

TENSES AS ANAPHORA*

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Abstract

A proposal to deal with French tenses in the framework of Discourse Representation Theory is presented, as it has been implemented for a fragment at the IMS. It is based on the theory of tenses of H. Kamp and Ch. Rohrer.

Instead of using operators to express the meaning of the tenses the Reichenbachian point of view is adopted and refined such that the impact of the tenses with respect to the meaning of the text is understood as contribution to the integration of the events of a sentence in the event structure of the preceding text. Thereby a system of relevant times provided by the preceding text and by the temporal adverbials of the sentence being processed is used. This system consists of one or more *reference times* and *temporal perspective times*, the *speech time* and the *location time*. The special interest of our proposal is to establish a plausible choice of "anchors" for the new event out of the system of relevant times and to update this system of temporal coordinates correctly. The problem of choice is largely neglected in the literature. In opposition to the approach of Kamp and Rohrer the exact meaning of the tenses is fixed by the resolution component and not in the process of syntactic analysis.

1 Introduction

On a Reichenbachian analysis tenses are interpreted as relating three kinds of temporal entities: the time of the event talked about, the speech time (time of utterance) and the refer-

ence time. In the original version these entities are understood as time-points. In the sequel frequently this system was transformed into interval-based approaches to describe the interaction of adverbials, tenses and aspect on sentence level (cf. v.Eynde(1987), Bras/Borillo(1988)) or to describe the course of events on text level (cf. Hinrichs(1986), Partee(1984)¹). A detailed criticism of the Reichenbachian analysis of tenses can be found in Bäumler(1979)). Motivated by text-phenomena the Kamp/Rohrer approach (1983,1985) splits the Reichenbachian reference time into three contextually given parameters by adding *temporal perspective points* and *location times*.

Our approach which is based on the Kamp/Rohrer analysis differs from treatments of the semantics of tenses (and aspects) which characterize the tenses by some simple operator (usually interpreted as a temporal quantifier) in that respect that the tenses are described in terms of their contribution to the problem of how the temporal structure of the events talked about can be constructed. The problem how to determine the times the context has to supply and to which the events have to be related is largely neglected in theoretical discussions of the semantics of tenses. It is the main topic of our discussion. Special attention has been paid to the interaction of tense, aspect and temporal adverbials in determining these relations. The approach represents a unified account of tense and aspects. Another problem dealt with is the problem of tense switch.

We will restrict the discussion to French tenses prevailing in (written) reports about past events (imparfait, passé simple, passé composé, plusqueparfait, conditionnel). The tense system

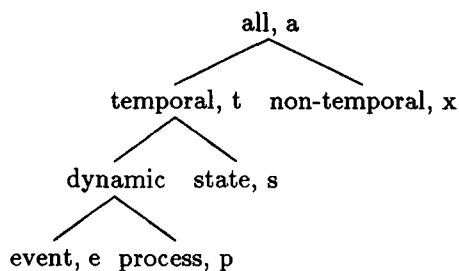
*The research was done in the context of ACORD (ES-PRIT P393) and LILOG, and was also supported by the German Science Foundation (Ro245/13-3)

¹Partee has discussed at length the parallelism between nominal and temporal anaphora. The idea of tenses as anaphora, as developed there, underlies to a certain extent our approach as well.

concerning the past, in contrast to that relating to the present or future time, is rather elaborated, especially in French. A proper theory of tenses has to account for this multiplicity.

