standard, this proposal is very much along the lines of the analysis put forward by Kusumoto (1998).

There are two operations that can apply in the course of the derivation to "bind" these free variables: existential closure and abstraction. These will be taken to be operations on LFs, as indicated in (31).

(31) a. Abstraction: $\text{CP}[v] \Rightarrow [\lambda\, v\ \text{CP}[v]]$
b. Existential Closure: $\text{CP}[v] \Rightarrow [\,\exists\, v\ \text{CP}[v]]$

Abstraction applies – as we have seen – in order to avoid type-clashes. Existential closure simply provides a strategy for interpreting free variables, as has become standard since Heim (1982). Both operations are clause-bound. With respect to abstraction, we follow von Stechow (1995a) in adopting the convention that variables bound by operators outside the CP must be abstracted over (to avoid the semantic problems associated with binding into an opaque context) and that these are the last variables to be abstracted over. Vacuous abstraction is not ruled out, and, as we mentioned above, in the case of normal propositional belief, vacuous abstraction must apply in order to preserve compositionality. We will, however, rule out vacuous abstraction when there are free variables that could be abstracted over. In other words, if abstraction must apply, then it should bind a free variable, if there is one to bind. Existential closure applies after abstraction to bind any variables which remain free. Note that variables which are deictically bound, such as the indexical pronouns and the temporal variable 0 are not bound by existential closure.

While this may seem an *ad hoc* set of principles, in fact what we see is that tenses are being treated as a type of indefinite pronoun, analogous to those Chierchia (2000) has recently been investigating in the nominal domain. When they are not bound they are treated like indefinites, and when they are bound they are treated like pronouns. Since abstraction and existential closure are independently required for the treatment of *de se* pronouns on the one hand and the treatment of indefinite noun phrases on the other, and it is not surprising that both operations end up playing a role in tense interpretation.

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[8] Abusch (1994) has argued that the only true tenses are present and past. The future tense itself is decomposed into a tense plus a modal-like operator. We will assume here that all tenses are of the same type, and that there are three: past, present, and future.

Von Stechow assumed that tense operators were ambiguous between a relative interpretation and an anaphoric interpretation. I will instead treat all tenses as relative and incorporate a kind of sequence of tense rule into the syntax, in the style of Stowell (1993), to handle those cases that at fist glance look strictly anaphoric. That is, I assume that the actual morphological spell-out of a tense operator is a determined by two factors: the identity of the tense operator itself, and whether or not it is marked with the morphological feature [pst]. The tense operators are spelled out morphologically as follows:

(32) The Tense Operators
PRES[pst] → *-ed*
FUTR[pst] → *would*
PAST[pst] → *-ed*
PRES → ∅
FUTR → *will*

The [pst] feature is lexically associated with the PAST operator, and is passed on to other tense operators whose perspective time index is "bound" by the event time index of another [pst]-marked operator, via the Tense Agreement Rule given in (33).

(33) Tense Agreement Rule
[... TNS[pst]$_i$ ... [... $_i$TNS ...] ...] ⇒ [... TNS[pst]$_i$ ... [... $_i$TNS[pst] ...] ...]

To illustrate the workings of the analysis, let us consider the treatment of (34).

(34) John believed that Bill would leave.

The LF for (34), which indicates the operators and their binding relations, is (35).

(35) John$_0$ PAST[pst]$_1$ believe that Bill$_1$ FUTR[pst]$_2$ leave.

The [pst] feature on the FUTR operator indicates that this operator is (syntactcally) bound by the [pst]-marked matrix tense. Note that this [pst] feature does not carry any semantic value.[9] To "break" the binding relation between the higher tense and the lower tense, which is in an opaque context, abstraction must apply to (35), yielding the structure in (36).

(36) John$_0$ PAST[pst]$_1$ believe that λ 1 Bill$_1$ FUTR[pst]$_2$ leave.

