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Tense

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11.1 Introduction

Our focus in this article is the semantics of tense, one of the main devices for encoding time in language. The grammatical category of tense is used to locate a situation or event in time, typically in interaction with aspect. When tense relates the speaker's temporal focus, what is normally called the reference time, to the speech time, we have deictic or absolute tense. Aspect, on the other hand, is concerned with the internal temporal structure of the event, e.g., whether the event time is included or not in the reference time.

Tense is typically marked by verbal morphology, normally an affix on the matrix verb or on an auxiliary verb, but the semantic tense operator is not interpreted at the verb. The operator can be located quite distant from the verb at the level of logical form. Thus we must distinguish between tense semantics and tense morphology.

We will assume that our model contains a set of times I , and, furthermore, that verbs have a temporal argument of the semantic type i (time intervals). The latter assumption will be revised when we include aspect in the analysis. Times are partially ordered by the relation $<$ “before” and $>$ “after”. Time intervals are coherent sets of time points. Hence they may overlap, stand in the inclusion relation and so on (von Stechow, 2009).

While everybody agrees that the meaning of past and future tenses is relational – with past placing the reference time *before* now and future *after* now – there is a longstanding issue in the literature as to the exact status of the reference time: is it quantificational or referential? We argue that this issue cannot be given a straightforward solution, because tenses, such as the simple past in English, are ambiguous between an indefinite (quantificational) and a definite (referential) interpretation of the reference time.

We will suggest that the data invite a dynamic account, according to which indefinite terms are analysed as introducing a new discourse marker (dm), whereas definite terms are considered to be anaphoric to an old dm and are in fact entirely presupposed.

Furthermore, since tenses are relational, this last point also concerns the other time involved in the tense relation, what is called the perspective time in (Kamp and Reyle, 1993) and much subsequent work, but which we will refer to as the temporal centre. For simple tenses in main clauses the temporal centre is either contextually given, i.e., anaphoric, or uniquely given by the speech time, hence referential and not quan-

tificational. In composite tenses, such as the past perfect in Germanic and Romance languages, the temporal centre is typically an anaphoric definite time, while the reference time is shifted backwards.

Thus, following most contemporary work in the domain of tense and aspect, we should carefully separate the reference time (a.k.a. the assertion time) from the temporal centre (a.k.a. the perspective time, temporal anchor for the sentence). In contrast, the classical notion of reference time going back to (Reichenbach, 1947) suffers from the defect of not distinguishing properly between these two temporal parameters.

11.2 Desiderata

The goal of this survey article is to indicate what kind of theory of tense is needed for a coherent analysis of examples like in (1) and (2) below. Along the way, we must address a wide range of questions concerning tense: its morphological and syntactic expressions as well as its interpretation at both the sentence and the text level.

(1) John left at 11. He didn't turn off the stove.

(2) John left at 11. He had arrived yesterday.

Barbara Partee remarked that the past in the second sentence of (1) cannot be an existential quantifier (Partee, 1973). If it were an existential quantifier, then we would have two options: either it would have the meaning shown in (3), or that shown in (4).

(3) There is a time before now at which he didn't turn off the stove.

This assertion is trivial, since (3) is a very weak statement and is likely to be true. The second option is

(4) There is no time before now at which he turned off the stove.

This option is too strong to be true, and it is certainly not the meaning of the sentence in the text. We can solve Partee's puzzle if we interpret the past in the second part of (1) as an anaphoric definite description. Then it would have the meaning:

(5) John leaves at [[a time₁ before now] which₁ is at 11]. He doesn't turn off the stove at [that time₁ before now].

The key to the solution is that the anaphoric definite description, underlined in (5), is scopeless with respect to negation.

In the second sentence of example (2), the composite past perfect involves both an indefinite and definite time, as we see from the paraphrase in (6), where the anaphoric definite description is underlined.

- (6) John leaves at [[a time₁ before now] which₁ is at 11]. He arrives at [[a time₂ [before that time₁ before now]] which₂ is on yesterday].

We will present a general theory that allows for different combinations of (in)definite tense, simple and composite tenses, and temporal adverbials, as in the examples above.

Importantly, both examples above involve an instance of cross-sentential temporal anaphora, so a fully satisfactory analysis must arguably be *dynamic*. The idea that tenses necessitate a dynamic semantics was originally put forth by Hans Kamp and colleagues in the early 1980s (Kamp and Rohrer, 1983). The development of DRT (Kamp and Reyle, 1993) was partly motivated by observations concerning temporal/narrative progression (and lack thereof) with French tenses.¹ We consider narrative progression to be a pragmatic phenomenon (be orderly!) and we will not have much to say about this in our study of temporal semantics. Hence, our argumentation for a dynamic semantics is to some extent orthogonal to Kamp's original insight. As pointed out by a reviewer, our dynamic approach, which is based on the idea that a dynamic treatment of definite/indefinite NPs could be replicated with tenses (and aspects – see Section 11.10), is more in the spirit of (Partee, 1984).

However, we will start our discussion by presenting a standard analysis of semantic tense, tense morphemes and temporal auxiliaries in a compositional, static framework. The idea is to clarify where exactly in the structure the various expressions of time fit in, and what actual contribution they make. This will be the topic of section 11.3. In Section 11.4 we will have a closer look at the notion of referential tense. Next, in Section 11.5 we will discuss the meaning of temporal adverbials and point out some temporal puzzles which temporal quantification gives rise to. In Section 11.6 we briefly analyse the analytic perfect construction, which we consider to be a sort of tense with either an extended now interpretation or a relative past semantics. In both cases the perfect modifies or changes the reference time. In Section 11.7 we motivate an analysis of tense in terms of (in)definiteness and we present the general

¹ We thank an anonymous reviewer for reminding us of this point.

tense architecture assumed here. Finally, in Sections 11.8 and 11.9, we formalise (in)definite tense in a dynamic framework. Section 11.10 shows how the formal analysis can be extended to include aspect. Some of the technical details concerning the dynamic framework can be found in an appendix.

11.3 Tense in compositional semantics

Most contemporary approaches to the syntax-semantics interface assume a structure as in (7):

- (7) Architecture $[_{TP} \text{ TENSE}[_{\text{PerfP}} \text{ PERFECT}[_{\text{AspP}} \text{ ASPECT}[_{VP}]]]]$

The following example motivates this particular three-way distinction between tense, perfect and aspect.

- (8) John has been working much lately.
 $[_{TP} \text{ N}[_{\text{PerfP}} \text{ XN}[_{\text{AspP}} \text{ IMPERFECTIVE}[\text{John work}]]]]$

Although our examples will mostly come from English, the general architecture we discuss should in principle apply to other languages as well.

A complete inventory in (7) would comprise matrix deictic tenses, namely, N, PAST* (i.e., PAST(N)), and FUT* (i.e., FUT(N)), at least two perfect relations, XN (extended now – see section 11.6) and PAST, a relative FUT, and a number of aspects, such as PERFECTIVE, IMPERFECTIVE etc., but languages may differ in which combinations of these they allow.

The nomenclature of verbal categories in (7), notably aspect, is most easily analysed on the assumption that the verb comes with an event/state argument (Rothstein, 2014). We will see how events can be integrated into our tense theory in sections 11.6 and 11.10, but for most of the discussion we will simplify the picture and leave aspect out. Here we assume that the verb comes with a temporal argument, the time interval (event time) at which the descriptive content of the VP obtains.

But what does it mean to say that a VP or a sentence is true “at an interval”? A problem immediately arises with accomplishments (*to build a castle*) which lack the sub-interval property and more naturally combine not with *at*-adverbials, but with *in*-adverbials (*to build a castle in two years*). The latter, however, do not specify the exact interval

throughout which the event obtains (see (Ogihara, 2007, p. 400) and (von Stechow, 2009) for discussion). In the absence of durative adverbials (“from 2 AM to 5 AM”), natural languages thus typically remain vague as to the exact duration of the event. A way of analysing such cases is to introduce a covert perfective aspect operator (see (Rothstein, 2014) and her chapter on aspect, or footnote ⁴ below), which captures the temporal configuration by letting the temporal trace of a VP-event be *included in* the reference time.

11.3.1 Present tense

The present N denotes the speech time, a distinguished time s^* . In our typed framework, the semantic present has the simplest type i (mnemonic for interval).