2 Representing events in DRT

In the framework of Discourse Representation Theory (DRT) (Kamp(1981)) a Discourse Representation Structure (DRS) is a pair $\langle U, K \rangle$ consisting of a set U of discourse referents (DRFs) and a set K of conditions. Discourse Referents are assumed to be sorted according to the following sort system (for our purposes only the temporal branch is relevant):



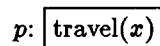
We shall use the indicated letters for DRFs of the corresponding sort². Conditions take the following forms:

1. $P(a_1, \dots, a_n)$, where P is an n -ary predicate symbol and the a_i are discourse referents. Conditions of this form are also called atomic. For 2-place temporal relations we will also use infix notation.
2. $DRS_1 \Rightarrow DRS_2$
3. t : DRS, where t is a temporal DRF

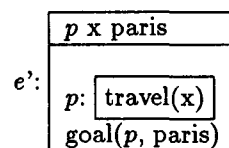
Thus DRT uses a variant of the Davidsonian method of talking about events: they are treated as a kind of objects. But DRT deviates from the Davidsonian representation in that instead of using additional argument places in the predicates

²For simplicity we will use the term *event* not just for the corresponding subsort of dynamic but also for dynamic or temporal objects in general. For the same reason we do not make a clear distinction between "aspect" and "Aktions-arten". The intended meaning should be clear from the context. The classification is related to the one given in Vendler(1967).

an event discourse referent is put before a DRS representing the nature of the event. This allows for a recursive definition of aspects and to account for aspectual change. So the *process* p of x 's travelling would be written in DRT as



and the *event* of x 's travelling to Paris would be written as



DRSs containing conditions as these are embedded into models by mapping the temporal DRFs on objects in a domain of temporal objects. A proper embedding is realized if the value of the event DRF fulfills conditions represented by the sub-DRS which the event introduces with respect to an interpretation function defined among other things on predicates such as *travel* in the example above.

An advantage of this representation on the other hand is that, following the usual definition of accessibility of DRSs from a DRS used in DRT, restrictions on the accessibility of DRFs as possible antecedents for anaphoras can be expressed, though for our purposes this will play only a subordinate role. On the other hand different modes of existence can be discriminated for the objects DRFs stand for, depending on the position of the sub-DRS where these DRFs are introduced, in the DRS of the whole text. In the case of reported speech for instance, the real existence of a reported episode is not necessary. Extensions of the original model theory of DRT (cf. Kamp(1981)) which point in this direction are given e.g. in (Asher(1986), Reyle(1986), Eberle(1988b)).

3 Basic Assumptions of the Semantics of Tenses and Adverbials

The basic tenses of French narrative texts are the *parfait* and *passé simple*. The interaction of the tense forms is often described by two pairs of opposition: On the one hand the *passé simple* is used to describe actions of the narrative, "the course events", whereas the *imparfait* serves to paint the

background of the story. On the other hand the imparfait can be used to describe events in progress as viewed from "inside", whereas the passé simple presents the event as a punctual entity. In order to reflect these dichotomies we require that an event introduced by passé simple serves as new reference time which must not start before the old one, and that the imparfait introduces a state which includes temporally the existing reference time. In this case no new reference time is created.

In the case of passé simple we do not require that the new reference time has to follow completely the old one in order to deal correctly with discourse situations as 'elaboration' or 'contrast' and others. To discriminate such textual functions an elaborate inference component is needed, which at present is not available. In addition there are cases where this inference component would need information about the proceeding of the whole story. This cannot be made available at this stage of processing.

Thus an underspecified relation *not-before* is necessary which can be defined, as other relations like *subset* (needed for the imparfait), out of the relations *overlap* and *before*, the only basic temporal relations used in the system³.

The plusqueparfait can be understood as *perfective state* giving background information with respect to the actual reference time of the story, (*Jean avait déjà mangé*), or as introducing or continuing a *flashback*.

The conditionnel is understood as a counterpart to the plusqueparfait describing an anticipation with respect to a perspective point in the past.

We think that passé composé in (written) narrative texts should be treated as analogue to the passé simple with respect to pure temporal relations⁴.

Temporal adverbials provide a location time for events in relation to the temporal structure of the preceding text. They can differ from each other by their characterization of the location time and their anaphoric behavior. Deictic adverbials like *demain, la semaine dernière* for instance create location times of different temporal extension with different ordering conditions regarding the evaluation time (*after* and *before*), but they are similar in that the evaluation time must be the speech

³For motivations and definitions cf. Kamp(1979), Reyle(1986), Eberle(1988b)).