Note that had we abstracted over the free variable 2 instead, the illicit binding relation between the higher and the lower tense would remain. Were we instead to abstract over both 1 and 2, then we would have an object of the wrong semantic type to appear as the object of

[9] As Kusumoto has noted, on accounts in which *would* is decomposed into a PAST operator plus a FUTR operator (cf. Abusch 1988), there is no explanation for the fact that *would* never gives rise to a "back shifted" reading, i.e., that (34) never means *John thought that Bill had been going to leave at noon.* This problem does not arise here, as *would* only appears when its perspective index is bound by a higher PAST operator, as in (35).

believe and the structure would be uninterpretable. Only the structure in (36) satisfies the constraints we have set up and yields an interpretable structure.

Interpreting the LF in (36) – applying existential closure at each clausal level but not to the distinguished speech time variable 0 – gives us the truth conditions in (37).

(37) $\exists$ t [t < t_0 & $\forall$<w',t'> $\in$ **Dox**(w_0,t,John) $\exists$t" [t" >$_{w'}$ t' & **leave**(w',t",Bill) = 1]]

The meaning of (34), then, is that there was a time in the actual past at which John located himself in a world and at a time at which Bill was going leave at a later time. This seems correct.

At this point we have already accounted for part of our puzzle, namely the fact that (2a) and (2b) cannot be synonymous. As we have just seen, the perspective time of an embedded FUTR is always bound by the higher tense, and therefore it is also always abstracted over. This means that the event time of the embedded FUTR is future shifted with respect to the local now. In the case of an infinitival complement, as we have mentioned, the complement clause is always directly applied to the local now. Of course this will have to be different in the case of *expect*.

Before we turn to the analysis of *expect*, let me illustrate my treatment of sequence of tense phenomena by deriving the two interpretations of the ambiguous sentences (38).

(38) Fritz believed it was raining.

The two interpretations – the same time interpretation and the back shifted interpretation – have two distinct LFs.

(39) a. Fritz_0 PAST[pst]_1 believe λ 1 it_1 PRES[pst]_2 be raining.
b. Fritz_0 PAST[pst]_1 believe λ 1 it_1 PAST[pst]_2 be raining.

The LF for the same time interpretation contains an embedded present tense operator, while that for the back-shifted reading contains an embedded past tense operator. Both are [pst] marked, and so they are homophones. The truth conditions for (39a) and (39b), then, are (40a) and (40b) respectively:

(40) a. $\exists$t [t < t_0 & $\forall$<w',t'> $\in$ **Dox**(w_0,t,Fritz) $\exists$t" [t" =$_{w'}$ t' & **be-raining**(w',t") = 1]
b. $\exists$t [t < t_0 & $\forall$<w',t'> $\in$ **Dox**(w_0,t,Fritz) $\exists$t" [t" <$_{w'}$ t' & **be-raining**(w',t") = 1]

Note that in the case of (39a), since the embedded tense is underlyingly a present tense, the perspective time index and the event time index must refer to the same time, while in the case of (39b) the event time index must refer to an earlier time then the perspective time index.

We are now in a position to give a new semantics for *expect* that no longer runs afoul of the problems that we raised above.

5 Tensed Complements of Future-Oriented Verbs

I would like to suggest that the difference between present-oriented verbs and future-oriented verbs is not just their temporal orientation, but the logical type of their complements. As we have seen, to adequately analyze tensed complements of present-oriented verbs such as

believe we need only abstract over the perspective time index. The event time index has typically been existentially interpreted. It appears that for future-oriented verbs such as *expect*, we need to abstract over both the perspective time and the event time. I propose, then, that the verb *expect* is translated as a predicate of type <<<*e*<*i*<*i*<*st*>>>><*e*<*i*<*st*>>>> with the following interpretation.

(41) [[**expect**]](w,t,x,P) = 1 iff $\forall$<w',t',x'> $\in$ **Dox**(w,t,x) $\exists$ $t'' >_{w'} t'$ $P(w,t'',t',x')$ = 1

The modification here with respect to the semantics we gave for *expect* above is simply that we have added an extra temporal argument to which the complement clause must be applied. Whereas before *expect* took as its clausal argument an intensionalized property of times, now it takes an intensionalized property of properties of times.

It may be easiest to understand how this new semantics for *expect* combines with our system for tensed-clause interpretation by way of example. Consider (42a), the logical form of which is given in (42b).