- (9) Present: N “now”, type i
 $[[N]] = s^*$ (“speech time”)

We will not be able to discuss more fine-grained approaches to the present.² In fact, for many languages the present is rather a non-past. In languages like Japanese and Russian, Aktionsarten and aspect decide whether the non-past is interpreted as denoting the speech time or a future time (e.g., Russian perfectives with present tense morphology are coerced into a future tense interpretation). Even a quick comparison of examples from English and German suggests that there may be differences in the denotation of present tense in “our languages” too:

- (10) a. (*) Mary comes tomorrow.
 b. Mary will come tomorrow.
 c. ✓ Maria kommt morgen.

The distribution of English present is more restricted than that of the German present, since it cannot straightforwardly be combined with future adverbials and is therefore less likely to denote a future time.

11.3.2 Quantificational past

English uses an auxiliary – an existential time shifter – in order to shift the reference time to a time after now (*will come* in (10b)). Many lan-

² See (Altshuler and Schwarzschild, 2013) for a recent discussion of alternative analyses.

guages, such as French and German, can make use of auxiliaries (formally, a “present perfect”) also to shift the reference time to a time before now. For time reference in the past English normally uses the simple past:

- (11) Mary called.
 $(\exists t)[t \text{ is before now} \ \& \ \text{Mary call}(t)]$
 There is a time t before now, such that Mary calls at t .

This statement of the truth-conditions in (11) is, not quite accurately, often attributed to the logician Arthur Prior. Prior (1967) uses the temporal auxiliaries *have* and *will* in the paraphrases of the truth-conditions of simple past and future: “It has been the case that” and “It will be the case that”. In Richard Montague’s PTQ (Montague, 1973) we find the syncategorematic symbol H (mnemonic for *has*).

- (12) $[[H\alpha]]^i = 1$ iff $(\exists i' \prec i) \ [[\alpha]]^{i'} = 1$ (À la Montague)

In order to evaluate $H\alpha$ at the evaluation time i , it is not enough to consider the intension of α at i ; we also have to consider some $i' \prec i$ and evaluate the intension of α there. As pointed out by Ogihara (2007, 393; 396–397), neither Prior nor Montague intended to represent the meaning of the English past tense *-ed* per se.

In our static framework, P^* is a deictic past, while P is the more general version, i.e., a relative past. These are both functors in the object language:

- (13) Deictic Past: P^* , type (it, t)
 $[[P^*]] = \lambda Q_{it}.(\exists t')[t' \text{ is before now} \ \& \ Q(t')]$
 (14) Relative Past: P , type $i(it, t)$
 $[[P]] = \lambda t. \lambda Q_{it}.(\exists t')[t' \text{ is before } t \ \& \ Q(t')]$

“is before” will be written as “ $\prec$ ”. In matrix clauses it will not matter whether we choose P or P^* , since the temporal centre of P will be the present N . Of importance, however, is our assumption, which is also in agreement with recent ideas of Heim’s, that the temporal centre (perspective time) is the *first* argument of P . Other authors may assume a different type for P , viz., (it, it) . We will justify our choice below when we explicate our conception of the syntax-semantics interface.

11.3.3 Have, will

The temporal auxiliaries contribute, in the simplest case, the same semantics as the relative “Priorian” tenses: they are time shifters, also called verbal quantifiers, that shift the reference time backwards (or forwards):

- (15) **have** (English), **avoir** (French): type $i(it, t)$
 $\lambda t. \lambda Q_{it}. (\exists t') [t' \prec t \ \& \ Q(t')]$

A consequence of this analysis is that we somewhat incorrectly predict full synonymy between the indefinite deictic past P^* and the present perfect.³ The structure differs, though, since [**have** t_1] is a quantifier generated in the head of the AuxP.

- (16) John has called.
 Jean a téléphoné.
 $[i \ N] \ [it \ \lambda_1 \ [t \ [it, t \ \mathbf{have} \ t_1]]_{it} \ \lambda_2 \ [\mathbf{John} \ [\mathbf{call} \ t_2]]]]$
 $(\exists t') [t' \prec s^* \ \& \ \text{John calls at } t']$

The auxiliary *will* is simply the mirror image of *have*:

- (17) **will**: type $i(it, t)$
 $\lambda t. \lambda Q_{it}. (\exists t') [t' \succ t \ \& \ Q(t')]$

“ $\succ$ ” stands for “is after”.

- (18) John will call.
 $[i \ N] \ [it \ \lambda_1 \ [t \ [it, t \ \mathbf{will} \ t_1]]_{it} \ \lambda_2 \ [\mathbf{John} \ [\mathbf{call} \ t_2]]]]$
 $(\exists t') [t' \succ s^* \ \& \ \text{John calls at } t']$

Note that English, unlike for instance French, does not have a synthetic/morphological future tense as such.

11.3.4 Tense morphology and interpretation

Judging from the morphology, it would seem that tense is located at the verb. However, most semanticists have treated tense as a sentential operator and so, if we follow this practice, then the relation between tense morphology and semantic tense must be more complicated.

³ This naïve parallel between deictic past and present perfect works better for German or French than for English which has an XN-semantics in the present perfect, see Section 11.6.1 below.

From the examples above, we can see that the morphological past *called*, the participle *called* (*have* subcategorises for a past participle) and the infinitive *call* (the auxiliary *will* subcategorises for an infinitive) all have a tenseless interpretation in our system. Every verb has a temporal argument, which is the first argument by convention:

$$(19) \quad [[\text{call}]] = [[\text{called}]] = [[\text{calls}]] = \lambda t \lambda x. x \text{ calls at } t.$$

A problem arises from the fact that tense is not interpreted where it is pronounced. Consider the past *-ed* and the meaning given in (13)/(14). Let us assume that at deep structure (DS) *-ed* occupies the place of the temporal argument of the verb. The semantics tells us that *-ed* is an existential quantifier. Like all quantifiers *-ed* has to be QRed for type reasons. The derivation of sentence (11) is therefore the following:

$$(20) \quad \begin{array}{l} \text{DS: Mary call}(-\text{ed}) \\ \text{QR} \Rightarrow \\ \text{LF: } -\text{ed } \lambda_1 \text{ Mary call}(t_1) \end{array}$$

We will adopt the theory of quantifier raising (QR) as described in (Heim and Kratzer, 1998): Quantifiers of type (at, t) are moved to a sentence-initial position. They leave a trace of type a (written as t_a), interpreted as a variable x_a . The movement index of the quantifier is interpreted as the binder λ_a . For the example under discussion this gives us the following structure and meaning:

$$(\exists t \prec s^*) \text{ Mary calls at } t$$

In order to mediate between semantics and morphology, we have to

assume that the QRed *-ed* is not pronounced at SS (surface structure), but transmits a feature uP (uninterpretable past) to the bound variable t_i , which determines the pronunciation of the verb as a past form.

A more abstract but equivalent analysis assumes Heim's theory of PRO (or TPRO; 'temporal' PRO) as a semantically empty pronoun without type and meaning. On this view, the DS of sentence (11) is:

Given that PRO has no meaning, it cannot be interpreted in situ and has to be moved. Since the verb requires a temporal argument, we obtain the structure:

At LF, PRO is deleted by the principle of full interpretation. The movement index i is interpreted as λ_i , and we derive the temporal abstract:

This structure can be modified by the operator P^* , and we get:

The important point is that semantic operators like P^* are not pronounced but transmit features under binding, here the feature uP , which determines the pronunciation of the verb *call* as a past form.

We write the origin of the feature P as iP ('interpretable past'). The landing site, i.e., the morphological function of the feature, is written as uP ('uninterpretable past').

When the main verb is non-finite, as in the perfect and future constructions, the verb itself has no inherent tense feature, but it still inherits a feature via the auxiliary, which in the case of *has called* and *will call* is a present tense feature. The temporal auxiliaries *has* and *will* are so-called verbal quantifiers in the theory of (Grønn and von Stechow, 2010). They change the reference time of the main verb, but also come with their own morphology, which must be licensed by a higher semantic

tense N. When *has* and *will* transmit their present feature to the non-finite verb, we have *feature transmission under semantic binding* (Heim, 1994b, 2005). The inheritance of the feature from the verbal quantifier by the non-finite verb becomes important for further feature transmission into embedded tenses (sequence of tense phenomena), but it does not play any role in ordinary matrix sentences since the feature is not pronounced on the non-finite verb.

