Scenarios for the Passé Simple and Imparfait

An event calculus approach to French semantics

Master's Thesis
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December 8, 2002

Contents

Acknowledgements

I would like to thank my supervisor, Michiel van Lambalgen, for all his help during the months I was working on this thesis. I'm also grateful to my family and friends for their great support.

Introduction

The goal of this thesis is to apply an AI technique for planning to natural language semantics (pragmatics). It could seem strange at first sight to relate both areas but let us formulate more precisely the topic and then try to explain the relevance of this approach.

The idea behind this thesis is to apply the AI formalism called *Event Calculus* to the semantics of two past tenses in French, namely the Passé Simple and the Imparfait, to obtain a cognitively plausible explanation of some phenomena related to tense and aspect.

The event calculus is a formalism to model reasoning with time and change and as such it is usually used to solve planning problems. But what has planning to do with tenses?
The main hypothesis underlying this thesis is that our experience of time is not primitive (i.e. time is not an input to our perceptions) but could lie in the necessity to solve planning problems. This hypothesis granted, it doesn't appear strange anymore to think that the comprehension of tenses in natural language could rely somehow on our ability to plan.

It seems then natural to first expose several methods for constructing time from events and this will be our task in chapter 1. The influence of this chapter on the rest of the thesis will be apparent to the reader when we will comment some methods used to treat the semantics of the French past tenses. In chapter 2 we sum up the needed data to explore the semantics of the Passé Simple and the Imparfait. We introduce the common linguistics views on those tenses and try to insert aspect in this picture. We will then turn to some theories used to account for temporal and aspectual problems in chapter 3. We will first discuss Kamp's framework, i.e. Discourse Representation Theory (from now on DRT), which doesn't account for aspectual problems. Then we will turn to de Swart's method which incorporates in Kamp's framework a treatment of aspectual information and extends DRT to Segmented DRT which "offers a theory of the semantics/pragmatics interface".[1] Finally we will expose Gosselin's framework which is much more influenced by cognitive considerations. The last two chapters will be devoted respectively to an introduction to the event calculus and to a treatment within the event calculus framework of some of our previous data. At this point we will try to make obvious why the use of the event calculus is relevant in the study of the Passé Simple and the Imparfait semantics. We can already say that the way aspectual classes are incorporated in the formalism and the notion of a *scenario* will be two of the features that make the event calculus formalism particularly well-suited for dealing with both aspectual and tense information in sentences with a Passé Simple and/or an Imparfait.

[1] See de Swart [3, p. 95]

Chapter 1

Formal time models

1.1 Introduction

> "I have become increasingly convinced that there are certain linguistic phenomena for which we can only account via a systematic analysis of the ways in which discourse participants process the information with which the discourse provides them. Among these phenomena there are some which concern reference to time...", [8, p. 381].

This citation of Hans Kamp from his article *Events, Instants and Temporal Reference*, [8], is a good starting point as it resumes quite clearly what our concern will be for the following pages, i.e. the treatment of temporal reference and more particularly in this chapter, the concept of time.

In the article mentioned above Kamp develops a new framework (opening the way for what will become DRT) to treat the problem of anaphora (in particular temporal anaphora). The idea goes roughly as follows, a discourse participant, say S, is talking to another discourse participant, say H, who of course listens. During the listening, the hearer H represents the information conveyed by S (to keep it simple assume that S utters a sequence of sentences $s_1, .., s_n$ about some events $e_1, ..., e_n$), information which will at least partly specify the temporal order of the events $e_1, ..., e_n$. This order will usually be structured by the features of the sentences such as the tenses of their verbs.
So far so good, our hearer H has made a representation of the discourse he heard, and this representation "contains" an ordering (possibly partial) of the events depicted. Now we face the problem to determine under which conditions such a structure is a *true* representation of its world or subject

matter; in order to do so, we follow Kamp: "Such a structure is a *true* representation of its world or subject matter if and only if the latter contains entities that can be correlated with the constituents of the structure so that the constraints which the structure imposes on those constituents are satisfied by the correlated entities.", [9, p. 20]. For instance, if the discourse "induced" a representation where the events $e_1, ..., e_n$ have the order $e_1 < e_2 < ... < e_n$, then there should be real events $E_1, ..., E_n$ corresponding to them and ordered in the same way, that is, $E_1 < E_2 < ... < E_n$.[1]
That suggests that there should be a connection between the events of the discourse and the real events, and so, there should also be some sort of connection between events and real times, that we could schematize as follows,

$$\text{Discourse (events)} \longrightarrow \text{"mental" time} \longrightarrow \text{"real" time ("real" events).}$$

To make this connection more precise we will present the construction used by Kamp which is due to Russell and Wiener[2], and will then present two other constructions due to Walker and Thomason.