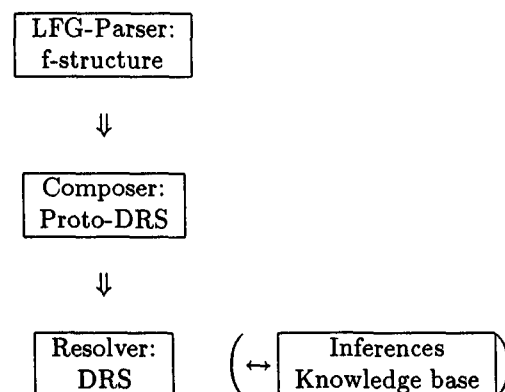
⁴For a more elaborate discussion of the French tense system cf. Kamp/Rohrer(1985), Eberle(1988c).

time, whereas in case of *le lendemain, la semaine précédente* the temporal relations and extensions are equivalent to the deictic analogues but the time of evaluation has to be a past reference time or perspective point. Frame-time adverbials like *ce jour-là* can be distinguished from *punctual* time adverbials like *à trois heures* and from adverbials, like *puis*, which simply state a temporal relation between the event to be introduced and a temporal antecedent. Some adverbials, like *puis* and *ensuite*, do not restrict the nature of the antecedent, it is just a reference time. But *maintenant* e.g. requires that the evaluation time is a perspective point of the text. The resolution component has to take into account such phenomena.

4 Aspects of Implementation

4.1 Architecture

The construction of the semantic representation for a discourse proceeds in several stages: each sentence is parsed using a Lexical Functional Grammar (LFG) (Kaplan/Bresnan(1982), Eisele/Dörre(1986)) which analyzes sentences into functional structures (f-structures), augmented by indices to indicate the linear order of words in the input string. The f-structure serves as input for the construction of a proto-semantic representation (cf. Reyle(1985), Reinhardt/Kasper(1987)). The last stage consists in integrating this representation into a semantic representation for the discourse, mainly by doing the necessary resolutions for anaphoric expressions. Accordingly, the system consists of three major modules:



The whole system is implemented in PRO-LOG. Here mainly the Composer and the Resolver will be discussed with respect to the treatment

of the tenses in these modules. The inference machine and knowledge base are at present not implemented. The proto-semantic representation for a sentence built up by the Composer differs from the semantic representation proper in that it not just contains the semantic information available from the sentence but also morpho-syntactic information from the f-structure needed to constrain the resolution process. Thereby, this information is passed to the Resolver which separates semantic and syntactic information and uses it. What sort of morpho-syntactic information is passed will be discussed later.

The concept of resolution here is broader than the usual one which comprises mainly determining the reference of anaphoric expressions like pronouns. We use the term as covering all kinds of context dependency beyond the single sentence level where something in the sentence has to be related to some entity in the preceding discourse. The term *temporal resolution* will be used to refer to the process of determining the temporal structure of the events the discourse is about.

The Resolver is intended to implement good heuristics based on purely linguistic knowledge. The evaluation of the readings produced should be left to the inference machine which also can access non-linguistic world knowledge.

4.2 Temporal Features in the F-Structure

In the Kamp/Rohrer system the tenses are analyzed by means of four features which have temporal and aspectual meaning:

- **PERF**ectivity,
- **PROG**ressivity,
- **TENSE**,
- **Temporal Perspective**

Tense forms can have several meanings or functions in discourse. Plusqueparfait for instance has a reading as flashback, and a perfective state reading with the temporal perspective "speech-time" or actually reached "reference time". Imparfait can have the perspective in the past at the reference time or at the speech time. Following Kamp/Rohrer(1985), the meanings of the main narrative tenses can be

described in the following way:

Form	TP	TENSE	PROG	PERF
passé s.	-PAST	past	-	-
imparfait	-PAST	past	+	-
imparfait	+PAST	pres	+	-
plusquep.	+PAST	past	-	-
plusquep.	-PAST	past	+	+
plusquep.	+PAST	pres	+	+
cond. I	+PAST	fut	+/-	-