11.4 Referential tense

The quantificational, indefinite analysis for the simple past predicts scopal interaction with negation (and also with quantifiers and intensional operators). As we recall from above, Partee's famous example (*I didn't turn off the stove*) challenged the standard Priorian and Montagovian analyses since neither of the two possible scopal relations captures the meaning of the sentence:

- (21) a. $(\exists t \prec s^*) \neg I \text{ turn off the stove at } t$
 b. $\neg(\exists t \prec s^*) I \text{ turn off the stove at } t$

The first statement is trivially true and the second is too strong to be true. Partee's claim was that this example showed that the past could not be an existential quantifier "there is a time before the speech time". Instead, Partee proposed an analogy between tenses and pronouns: "I will argue that the tenses have a range of uses which parallels that of the pronouns, including a contrast between deictic (demonstrative) and anaphoric use, and that this range of uses argues in favour of representing the tenses in terms of variables and not exclusively as sentence operators" (Partee, 1973, p. 601).

Partee presumably had in mind a referential past along the lines of what was later formulated in (Heim, 1994a), with a presuppositional semantics as follows:

- (22) Referential Past
 $[[\text{PAST}_i]]^g$ is only defined if $g(i) \prec s^*$. If defined, $[[\text{PAST}_i]]^g = g(i)$.

We thus get the following LF for Partee's example with PAST_5 being a temporal variable of type i:

(23) $\neg$ I turn off the stove(PAST₅)

Now, what is the meaning of the verb *turn off* above, a so-called achievement predicate? Turning off the stove is a very short event that only takes a moment, so it is unlikely that PAST₅ denotes a particular moment that the speaker has in mind. Rather, PAST₅ refers to a stretch of time, say the two hours before my leaving. Suppose that this is the interval (10 AM, 12 AM). We must say what “I turn off the stove” means when evaluated with respect to this interval, which we call t_5 . Obviously the action cannot take place *at* t_5 , because the length of the event is not 2 hours. So the event must take place *in* t_5 .

This brings us back to aspect. We have to assume that the lexical entry of the verb contains a covert aspectual operator, viz. the perfective. According to this analysis, the sentence actually means:

(24) $\neg(\exists t \subseteq g(5))$ I turn off the stove at t ,
where $g(5) \prec s^*$ & $g(5) = (10 \text{ AM}, 12 \text{ AM})$

Nevertheless, even though we have to slightly extend Partee’s analysis by adding perfective aspect – the inclusion relation $t \subseteq g(5)$, where t is the event time – the Partee problem convinces us that tenses can be anaphoric/definite.

In Partee’s original article, the slogan is that tenses are pronouns. The present tense used deictically is like the indexical 1st person pronoun *I*, while the past tense is an anaphoric or deictic pronoun – a free variable denoting a particular time in the past. An interesting prediction of this approach, noted by Partee herself, is that the English “future”, which is not a semantic tense, but makes use of the time shifting verbal quantifier *will*, should not be anaphoric in nature.

The referential approach was developed in a static framework by (Abusch, 1994; Heim, 1994a; von Stechow, 1995; Kratzer, 1998) and others. However, just as the indefinite tense analysis traditionally attributed to (Prior, 1967) cannot be the whole story, there are also arguments against the presuppositional semantics, i.e., the view that tenses are temporal variables with a presupposition.

One problem is the question of how it would be possible, on the latter approach, to explain obligatory backward-shifting of a past in an intensional context under an attitude verb in non-SOT-languages like Russian (Grønn and von Stechow, 2010, 2012).

(25) Ona [...] sprosila^{PAST,PF}, spal^{PAST,IMPF} li on. (Tolstoy, “Anna

Karenina”).)

She [...] asked him if he had slept. (translation from the RuN parallel corpus)

The backward-shifting remains mysterious with the meaning of past given in (22). We can also have backward-shifting in English with an embedded simple past:

(26) John said that Mary left.

(Kratzer, 1998) assumes for such examples that the past tense is ambiguous between a referential tense and a quantificational relative past, which she calls *perfect aspect*. In Russian, an embedded synthetic future can shift the event time as well:

(27) Ona byla nemnogo prostuzhena i skazala^{PAST,PF}, chto oni segodnja pobudut^{FUT,PF} doma. (Kurkov, “Piknik na ldu”).
She had a bit of a cold, said they would be staying in for the day. (translation from the RuN parallel corpus)

Advocates of a referential theory would have to say that the Russian future is ambiguous between a referential tense and an aspect, say *prospective*. The quantificational approach needs no such ambiguities.

There could be a way out of the dilemma if we were to develop a “mixed” approach, analysing past/future tense as an existential quantifier over *contextually restricted times*. For instance, the Partee example could be analysed as “... at some past time *this morning*” (existential + referential). The anaphoric component can thus be hidden in the domain restriction. We refer the reader to (Bäuerle, 1978; Bäuerle, 1979; Ogihara, 2007; von Stechow, 2009; Altshuler and Schwarzschild, 2013) for further discussion of this possibility. Instead, we will below advocate an ambiguity approach in the tense domain (indefinite vs. definite tense). This is in our view the simplest analysis, where the distinction between quantificational and referential interpretations is directly reflected at the level of logical form (LF).

11.5 Quantification and adverbials

11.5.1 Tense and quantification

We cannot do justice to all the quantificational puzzles that can arise in the semantics of tense. Here we will only mention one example, the Bäuerle-von Stechow Problem, as an illustration.

- (28) a. Yesterday, Mary called exactly once.
b. Yesterday, Mary called exactly 3 times.

Comparison of the two sentences shows that *once* = *at one time*. In the following analysis, both **yesterday**_(it) and **exactly one time**_(it,it) restrict the past reference time:

- (29) $[\text{it}, t \text{ P N}] [\text{it} [\lambda_1 \text{ on yesterday}(t_1)] [\text{it at exactly one time } \lambda_2 \text{ Mary call}(t_2)]]$
 $(\exists t)[t \prec s^* \ \& \ t \subseteq \text{yesterday} \ \& \ (\exists! t')[t' \subseteq t \ \& \ \text{Mary calls at } t']]$
 $(\exists! t')[\alpha(t')]$ means “There is exactly one time satisfying α ”.

The truth-conditions shown are obviously wrong, since they are compatible with a scenario in which Mary also called at a time t ” included in yesterday, but not included in t . This problem has caused a lot of trouble and led many people away from the quantificational analysis of tense. Bäuerle and von Stechow (1980) concluded that past has a predicate meaning $\lambda t.t \prec s^*$. *Mary called* means $\lambda t.t \prec s^* \ \& \ \text{Mary calls at } t$. The quantification is provided by adverbials such as *exactly once* or, in the default case, existential generalisation. Several people have taken up this proposal, e.g., Musan (2002); von Stechow (1995) and occasionally Ogihara.

In the following we will ignore this problem. For more puzzles related to tense and quantification, see (von Stechow, 2002, 2009).

11.5.2 Temporal adverbials

Temporal adverbials are of various kinds, some of which play a crucial role in determining the reference time of the sentence, and sometimes also the temporal centre (i.e., the perspective time at which the subject locates herself). For *yesterday* and PPs like *on my birthday*, sometimes referred to as positional or definite temporal adverbials, there are several alternative, though ultimately perhaps equivalent, analyses in the liter-

ature. Here we will simply assume that these expressions are predicates of times:

- (30) Predicate format of positional temporal adverbials, type (it):
 $[[\text{on my birthday}]] = \lambda t.t \text{ is on my birthday}$

Positional adverbials always restrict tense or some other functor which provides the quantification:

- (31) Mary called on my birthday.
 $[\text{it}, t \text{ P N}] [\text{it } \lambda_1 [[\text{on my birthday } t_1] [\text{Mary } [\text{call } t_1]]]]$

The relevant version of *Predicate Modification* is:

- (32) Let α be a tree of type t with daughters β and γ of type t . Then
 $[[\alpha]] = 1$ iff $[[\beta]] = 1 = [[\gamma]]$.

The interaction between temporal adverbials and tenses is subject to certain pragmatic constraints. As observed by several authors, speech time modification is usually disallowed:

- (33) John leaves at six.
 (*) $\text{N } \lambda_1 [[t_1 \text{ at six}] [\text{John leave } t_1]]$

The sentence can only have a so-called “scheduled reading”, i.e., a special kind of future reading, hence the LF in (33) does not capture the meaning of the sentence. Similarly, in (34), the adverbial modifies the past, not the speech time:

- (34) John left at six.
 $\text{N } \lambda_1 \text{P}(t_1) [[\lambda_2 \text{ at six}(t_2)] [\lambda_3 \text{John leave}(t_3)]]$

Klein invokes a pragmatic principle saying that a definite time (here: the speech time) cannot be further specified (Klein, 1992). We will have more to say about this in connection with the interaction between temporal adverbials and the past perfect. See (40) below.