(42) a. Fritz expects that Arnim will laugh.
b. Fritz_0 PRES_1 expect [Arnim_1 FUTR_2 laugh]

In order to get the right type of clausal argument for *expect* we need to abstract twice. First we abstract over the free variable 2, since it is there, and then we abstract over the improperly bound variable 1, because this variable must be abstracted over last. This yields the structure in (43):

(43) Fritz_0 PRES_1 expect λ 1 λ 2 [Arnim_1 FUTR_2 laugh]

This structure can be interpreted, and the truth conditions for it are given in (44).

(44) $\exists t$ [$t = t_0$ & $\forall$<w',t'> $\in$ **Dox**(w_0,t_0,Fritz) $\exists$t" [t" $>_{w'}$ t' & **laugh**(w',t",Arnim) = 1]]

Note here that the existential force associated with the variable t" – the time at which Arnim laughs – is contributed by the lexical semantics of the predicate *expect.* Furthermore, note that the relationship between the local now – t' – and this time of laughter is doubly specified, once by the lexical semantics of the attitude verb itself and once by the tense. This double specification accounts for the requirement that the complement of *expect* must be a future tense clause. If the complement clause were a present tense or past tense clause, the two temporal specifications would be in conflict.[10]

So far so good; but what about infinitival complements? Note that given our new semantics, infinitival clauses are now of the wrong type to appear as the clausal complement of *expect.* Infinitival clauses are interpreted as properties of time, but *expect* needs a complement that is a property of properties of time. In order to get the right type, then, we need to apply vacuous abstraction. Let us consider the infinitival version of (42a):

[10] It might be the case that the spcifications have somewhat different weight. The marginal acceptability of non-future tensed complements as in (25) indicate that the lexical specification might, in fact, be some sort of default presupposition, which overt temporal specification can override.

(45) Fritz expects Arnim to laugh.

Now in order for the sentence to be interpreted, the infinitival complement must be "type shifted" via abstraction. The logical form, then, is (46).

(46) [Fritz_0 PRES_1 expect λ 2 [Arnim to laugh]]

The temporal variable 2, like the variables introduced by Lewis for non-*de se* belief, will play no role in the specification of the truth conditions of the sentence. The complement clause will be first applied to the "local now", and this will, in a sense disappear. Then it will be applied to the time t" which is interpreted as the laughing time. The truth conditions for (45), then, will be those in (47).

(47) $\exists t\,[t = t_0 \,\&\, \forall \langle w',t' \rangle \in \mathbf{Dox}(w_0,t_0,\text{Fritz})\ \exists t''\,[t'' >_{w'} t' \,\&\, \mathbf{laugh}(w',t'',\text{Arnim}) = 1]]$

(44) and (47) are, of course, identical. In the course of calculating (47), however, the temporal relations between t" and t' were specified only once, by the lexical semantics of *expect*. We have, then, an account of the synonymy of (42a) and (45) – and, therefore, of the synonymy of (1a) and (1b). Our puzzle is solved.

6 Conclusion

The contrast between present-oriented verbs and future-oriented verbs presents many challenges for a compositional analysis of the temporal interpretation of the complement clause of attitude verbs. Owing to the groundbreaking work of von Stechow and others, we have been able to come to grips with the scope of these challenges. It is clear that no simple modification of any "off the shelf" analysis of tense interpretation can solve the puzzle. Accounting for the variable behavior of infinitival complements, however, appears to be yet another of the brute empirical facts that demonstrate to us that a more flexible dynamic approach to natural language semantics is necessary. Accordingly, we have been forced to adopt an analysis on which tenses have a flexible interpretation. On the one hand they are operators, taking times and predicates as arguments, while on the other hand they are like pronouns and can be bound by other operators. This flexibility allowed us to preserve the intuition that, temporally, infinitival clauses should have a uniform interpretation and to relate the future-tense-like interpretation of infinitival complements of future-oriented verbs to the fact that these verbs appear to select for future-tensed finite complements.

The formal analysis we have presented here only begins to address the problems, of course, and there are a number of remaining questions to be investigated. Foremost among them is the question why there are no "past-oriented" verbs, in the sense that there are no verbs whose infinitival complements are interpreted as past times. This may (or may not) correlate with the fact that in so many languages present tense sentences can be used with both present and future interpretation, but not with past interpretation. And, of course, we have not even touched on the contrast between finite and infinitival adjunct clauses.

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