Since it is not desirable to represent these ambiguities syntactically we use the Kamp/Rohrer categories in a slightly different way to get unique descriptions of the tenses. It is completely left to the resolver to account for these ambiguities. Since we exclude the TP-feature we need the additional TENSE-value *conditionnel*. To mark tenses in indirect discourse the transposed-feature is added:

feature	value
perf	+/-
prog	+/-
tense	past/present/future/conditionnel
transposed	+/-

Since we do not discuss embedded clauses in this paper, in the following the transposed-feature is skipped. The tenses are analyzed by these means as shown in Table 1.

4.3 Tenses and Temporal Adjuncts in the Composer

Here we will discuss what sort of information the Composer adds to the Proto-DRS when it encounters a tense feature or temporal adjunct or sub-clause. It consists basically of two kinds:

1. DRS-conditions, which do not depend on the resolution process
2. Interface structures for the Resolver, called *occurrence information* and represented as a 6-place occ-term.

The occurrence information is used to transmit morpho-syntactic information from the parser to the resolver. For the tenses this occurrence information has the form

occ(DRF, Pos, TF, Tense, tense, Pointer)

imparfait:	perf = -,	prog = +,	tense = past
passé simple:	perf = -,	prog = -,	tense = past
passé composé:	perf = +,	prog = -,	tense = present
plusqueparfait:	perf = +,	prog = -,	tense = past
conditionnel I:	perf = -,	prog = -,	tense = conditionnel

Table 1: Decomposition of the Tenses into Semantic Markers

Form	DRS	Occurrence Information
présent	t: DRS	occ(t, -, -, pres, tense, Pointer)
imparfait	t: DRS	occ(t, -, tf(-, +prog, -), past, tense, Pointer)
passé simple	t: DRS	occ(t, -, tf(-, -prog, -), past, tense, Pointer)
perf. participle:	t: DRS	occ(t, -, tf(perf, -, -), -, -, -)
conditionnel:	t: DRS	occ(t, -, -, cond, tense, Pointer)

Table 2: Temporal Information introduced by the Composer

with the following slots:

DRF the temporal discourse referent, which the resolution process has to locate, usually introduced by the verb

Pos verb position in surface structure,

TF $tf(Perf, Prog, Tr)$, the *temporal features* term. The *Perf*-slot marks the analytic tenses, *Prog* serves to distinguish for instance *imparfait* and *passé simple*, *Tr* stands for the value of the *transposed* feature.

Tense past | present | future | conditionnel, values of the *tense* feature,

tense marker, indicating that the *occ*-term stems from a tense feature. It is also the trigger for temporal resolution.

Pointer indicates the occurrence of the tense in main or embedded clauses. The clauses are indexed in a unique way (by natural numbers). The pointer is a pair consisting of the index of the superordinate clause and the index of the clause itself. Main clauses point to themselves. Such an indication is necessary for the treatment of embedded sentences. The pointer encodes a simplified tree structure for the sentence and allows moving around in the tree.

Temporal adjuncts and subclauses also provide occurrence information marked in a special way. They contribute an *occ*-term of the following kind:

$occ(DRF, Pos, -, Rel, set-time, Pointer)$

DRF here represents the time introduced by the adverbial

Pos its position in the surface structure

Rel the temporal relation introduced. For instance *trois jours avant* introduces *before*.

set-time indicates a special resolution mode for temporal adjuncts and indicates that this information was contributed by a temporal adjunct. In the resolution process the marker will cause the DRFs of the tense markers to resolve to **DRF**.

The information shown in table 2 is introduced by the Composer for the tenses (the “-” represent initially empty slots which get filled in in the process of combining the meanings).

It will be noticed that the tenses do not introduce new conditions into the DRS since the temporal relations cannot be determined without respect to the nature of the temporal ‘antecedent’ and therefore have to be generated in the Resolver.