11.6 The perfect

The analytic perfect construction in Germanic and Romance languages is a rich source of puzzles and idiosyncrasies of various sorts. We will briefly review some of these below.

11.6.1 Present perfect and XN

The so-called Present Perfect Puzzle refers to the fact that positional (definite) past adverbials cannot modify a present perfect in English (or Mainland Scandinavian), but they can in German and French:

- (35) a. Mary called yesterday.
 b. (*) Mary has called yesterday.
 c. ✓ Maria hat gestern angerufen. (German)
 d. ✓ Marie a téléphoné hier. (French)

These facts follow from an extended now (XN) semantics for the English/Scandinavian present perfect – provided that temporal adverbials modify XN – and a relative past semantics for the German/French perfect in combination with an intersective semantics for definite temporal adverbials, cf. (Pancheva and von Stechow, 2004) among others.

- (36) Extended Now (McCoard, 1978), (Dowty, 1979); quantifier type $i(it, t)$
 $[[\text{PERF}_{\text{XN}}]] = \lambda t. \lambda Q. (\exists t') [XN(t', t) \ \& \ Q(t')]$,
 where $[[XN(t', t)]] = 1$ iff t is a final subinterval of t' .

Once more we have to assume an aspect operator⁴ in an eventive framework – this time to solve the Present Perfect Puzzle. We will first show how definite adverbials are compatible with the German variant of (35c). We are assuming the same simple denotation for N in both English and German; this will turn out to be correct here:

- (37) Maria hat gestern angerufen (German)
 $N \ \lambda_1 \text{ PAST}(t_1) [\lambda_2 [[t_2 \text{ on yesterday}]] [\text{PF}(t_2) \ \lambda_3 \text{ Mary called}(e_3)]]]$
 (German)
 $(\exists t)[t \prec s^* \ \& \ t \subseteq \text{yesterday} \ \& \ (\exists e)[\tau(e) \subseteq t \ \& \ \text{Mary call}(e)]]$

However, the same adverbial leads to a contradiction in an XN-configuration as in English:

- (38) $N \ \lambda_1 \text{ PERF}_{\text{XN}}(t_1) [\lambda_2 [[t_2 \text{ on yesterday}]] [\text{PF}(t_2) \ \lambda_3 \text{ Mary called}(e_3)]]]$
 $(\exists t)[XN(t, s^*) \ \& \ t \subseteq \text{yesterday} \ \& \ (\exists e)[\tau(e) \subseteq t \ \& \ \text{Mary call}(e)]]$
 $\Rightarrow s^* \subseteq \text{yesterday}!$

⁴ The standard semantics for perfective aspect, following (Krifka, 1992) and others:
 $[[\text{PF}]] = \lambda Q. \lambda t. (\exists e) [\tau(e) \subseteq t \ \& \ Q(e)]$, where Q is a predicate of events, and $\tau(e)$ is the running time of e . In our framework, the time argument will be the first: $\lambda t. \lambda Q \dots$

We conclude that the combination $N + \text{PAST}$, which we find in German and French, is not available for the English present perfect (probably due to the competition with the simple past). Furthermore, the time adverbial *yesterday* cannot modify the event for type reasons. Note that if the theory referred to event times instead of events, then modification of the event time by *yesterday* would not be blocked.

11.6.2 Past perfect

The past perfect consists of two nested layers of “past”, the backward-shifting lexically expressed by the auxiliary and the past operator licensing the past tense morphology of the auxiliary.⁵ In interaction with the past perfect, temporal adverbials may therefore create an ambiguity:

- (39) Mary had left at six
- a. $[\text{it}, t \text{ P N}] [\text{it} [\text{it} \lambda_1 \text{ at six}(t_1)] [\text{it} \lambda_2 [t [\text{it}, t \text{ have}(t_2)] [\text{it} \lambda_3 \text{ Mary left}(t_3)]]]]$
 $(\exists t \prec s^*) t \text{ at 6 o'clock \& } (\exists t' \prec t) \text{ Mary leaves at } t'$
- b. $[\text{it}, t \text{ P N}] [\text{it} \lambda_1 [t [\text{it}, t \text{ have}(t_1)] [\text{it} [\text{it} \lambda_2 \text{ at six}(t_2)] [\text{it} \lambda_3 \text{ Mary left}(t_3)]]]]$
 $(\exists t \prec s^*)(\exists t' \prec t) t' \text{ at 6 o'clock \& Mary leaves at } t'$

(39a)

is a past-time modification: the leaving is before six. (39b) is a perfect-time or event-time modification, the leaving is at six.

The ambiguity of the past perfect was not attested for the present perfect in English. The present perfect in English is special since it has an XN-semantics, while the past perfect mostly behaves as expected from a compositional point of view, on a par with the present perfect in German. The relative past reading of *had P-ed*, unlike *has P-ed*, is compatible with definite temporal adverbials, as we have just seen. Furthermore, the ban on modification of the higher tense, as we saw in the present perfect, disappears in the English past perfect, where the adverbial can modify either the higher or lower time.

Consider, however, the following contrast:

- (40) a. (*) At six John had left at five.
 b. At six John had left an hour before.

⁵ In addition, the past perfect may have an “XThen” interpretation parallel to XN in the present perfect.

- c. (*) At seven John had left at five. 1
 d. At seven John had left an hour before. 2

The first example in (40a) illustrates Klein's prohibition of double temporal specification (Klein, 1992). However, in the meta-language (40a) and (40b) would be completely equivalent. An explanation for this phenomenon can be found by comparing the truth-conditions of (40a) and (40c) – again the truth-conditions are the same: $[[(40a)]] = [[(40b)]] = [[(40c)]]$. This is not so for (40b) and (40d) with a topic time contrast, a minimal pair which clearly express different propositions. So, when the highest adverbial does not play any role semantically, as in (40a) and (40c), the construction is pragmatically blocked. 3
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The different distribution of combinations involving the perfect auxiliary in English and German is listed in Table 11.1. 12
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	Present Perfect		Past Perfect	
English	(*)N + PAST	N + XN	PAST(N) + PAST	PAST(N) + XThen
German	N + PAST	N + XN	PAST(N) + PAST	PAST(N) + XThen

Table 11.1 *The interpretation of complex tenses*

Thus, in German, every perfect is ambiguous. While German allows any combination of a tense and a perfect relation, English does not have the combination N + PAST. 14
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Recall from the introduction that the past perfect, interpreted with the admissible combination PAST + PAST, is typically used with an anaphoric higher tense (the temporal centre for the lower tense). Thus, example (39) above will, when used in a discourse, contain the information $t \prec s^*$ & $(\exists t' \prec t)$. The underlined part is a presupposition, a standard case of cross-sentential temporal anaphora. We cannot express this straightforwardly in a static framework. We will turn to this issue in the following sections. 17
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11.7 (In)definite tense 25

Both the quantificational approach to tense and the alternative referential approach have their weaknesses. There is no simple way of treating temporal anaphora in the quantificational approach. 26
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- (41) John came home at 12. Mary was asleep (then). 29

The referential approach can have the same temporal variable (or the same deictic tense) in both sentences. A drawback of the referential approach, though, is that it cannot account for backward-shifting in embedded contexts, e.g. in complement clauses. At least non-SOT-languages like Russian (cf. (25) above) and Japanese need quantificational tenses. For more discussion of this question, see (von Stechow and Grønn, 2013a,b) and (Sharvit, 2014).

We believe that any theory of tense that is able to overcome the disadvantages of the two approaches mentioned must be a dynamic one. The following system is an intensional version close to other dynamic systems, such as the ones proposed in (Muskens, 1996) and (Beaver, 2001). The applications will be focused on tense (and aspect). An alternative dynamic system with a similar focus as ours is (Bary, 2009).

The main claim is that an indefinite tense introduces a new temporal discourse marker, while a definite tense is anaphoric to an old dm, presupposing its descriptive content, i.e., the temporal relation. To implement this idea, we will treat tenses and aspects as purely relational, with a covert indefinite or definite article on top.

Many languages (e.g. Russian) have no overt $[\pm\text{def}]$ marking in the nominal domain. NPs in such languages are then ambiguous with respect to $[\pm\text{def}]$. Since we find ambiguity in the nominal domain, we should not be surprised to find it in other domains as well. By loosening the correspondence between (in)definiteness and article morphology, we discover that the ambiguity is found not only in the temporal domain, but also in the event domain (e.g., aspect in Russian, cf. Section 11.10).

11.7.1 The $[\pm\text{def}]$ -ambiguity of tense

One of the motivations for the development of dynamic approaches in the 1980s was the analysis of donkey anaphora in the nominal domain. We note that similar cases can also involve tense, as in the following temporal donkey sentence:

- (42) When a farmer had a donkey, the farmer usually beat the donkey.

The past tense in the antecedent should be an indefinite term (like *a farmer/a donkey*), but the past tense in the consequent must be a definite term (like *the farmer/the donkey*). A similar observation was also

made in (Partee, 1984, 268ff.). The following paraphrase illustrates the intended interpretation of donkey tense:

- (43) Usually, when a farmer had a donkey at some past time, the farmer beat the donkey at that past time.

By treating the simple past as ambiguous between an indefinite and a definite tense, contra McCoard (1978) who claims that the simple past is only definite, we can explain a lot of thorny data.

11.7.2 The $[\pm\text{def}]$ -ambiguity and the perfect

The perfect is a shifter – a relative past – and therefore indefinite, though it typically contains a definite temporal centre, cf. (2), repeated below:

- (44) John left at 11. He had arrived yesterday.

In the style of Heim’s dissertation (Heim, 1982), we want to say, starting from the first sentence, that a new temporal discourse marker 1_i (i = indefinite) is before now and that John leaves at t_1 (bound variables are always definite), which is at 11. For the second sentence, we intuitively want to pick up the old discourse marker 1_d (d = definite). This time is presupposed to be a past time (before now), and it serves as the temporal centre (perspective time) in a temporal relation with a new discourse marker 2_i , such that $t_2 \prec t_1$ and t_2 is the time of John’s arrival yesterday.

11.7.3 A uniform type for $\pm\text{def}$

Definites, like pronouns, are commonly analysed as referring terms with contextually dependent anaphoric and deictic uses, while indefinites are existential quantifiers. This view stipulates differences between definites and indefinites along three dimensions: semantic type, uniqueness, and presuppositionality (Heim, 2011). Since the (in)definite article is covert in the tense domain, we want tenses to have a uniform type. In fact, we will propose below a uniform semantic type for definites and indefinites across all domains.

We will adopt the idea from Heim’s dissertation, where definites, just like pronouns, carry an old index at LF. However, our implementation will be different, since both indefinites and definites will have the format of dynamic generalised quantifiers, cf. (Muskens, 1996; Beaver, 2001).

The restriction of the quantifier in the temporal domain will contain at least the temporal relation contributed by tense proper ($\prec$, $\succ$). In the case of definites, the restriction will be entirely presupposed.

11.7.4 Tense architecture

In the system to be developed in what follows, we have deictic tenses and relational tenses, i.e., two-place predicates of times. These are constants which have the same denotation in every model (we will adapt these meanings to the dynamic framework in section 11.8 below):

(45) Deictic tenses

$$F(N) = s^*$$

$$F(PAST^*) = \{t \mid t \prec s^*\}$$

(46) Relational tenses

$$F(PAST) = \{ \langle t, t' \rangle \mid t \prec t' \} = F(\text{have})$$

$$F(FUT) = \{ \langle t, t' \rangle \mid t \succ t' \} = F(\text{will})$$

$$F(XN) = \{ \langle t, t' \rangle \mid t' \text{ is a final subinterval of } t \} = F(\text{has})$$

We distinguish between the temporal relation and the temporal centre. The T-centres are N (a deictic pronoun), Tpro (a definite dm), TPRO (a semantically void pronoun that will create a temporal abstract). The T-centre is obligatory, while the T-relation is optional. This is the theory we have defended in several recent papers (Grønn and von Stechow, 2010, 2012; von Stechow and Grønn, 2013a,b).

To this system we add a covert indefinite or definite article. If the article introduces a new discourse marker, then the tense will be a shifter; if the discourse marker is old, the tense is anaphoric.

We thereby eventually arrive at the tense architecture shown in Figure 11.1.

On this view, most tenses are not simply pronominal as in (Partee, 1973), but rather are relations between two times, of which only one is a pro-form.

11.7.5 A note on temporal modification

In our system, tenses are definite or indefinite terms which have the format of (dynamic) generalised quantifiers. In the nominal domain, the restriction and nucleus of a generalised quantifier can easily be modified

Figure 11.1 Tense architecture

by intersective adjectives, relative clauses etc. We think that there are similar devices in the temporal domain as well.

In (von Stechow and Grønn, 2013b) we give an intersective analysis of *when* adjuncts as temporal relative clauses. Information structure determines whether the *when* clause is part of the restrictor or nucleus of the matrix temporal quantifier, as in the following examples with indefinite tense:

- (47) a. When I was young, I read “War and Peace”. (the topicalised *when* clause is a free relative clause in the restrictor of the indefinite article)
- b. I read “War and Peace” when I was young. (*when* clause in the nucleus of the indefinite article)

Which combinations of temporal modifiers and tenses are possible, is, of course, an empirical question, but it is clear that the system needs a lot of flexibility. For instance, the following past perfect (*had left*) should arguably be decomposed into two indefinite past tenses:

- (48) a. John’s wife had already left, when he came to the party.
- b. There is a time at which John’s wife leaves (and this time is) before a past time at which John comes to the party.

The temporal centre of the past perfect is not a definite anaphoric tense in this case, but an indefinite past modified by a *when* clause.

11.8 (In)definite operators in a dynamic framework

Our dynamic framework is presented in the appendix, written in telegram style for those who are interested in the formalisation of the system. An easier way out would be to make the points below informally in the DRT-style of (Partee, 1984).

11.8.1 Indefinites

Given the framework outlined in the appendix, we can introduce the indefinite operator **ind** which serves not only in the formalisation of the indefinite article in English, but also in the covert indefinite article above tense and aspect. The operator **ind** introduces d as a new dm and updates the context with the restriction $P(d)$ and the nucleus $Q(d)$, formally:

- (49) The indefinite operator **ind**, type $d((d,cc),((d,cc),cc))$
 $F(\mathbf{ind}) = \lambda d.\lambda P.\lambda Q.\lambda c: d \notin \text{dom}(c). \{ \langle f, w \rangle \mid \exists g \in c: g \subseteq f \ \& \ d \in \text{dom}(f) \ \& \ \langle f, w \rangle \in (([c \text{ add } d] + P(d)) + Q(d)) \}$

This is the typed version of Heim's semantics for indefinites. To understand the definition, we have to introduce Beaver's add-operator. What 'c add d' says is that we make the d -assignments in c a bit bigger: we enlarge their domain by the discourse marker d , where d may have any value. We have to carry out this trivial modification of the context, since $c + P(d)$ might be undefined if d is new.

- (50) Beaver's add-operator
 $c \text{ add } d = \{ \langle f, w \rangle \mid (\exists g \in c) g \subseteq_d f \ \& \ \langle g, w \rangle \in c \}$
 [i.e., f is an incrementation of g by adding d to the domain of g]

Let us consider the following example with an indefinite deictic forward shifter in the temporal domain:

- (51) It will rain.
 $\text{ind}^5 \text{ WILL}^* \text{ RAIN}$
 There is a time $f(5)$ after now and it rains at $f(5)$

5 stands for the dm 5_{di} . This sentence doesn't contain variables. Formally, the context change potential (CCP) of the entire sentence is therefore:

$$(52) \quad \lambda c: 5 \notin \text{dom}(c). \{ \langle f, w \rangle \mid \exists g \in c: g \subseteq f \ \& \ 5 \in \text{dom}(f) \ \& \ f(5) \succ N \ \& \ f(5) \in F(\text{rain})(w) \}$$

11.8.2 Definites

The definite article picks up a familiar dm, i.e., one that is in the domain of the local context. Furthermore, the entire restriction must be entailed by the context, i.e., it is presupposed. To make this precise, we first say what it means for a CCP to be entailed by a context. The relevant notion is defined by means of Beaver's $\downarrow$ -operator, which we explain below.

Heim defines entailment in this sense by saying that c entails p iff $c + p = c$. The intuition is that an entailed CCP doesn't add any new information to the context when the sentence is uttered, hence the context remains the same. However, this doesn't work for indefinites because indefinites add new dms to the context, so after the update the context is different.