4.4 Temporal Resolution

For temporal resolution the Resolver uses a stack of a system of times consisting of quintuples of the form:

1. reference time (usually the last event)
2. temporal perspective point
3. temporal location time (usually identical to the reference time)
4. speech time (at present kept constant for the whole discourse)
5. last resolved tense (with its occurrence information)

Every resolution process generates such a quintuple which gets stacked. If the temporal perspective point is changed (plusqueparfait and conditionnel), a substack is created and used till the original perspective point is restored.

The resolver removes the occurrence information for the tenses and temporal adjuncts from the proto-DRS. The tenses get resolved according to the rules discussed below. The presence of temporal adjuncts changes the flow of resolution as it requires that the temporal DRF introduced by the adjunct has to be resolved in accordance with the DRF introduced by the tense.

We will illustrate the effect of some resolution rules reflecting the heuristics of the system by discussing two sample texts.

- s1 Ce jour-là il pleuvait très fort.
 e2 Jean regarda par la fenêtre.
 s3 Marie n'était pas là.
 e4 Il mit son imperméable
 e5 et sortit.

ce jour-là introduces the location time t for the first state, $s1$, (*pleuvoir*). The Composer augments the DRS by the condition $day(t)$ and the Resolver by the condition $t \subset s1$.⁵ The first times-quintuple consists of a variable for the reference time, (no event is actually mentioned), the perspective point is assumed to be the speech time. The speech time is fixed by "now", t is the location time and in the last position the occ-term of $s1$ is stored. Since a reference time does not yet exist, the integration of $e2$ produces a temporal relation with respect to the last location time: $e2 \subset t$, i.e. $e2$ happens within t . A second times-quintuple is put onto the stack with the reference time $e2$ and the new occ-term. The other time coordinates remain constant.

⁵Because of the definite description *ce jour-là* the NP-Resolver has to establish an equation between t and a DRF of the preceding text which is a day. If there is no such antecedent t has to be accommodated. The latter case is at present not implemented.

$e2$ serves now as reference time for $s3$. The new relation $e2 \subset s3$ is introduced and the information which stems from the occ-term of $s3$ and the old tenses is put as a third times quintuple onto the stack. The reference time is not changed. It should be noticed that for new states the "smallest" available location time is used. Normally this is the reference time of the previous quintuple if existent. For it is not necessary that the explicit given location time, *ce jour-là* in the given example, serves as location time for subsequently introduced states as well. $e4$ is ordered with respect to $e2$, $e5$ with respect to $e4$ by the *not-before*-relation and the time stack is updated in the obvious way. All states and events are located obviously before the speech time now. We omit the full DRS of the example here.

- e1 Le 6 octobre Pierre arriva à Paris.
 e2 Le 3 octobre il était parti.
 e3 Le lendemain il avait traversé l'Espagne.
 s1 Et maintenant il était là.

According to the different meanings of the plusqueparfait mentioned in section 3 different rules are available to deal with the plusqueparfait of the second sentence. However, especially in cases where a frame time as in the example exists, the possibility to introduce a flashback is preferred. A new stack in the stack is created and the new event serves as reference time for subsequent events in the flashback. The last reference time of the high level is now regarded as temporal perspective for the events occurring in the flashback. They are localized before that perspective. *le lendemain* in the third sentence has to be resolved to an existing reference time, i.e. $e1$ or $e2$. Since we are already in a flashback, in processing the plusqueparfait of the continuation of this flashback is preferred. Thus a solution with $e1$ as antecedent for *le lendemain* would lead to a cyclic structure and should be ruled out by the inference component. The correct ordering conditions are given by establishing $e2$ as antecedent for the time introduced by *le lendemain* and t as location time for $e3$. The perspective time is copied from the stack. Thus we get the conditions:

$$e2 < t, e3 \subset t, e3 < e1$$

The embedded stack is updated by the new quintuple.

The implemented heuristics require that the tense switch from a plusqueparfait of a flashback to pas

simple or passé composé or the explicit reference to the perspective point, for instance by means of “maintenant”, always lead to a reactivation of the initial level, from which the first flashback started, that is, all substacks are popped. Without *maintenant* the imparfait of *s1* could lead to the continuation of the flashback or to the continuation of the main story. It is regarded as the state variant of both categories.