Beaver has found a method that works for indefinites. The crucial ingredient is the $\downarrow$ -operator which is defined thus:⁶

$$(53) \quad c + \downarrow p = \{ \langle f, w \rangle \in c \mid \exists g: f \subseteq g \ \& \ \langle g, w \rangle \in c + p \}$$

$$(54) \quad \text{Entailment} \\ c \models p \text{ iff } c + \downarrow p = c.$$

Therefore the definite operator can be defined as in (55). Presuppositions are written with the notation '·'.

$$(55) \quad \text{The } \mathbf{def}\text{-operator} \quad \text{type } d((d, cc), ((d, cc), cc)) \\ F(\mathbf{def}) = \lambda d. \lambda P. \lambda Q. \lambda c: c \models P(d). \{ \langle f, w \rangle \in c \mid (\exists g \in c) g \subseteq f \ \& \ \langle f, w \rangle \in c + Q(d) \}$$

So the definite article presupposes its entire restriction, and only the nuclear scope can introduce new information. However, if P merely amounts

⁶ The motivation behind the definition of entailment by means of the $\downarrow$ -operator is this:

Suppose we update a context c by uttering the sentence A^1 *farmer has a² donkey*. The semantics of the indefinite article requires that we add a new dm for the indefinite articles, say 1 and 2.

The new context created by this utterance is c_1 . This context should entail the CCP A *farmer has a donkey*, because we have just said that. If we add something that has already been said, e.g., A^3 *farmer has a⁴ donkey*, we don't change the information contained in the context c_1 . Beaver's definition of entailment takes care of this situation because the $\downarrow$ -operator is purely eliminative and doesn't add any new dms to the context.

to the tense relation proper (e.g., $\prec$), then the presupposition can be rather weak, since there may be several indefinite past tenses in the prior context.

As we noted above in section 11.7.5, *when* clauses, temporal PPs etc. may be added to the restriction of both **ind** and **def**. In the latter case, to avoid ambiguity, the speaker should make the restriction of the definite as informative as possible, following the pragmatic principle: maximise presuppositions! This will help the hearer to find the correct antecedent.

It should be noted that **ind** and **def**, despite their semantic type, are not genuine quantifiers (like EVERY, which is not treated here), because the result of applying either of them is still an open sentence. In truth-conditional terms, the dm introduced/picked up by the article is a constant and ultimately a free variable in some sense. The result of an update is always an open proposition.

11.9 Analysis of tense in a typed dynamic system

We now have to introduce temporal arguments for dynamic predicates. By convention, the temporal argument will always be the first one after the world argument, which is implicit.

$$(56) \quad F(\text{SLEEP}) = \lambda d_{di}. \lambda d'_{de}. \lambda c: d_{di}, d'_{de} \in \text{dom}(c). \{ \langle f, w \rangle \in c \mid F(\text{sleep})(w)(f(d_{di}))(f(d'_{de})) = 1 \}$$

We assume that verbs, adjectives, prepositions and tenses have temporal arguments.

(57) Tenses

Present: N is a distinguished dm of type di.

PAST and FUT: type (di, (di, cc))

$$F(\text{PAST}) = \lambda d_{di}. \lambda d'_{di}. \lambda c: d, d' \in \text{dom}(c). \{ \langle f, w \rangle \in c \mid \langle f(d') \prec f(d) \rangle \}$$

$$F(\text{FUT}) = \lambda d_{di}. \lambda d'_{di}. \lambda c: d, d' \in \text{dom}(c). \{ \langle f, w \rangle \in c \mid \langle f(d') \succ f(d) \rangle \}$$

Thus, tenses are purely relational and must be combined either with the indefinite or the definite article. In the first case, they introduce a new reference time, while in the second case they are anaphoric. Let's see how this works on a concrete example (from German in order to avoid interference with aspect):

- (58) Alla schlief. Sie trdumte. 1
 $\text{ind}^1 \text{PAST}(\text{N}) [\lambda_2 [\text{def}^3 \text{ALLA} [\lambda_5 \text{SLEPT}(t_2)(t_5)]]]$ 2
 $\text{def}^1 \text{PAST}(\text{N}) [\lambda_4 \text{DREAMT}(t_4)(\text{SHE}_3)]$ 3

The first PAST is indefinite. It introduces a new reference time at which Alla was asleep (proper names like ‘‘Alla’’ are treated as definites). The second PAST is definite. The sentence does not mean that Alla was dreaming at some time or other – it means that Alla was dreaming at the first time. Here is an account of the CCP. 4
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- (59) $c_0 + \text{ind}^1 \text{PAST}(\text{N}) \lambda_2 \text{def}^3 \text{ALLA} \lambda_5 \text{SLEPT}(t_2)(t_5)$ is only 9
defined if $1 \notin \text{dom}(c_0)$, $\text{N}, 3 \in \text{dom}(c_0)$. If defined, the result is 10
 $\{ \langle f, w \rangle \mid \exists g \in c_0: g \subseteq_1 f \ \& \ f(1) \prec f(\text{N}) \ \& \ f(3) = \text{Alla} \ \& \ f(3)$ 11
sleeps at $f(1)$ in $w \} = c_1$ 12
 $c_1 + \text{def}^1 \text{PAST}(\text{N}) \lambda_4 \text{DREAMT}(t_4)(\text{SHE}_3)$ is only defined if 13
 $c_1 \models \text{PAST}(\text{N})(1)$. This is given. So we have to calculate 14
 $c_1 + \text{DREAMT}(1)(\text{SHE}_3)$, which is only defined if $1, 3 \in \text{dom}(c_1)$, 15
which is the case. 16
So the result is $\{ \langle f, w \rangle \in c_1 \mid f(3) \text{ dreams at } f(1) \text{ in } w \}$. 17

Next, let’s analyse an example involving the past perfect, which is typically used anaphorically. 18
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- (60) Mary arrived at 6 AM. John had left. 20
 $\text{ind}^1 \text{PAST}(\text{N}) [\lambda_2 [\text{def}^3 \text{MARY} [\lambda_9 [\text{AT } 6(t_2) \ \& \ \text{ARRIVE}(t_2)(t_9)]]]]]$ 21
 $\text{def}^1 \text{PAST}(\text{N}) [\lambda_4 [\text{ind}^5 \text{HAVE}(t_4) [\lambda_6 [\text{def}^7 \text{JOHN} [\lambda_8 \text{LEFT}(t_6)(t_8)]]]]]]]$ 22

The text means that Mary left at 6 AM, and John had left before that time. So the past perfect introduces a new past (event) time, whose temporal centre is anaphoric to a given past time. The HAVE in the second sentence is synonymous with a relative PAST. Temporal adverbials (‘‘at 6 AM’’) are analysed as syntactic adjuncts which semantically combine with the VP through PM. 23
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- (61) $[[\text{AT } 6 \text{ AM}]] = \lambda d_{di}. \lambda c: d \in \text{dom}(c). \{ \langle f, w \rangle \in c \mid f(d) \text{ is at } 6 \text{ AM} \}$ 29
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The reader may check for herself that the effect of this text on a context c , the domain of which contains 3_{de} and 7_{de} , is as follows: 31
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- (62) $\{ \langle f, w \rangle \mid \exists g \in c: g \subseteq_{1,5} f \ \& \ f(1) \prec f(\text{N}) \ \& \ f(1) \text{ is at } 6 \text{ AM} \ \& \$ 33

$f(3) = \text{Mary} \ \& \ f(3) \text{ arrives at } f(1) \text{ in } w \ \& \ f(5) \prec f(1) \ \& \ f(7) =$
 $\text{John} \ \& \ f(7) \text{ leaves at } f(5) \text{ in } w\}$

Here is our analysis of the anaphoric PAST in Partee's example:

- (63) I left home at 11. I didn't turn off the stove (*at that time in the past*).
 $\text{ind}^1 \text{ PAST}(N) [\lambda_3 [\text{AT } 11(t_3) \ \& \ \text{LEFT}(t_3)(I)]]$. ($= p$)
 $\text{NOT} [\text{def}^1 \text{ PAST}(N) [\lambda_2 \text{ TURN-OFF-THE-STOVE}(t_2)(I)]]$ ($= q$)

The standard dynamic semantics for $\text{NOT}_{(\pi, \pi)}$ is as follows:

- (64) Negation. $F(\text{NOT}) =$
 $\lambda p_{\pi}. \lambda c: c + p \text{ is defined. } \{ \langle f, w \rangle \in c \mid \neg(\exists g) f \subseteq g \ \& \ \langle g, w \rangle \in c + p \}$

Here is the calculation for the example.

- (65) $c_0 + p = \{ \langle f, w \rangle \mid \exists g \in c_0: g \subseteq_1 f \ \& \ f(1) \prec f(N) \ \& \ f(1) \text{ at } 11 \ \& \ I \text{ leave at } f(1) \text{ in } w \} = c_1$
 $c_1 + q = \{ \langle f, w \rangle \in c_1 \mid \neg(\exists g) f \subseteq g \ \& \ g(I) \text{ turn-off-the-stove at } g(1) \}$
 $= \{ \langle f, w \rangle \mid (\exists g) g \subseteq_1 f \ \& \ f(1) \prec f(N) \ \& \ f(1) \text{ at } 11 \ \& \ I \text{ leave at } f(1) \text{ in } w \ \& \ \neg I \text{ turn-off-the-stove at } f(1) \}$

This is the reading Partee had in mind. Since the entire definite tense is presupposed, we get rid of the scope interaction with the negation without giving up the relational semantics of the deictic PAST, viz. that the reference time is before the speech time.

In the next section we will show that the application of the definite/indefinite distinction to the temporal domain is a general phenomenon which concerns not only times, but also events.

11.10 Integrating (in)definite aspect

For simplicity we have chosen to mostly leave aspect and events out of the analysis above. We will now show that we can introduce aspect without having to modify the principles underlying the theory.

Let's illustrate how aspect fits into the picture with a classical example of event anaphora from Russian:

(66) Anaphoric use of the Imperfective

V Āltoj porternoj ja napisal^{PF,PAST} pervoe ljubovnoe
 In this tavern I wrote^{PF,PAST} first love
 pis'mo Vere. Pisal^{IPF,PAST} [karndashom]_F.
 letter to-Vera. I-wrote^{IPF,PAST} [with-pencil]_F.
 'In this tavern I wrote my first love letter to Vera. I wrote
 it with a pencil.' (Chekhov)

(Grønn, 2004) defends the view that the Russian imperfective is ambiguous. Its core meaning is that the event time includes the reference time, but it can also mean the same as the perfective, viz. that the event time is included in the reference time. The same thing happens when an imperfective mentions a previous event, as in (66).

Aspect localises the event time with respect to the reference time; see (Klein, 1994). This means that we have to change the entries for verbs, so that instead of the time argument, they have an event argument. The combination with tense is mediated by aspect, so the entry for WRITE is as shown in (67), where we are using the notation *e* for dms of type *dv*.

$$(67) \quad F(\text{WRITE}) = \lambda e_{dv} . \lambda d_{de} . \lambda d'_{de} . \lambda c : e, d, d' \in \text{dom}(c). \\ \{ \langle f, w \rangle \in c \mid F(\text{write})(f(e))(f(d))(f(d')) = 1 \}$$

The semantic aspects are now purely relational, just like tense:

(68) Dynamic Aspects: type $di(dv, cc)$

a. Dynamic Perfective:

$$F(\text{PF}) = \lambda d_{di} . \lambda e_{dv} . \lambda c : d, e \in \text{dom}(c). \{ \langle f, w \rangle \in c \mid \tau(f(e)) \subseteq f(d) \}$$

b. Dynamic Imperfective:

$$F(\text{IPF}) = \lambda d_{di} . \lambda e_{dv} . \lambda c : d, e \in \text{dom}(c). \{ \langle f, w \rangle \in c \mid f(d) \subseteq \tau(f(e)) \}$$

Compare these entries for aspect with the traditional ones in Footnote ⁴ above.

As with tense, our new aspects are indefinite or definite. An indefinite aspect introduces a new event, a definite aspect is anaphoric to an old event. The “fake” Russian imperfective in (66) is a morphological imperfective that can be interpreted as an anaphoric perfective.

Usually, a semantic perfective marks its verb with the [pf] feature. But when the aspect is definite, the aspect can be neutralised, and instead

the unmarked aspectual feature is assigned to the verb. As a result, we get a semantic perfective and an unmarked imperfective verb form.

Here is an account of the Russian example, which for the sake of simplicity is analysed as if it were English. The past tense originates as the first argument of PF. It has to be QRed for type reasons.

$$(69) \quad \text{ind}^1 \text{ PAST}(\text{N}) [\lambda_6 [\text{ind}^2 \text{ PF}(\text{t}_6) [\lambda_3 [\text{A}^4 \text{ LETTER} [\lambda_5 \text{ WROTE}(\text{e}_3)(\text{x}_5)(\text{I})]]]]]. \\ \text{def}^1 \text{ PAST}(\text{N}) [\lambda_{10} [\text{def}^2 [[\lambda_{11} \text{ PF}(\text{t}_{10})(\text{e}_{11})] [\lambda_7 \text{ WROTE}(\text{e}_7)(\text{it}_4)(\text{I})]] \\ [\lambda_8 [\text{A}^9 \text{ PENCIL} [\lambda_{12} \text{ WITH}(\text{e}_8)(\text{x}_{12})]]]]]]]$$

It is revealing to see that everything that is indefinite in the first sentence is definite in the second one. An Aspect Neutralisation Rule ensures that the definite PF-operator can license the feature [u-ipf], even though it is a semantic perfective.⁷ The second aspect operator could not be a semantic imperfective because one and the same event cannot be both complete and incomplete. It follows logically that the second aspect feature cannot be semantically interpreted.

The meaning of the text is therefore:

$$(70) \quad c + (69) \text{ is only defined if } 1, 2, 4, 9 \notin \text{dom}(c). \text{ If defined:} \\ c + (69) = \{ \langle f, w \rangle \mid \exists g \in c: g \subseteq f \ \& \ 1, 2, 4, 9 \in \text{dom}(f) \ \& \ f(1) \prec \\ f(\text{N}) \ \& \ \tau(f(2)) \subseteq f(1) \ \& \ \text{letter}_w(f(4)) \ \& \ \text{write}_w(f(2))(f(4))(f(\text{I})) \\ \ \& \ f(2) \text{ with}_w(f(9)) \ \& \ \text{pencil}_w(f(9)) \}$$

This event anaphora example also illustrates the principle “maximise presuppositions!” by making the restriction of **def** as informative as possible. We want to capture the fact that in the second sentence of (66) only the adjunct “with a pencil” is focused and provides new information – hence the writing-predicate, not just the aspectual relation, should be backgrounded and part of the presupposition. To achieve this we must make sure that the definite operator takes the aspectual relation *and* the verbal predicate as its first argument (the restriction). The two

⁷ In examples such as (66), we assume a checking relation from the semantic PF to the uninterpretable imperfective (!) aspect feature of the event argument of the verb, see (Grønn and von Stechow, 2012) for technical details.

Our Aspect Neutralisation Rule says that *definite aspects are neutralised with respect to their morphological feature*. Whether a language adheres or not to this rule is an important factor in the division of labor between morphological aspects in Slavic languages. In Russian, perfective morphology is typically used for indefinite complete events (e.g. in narrative progression), while definite aspects – and imperfective morphological aspect – are never used in cases of narrative progression. West Slavic languages, on the other hand, apparently do not have this rule and the unmarked imperfective is accordingly not used with definite aspect but may occur in contexts of narrative progression.

properties of events are then combined by predicate modification. Only the adjunct “with a pencil”, which is also a dynamic event property, is left in the nucleus of the definite article.

11.11 Conclusion

Do we need a dynamic framework for temporal anaphora? A static framework would have to represent the arguments of tenses by free variables that are existentially bound on the text level. We would still need the $[\pm\text{def}]$ -distinction to make sure that indefinite variables are new, while definite ones are old. We would have to make sure syntactically that indefinite variables in the scope of negation or other operators are not used later in the text. Furthermore, we would need a fourth kind of free variables in order to represent deictic words, which would not be bound at the text level. It is clear that the restrictions on co-indexing will be very difficult to formulate. Therefore Occam’s razor says that the dynamic framework is the better framework for the analysis of temporality.

Appendix: A dynamic framework

The system consists of two parts, one static and one dynamic, with the latter building on the former. The static part is here mainly used for making clear the status of discourse markers that are not interpreted by the outer assignment a , but by the inner assignment f . So our system has dms as constants in the static part. There are also variables for dms that are interpreted by the outer assignment a .

We introduce d (shorthand for de , di or dv) as the type of discourse markers (dm) and π as the type of context change potentials (CCP). Predicates of type $d\pi$ are called *dynamic predicates*. With Beaver (2001) we assume that for each dynamic predicate, e.g. $[\text{RAIN}_{di\pi}]$, there is a unique first order *static predicate* (here of type it), i.e., we have a corresponding static expression written in small letters: $[\text{rain}_{it}]$.