The (simplified) DRS of the example above thus looks as follows:

<i>now</i>	<i>t1</i>	<i>t2</i>	<i>t3</i>	<i>e1</i>	<i>e2</i>	<i>e3</i>	<i>s1</i>
6 octobre(<i>t1</i>)							
e1: arriver(<i>pierre</i>)							
goal(<i>e1</i>) = paris							
$e1 \subset t1$							
$e1 < now$							
3 octobre(<i>t2</i>)							
e2: partir(<i>pierre</i>)							
$e2 \subset t2$							
$e2 < now$							
$e2 < e1$							
day(<i>t3</i>)							
e3: traverser(<i>pierre,espagne</i>)							
$e3 \subset t3$							
$e3 < now$							
$e3 < e1$							
next-day(<i>t3,t2</i>)							
s3: être-à(<i>pierre,paris</i>)							
$e1 \subset s1$							
$s1 < now$							

In our opinion cases as in the example above cannot be treated without adding new parameters to the Reichenbachian system. At least doing it facilitates the job. Beyond the imparfait/passé simple, passé composé-distinction French does not make use of an explicit morphological aspect marking. Therefore, for instance in the case of conditionnel, treated as anticipation of an episode, we use the Aktionsart-characterization of the verb stored in the temporal sort of the DRF to specify the value of the prog-feature. An episode of states and dynamics then is treated similar to an imparfait-passé simple-story transposed by the stored (past) perspective time. By this means we get an interaction of Aktionsarten and tenses.

Similar to the case of flashback the tense switch from conditionnel to another past tense form marks the end of the anticipation and the reactiva-

tion of the initial level.

5 Conclusion and Problems

The implemented system assigns DRSs to natural language texts in such a way that the partial event structure, substructure of the whole DRS, reflects the events and temporal relations of the story. The system is incomplete at present in the following respects:

- The interaction of nominals and aspects is not accounted for.
- A principled treatment of tenses in embedded clauses is missing.
- The resolution of deictic/anaphoric temporal adjuncts is rudimentary.
- Knowledge about event types is at present not available to the Resolver.

Thus the output event structure is generally underspecified. The integration of an inference component combined with background knowledge should restrict the number of possibilities to order the events linearly. In dependence of the Aktionsart the events of the DRS can be assigned subevents marking the boundaries of the event as suggested by Moens and Steedman(1986), (cf. Eberle(1988b)). These subevents can be regarded as having no temporal extension. Thus on the subevent-level *before* and *equivalent* exhaust the intuitive possibilities of temporal relations. By means of this finer granulation the (linear) event substructure of a DRS corresponds to a unique (linear) interval structure provided the event relations *before* and *overlap* are defined in terms of Allen's interval structures (cf. Allen(1983)). Thus inferencing systems which deal with intervals, as the Allen system, become available but also systems which deal with point-like events as the event calculus of Kowalski/Sergot(1985). In addition we get the possibility to deal with temporal relations on different levels of precision.

In Eberle(1988a) the possibilities of monotonic reasoning in partial event structures (in the sense of the Kowalski/Sergot-approach) were investigated. It is planned to extend the algorithm suggested there which adds deduced events to the structure, in order to deal with measure statements, knowledge about hierarchies of event types (e.g. subevent

typologies) and temporal frames for event types (average duration of an event type). One aim is to rule out circular structures as mentioned in section 4.4. For simple cases we are able to do it yet. In such conflicting cases one has to backtrack to the Resolver, the Composer or the Parser to generate other readings. In this sense the suggested analysis system is non-monotonic since it generates other temporal relations if necessary. When finally a consistent reading has been arrived at, the event calculus can be used for non-monotonic reasoning, e.g. to deal with the problem of the validity of location times with respect to events localized before or after events for which an explicit relation of inclusion holds.

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