We can also have dynamic λ -abstracts:

$$(71) \quad [\pi \ [N_{di} \ [_{di\pi} \ \lambda\nu \ [\text{RAIN} \ \nu]]]] \text{ (“it rains”)}$$

Apart from type differences, dynamic expressions look virtually the same

as their static counterparts, and we can use almost everything we know from Montague Grammar. However, these expressions have a different interpretation, as we will see.

Syntax

For the syntax of the dynamic system we only need expressions of the types d and π and the rule that combines two types a and b to (ab) . d and π might therefore be regarded as basic. But for the interpretation it is more perspicuous to decompose π . These are the types we use:

(72) Types

Basic: e (individuals), i (times), v (events), de (dms for ordinary individuals), di (dms for times), dv (dms for events), t (truth-value).⁸

Complex: If a and b are types, (ab) is a type. If a is a type (wa) and (ga) are types.

Intuitively, w is the type of worlds and g is the type of dm-assignments. These types are in some sense intensional. They are not basic but always form functions. We use the following abbreviations: $c := (g(wt))$ (type of contexts, information states), $\pi := (cc)$ (type of CCPs).

The lexicon of the language consists of a set of constants and a set of variables for any type a . The dms are constants. Thus the lexicon is $\cup_{a \in Type} Con_a \cup \cup_{a \in Type} Var_a$. We assume that there are no constants of type g or w in the lexicon. Thus the language is intensional.

(73) Syntax

Con. If α is a constant of type a , α is an expression of type a .

Var. If x is a variable of type a , x is an expression of type a .

FA. If α is an expression of type ab and β is an expression of type a , then $\alpha(\beta)$ is an expression of type b .

PM. If α and β are expressions of type (at) or $(d\pi)$, then $[\alpha \beta]$ is an expression of the same type, where d stands for de , di or dv .

Abstraction. If x is a variable of type a and α is an expression of type b , then $[\lambda x \alpha]$ is an expression of type (ab) .

⁸ Sometimes we ignore the sortal distinction between de , di and dv and simply write d for the basic type of discourse markers.

The rule FA is the combination of a functor and an argument, i.e., Functional Application. PM is what Heim and Kratzer (1998) call Predicate Modification.

Semantics

The interpretation function for the language is based on a familiar intensional model

- (74) $M = (E, I, V, DM_e, DM_i, DM_v, W, N, \dots F)$
 where E, I, V are sets of individuals, times and events, respectively, and DM_e, DM_i, DM_v are sets of discourse markers for individuals, times and events, respectively. N is a distinguished time (the speech time). F interprets the constants.

Next we define the semantic domains for each type. Let DM be $D_{de} \cup D_{di} \cup D_{dv}$.

- (75) Semantic domains
 $D_e = E, D_i = I, D_v = V, D_{de} = DM_e, D_{di} = DM_i, D_{dv} = DM_v,$
 $D_w = W$
 $D_g = \{f \mid f \text{ is a partial function from } DM \text{ into } E \cup I \cup V \text{ that respects the types}\}$
 $D_{(ab)} = \{f \mid f \text{ is a partial function from } D_a \text{ into } D_b\}$
 F interprets the predicates by assigning them appropriate intensions.

All the functional domains are partial. It follows from the definition that $D_c = D_{(g(wt))} =$ sets of $\langle f, w \rangle$ pairs. Similarly, $D_\pi = D_{cc}$ i.e. the partial functions from D_c into D_c .

The functions in D_g are called *d-assignments*. All the d-assignments in a context c have the same domain. The variables used by these assignments are denoted as $\text{dom}(c)$. The worlds used in a context c are called the proposition of c .

- (76) Where c is a context:
 a. $f \in c := \exists w \langle f, w \rangle \in c$
 b. $\text{dom}(c) = \cup_{f \in c} \text{dom}(f)$
 c. $\text{Prop}(c) = \{w \mid \exists f \langle f, w \rangle \in c\}$

- (77) Truth
 A context c is true in a world w if $w \in \text{Prop}(c)$.

The interpretation function for our language depends on a model M and an outer variable assignment a . We use the usual conventions, i.e., $a[x/u]$ is that assignment a' that is like a except for the variable x , which is mapped to u . Variable assignments must not be confused with dm-assignments, which may be thought of as Kamp's embedding functions (here: inner variable assignments). We use the $+$ -notation of (Heim, 1982) (Heim, 1983), i.e., if p is a CCP and c is a context, then $c + p$ stands for $p(c)$. Since p is a partial function, the application might be undefined. The admissibility condition for p is what is called the presupposition of p .

The semantics of the language is defined below:

- (78) Definition of $[[\dots]]^{M,a}$
- Con. If α is a constant of type b , $[[\alpha]]^{M,a} = F(\alpha)$ [an intension].
 - Var. If x is a variable of type b , $[[x]]^{M,a} = a(x)$.
 - FA. If α is an expression of type ab and β is an expression of type a ,
 $[[\alpha(\beta)]]^{M,a} = [[\alpha]]^{M,a}([[\beta]]^{M,a})$.
 - PM. If P and Q are expressions of type $(d\pi)$,
then $[[[P Q]]]^{M,a} = \lambda d \in D_d. \lambda c: d \in \text{dom}(c). \{ \langle f, w \rangle \mid (\exists g \in c) g \subseteq f \ \& \ \langle f, w \rangle \in ((c + [[P]]^{M,a}(d)) + [[Q]]^{M,a}(d)) \}$
[not an intersective “and”; but a dynamic “and”].
 - Abstraction. If x is a variable of type b and α is an expression of type c , then $[[[\lambda x \alpha]]]^{M,a} = \lambda u \in D_b. [[\alpha]]^{M,a[x/u]}$.

Dynamic predication

Let us illustrate the system by going through the evaluation of the sentence “he₃ sleeps”, ignoring tense.

(79) $\text{SLEEP}_{de,\pi} (3_{de})$

Since the expression doesn't contain a variable, the evaluation doesn't depend on the outer variable assignment a . Recall that the dm 3_{de} is a constant. Therefore:

(80)
$$\begin{aligned} & [[\text{SLEEP}_{de,\pi} (3_{de})]]^M \\ &= [[\text{SLEEP}_{de,\pi}]]^M([[\text{SLEEP}_{de,\pi}]]^M) \quad (\text{by FA}) \\ &= F(\text{SLEEP}_{de,\pi})(F(3_{de})) \end{aligned}$$

The result should be a CCP. In order to know which CCP it is, one has to look at the interpretation of SLEEP by F. Recall that we assume with Beaver that SLEEP uniquely determines a corresponding static predicate of type (et) written in small letters, here **sleep**. The correspondence is given by the following meaning postulate (Beaver's MP8):

(81) MP8 (Beaver, 2001, 178)

Let M be a model and let P be a dynamic predicate constant of type (d, cc). Then there is static predicate constant V of type (et) such that for every dm d: $F(P)(d) = \lambda c: d \in \text{dom}(c). \{ \langle f, w \rangle \in c \mid f(d) \in F(V)(w) \}$

MP8 links dynamic predicates with static ones. Since $F(\text{sleep}_{et})$ is an intension, $F(\text{sleep})(w)$ is an extension. If d is a dm of type de, then $f(d)$ will be an individual that has to be in the set of the sleepers in w. Beaver's postulate MP8 can be generalised in an obvious way to n-place dynamic predicates. Applied to the meaning of $F(\text{SLEEP})$, the postulate gives us the following:

(82) $F(\text{SLEEP}_{(de,cc)}) = \lambda d \in D_{de}. \lambda c \in D_c: d \in \text{dom}(c). \{ \langle f, w \rangle \in c \mid f(d) \in F(\text{sleep}_{et})(w) \}$

Suppose $F(3_{de}) = 3_{de}$, then we have:

(83) $F(\text{SLEEP}_{de,\pi})(F(3_{de})) = F(\text{SLEEP}_{de,\pi})(3_{de})$
 $= \lambda d \in D_{de}. \lambda c \in D_c: d \in \text{dom}(c). \{ \langle f, w \rangle \in c \mid f(d) \in F(\text{sleep}_{et})(w) \} (3_{de})$
 (by F and MP8)
 $= \lambda c \in D_c: 3_{de} \in \text{dom}(c). \{ \langle f, w \rangle \in c \mid f(3_{de}) \in F(\text{sleep}_{et})(w) \}$
 (λ -conversion)

We add the definition of truth in a context.

(84) Let c be a context, w a world and p a CCP. Then p is true with respect to w and c if $w \in \text{Prop}(c + p)$. (i.e., iff $f(3_{de})$ sleeps in w.)

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