1.2 Kamp's construction of time

1.2.1 Origins of the construction

Our main hypothesis about the nature of time is that time has the structure of the continuum, i.e. isomorphic to the real numbers. The notion of point-like instant was (is) for a long time a successful mathematical tool in physics, a simplifying device analogue of the geometrical point. But it still can be asked on what ground we base the assumption of continuity (of time, or more in general in physics) or point-like instant, and further is it really needed or can we do without?

It is against the use of the durationless instant (among other entities) as a postulated entity that Russell reacts in [16]. His construction is one of the first attempts to construct mathematically the "real time" of the "real world" from what actually happens in the world [21, p. 45], and was motivated by the idea that durationless instants shouldn't just be postulated but that a construction should justify their use by physicists or mathematicians. He explained this position saying that instants without duration cannot be part of our experience of the world as "events of which we are conscious

[1]This example is only given as an illustration but it should not be considered for anything more than a great simplification of a far more complex process. It is just meant to sketch ideas that we will further explore in greater details.

[2]See [16], [17] and [27].

do not last merely for a mathematical instant, but always for some finite time, however short", and applying *Occam's razor*, i.e. entities are not to be multiplied without necessity, he then concludes that "instants, therefore, are not among the data of experience, and, if legitimate, must be either inferred or constructed", [16].
As it seems not clear how instants could be inferred, he opted for the constructive approach, and took as primitive the events (things that happen in the world and that we experience consciously).[3] He distinguishes two ways in which such a construction could be performed: first by means of temporal enclosure (this is a method similar to the one used by Whitehead to define points), or by means of temporal overlap. This last method is the one that is privileged. Russell, in this lecture, tries to make a bridge between the world of physics (postulated instants) and the world of sense (the data our sense gives us). From this point of view he claimed that our experience of time provides us with two fundamental relations among events, those of overlap (simultaneity) and the relation of precedence (*earlier than*), which satisfy on the set of events the postulates A1-A7 of section 2.2. So the instants should be constructed from the sense-data we have, that is: events, relation of precedence and overlap. Russell then defined the instants as a maximal "group of events, so that there is some time, however short, when they all exist", and summed up the properties one could expect instants to have.
However we can still ask ourselves whether the construction will yield the temporal continuum of instants? This question was further investigated by both Wiener [27] and Russell, with in addition the problem of the existence of instants [17], but these problems are quite difficult to handle mostly because it is not easy to see what assumptions about the temporal relations will ensure that the resulting construction is isomorphic to the real numbers, see [26].

Hence the basic elements of the construction are a set of events, which are considered to be of finite duration, and the two relations, "wholly precede" and "overlap". Now we will make precise how to define times (instants) in terms of those events.

1.2.2 The Russell/Wiener construction

The main idea of the construction is to define temporal instants as maximal sets of pairwise overlapping events. We are given two binary temporal relations, the relation of complete precedence will be noted $\propto$, and the relation

[3] The concept of event is and will remain vague. See [10, p. 505], "...our pretheoretical conception of what events are is fundamentally undetermined."

of temporal overlap $\bigcirc$; that is, we have the structure $E = (W, \propto, \bigcirc)$, where W is the set of events. Further we assume that these relations satisfy the following postulates:

A1: $x \propto y \rightarrow \neg\, y \propto x$

A2: $x \propto y \wedge y \propto z \rightarrow x \propto z$

A3: $x \bigcirc x$

A4: $x \bigcirc y \rightarrow y \bigcirc x$

A5: $x \propto y \rightarrow \neg\, x \bigcirc y$

A6: $x \propto y \wedge y \bigcirc z \wedge z \propto t \rightarrow x \propto t$

A7: $x \propto y \vee x \bigcirc y \vee y \propto x$

Axiom A2 (the relation $\propto$ is transitive) is actually superfluous, it can be derived from the stronger axiom A6 and A3. These postulates must be justified by the intuitive way in which we experience the connection between events (in the same manner as the two relations are said to be "part of the crude data" of our immediate experience [16]), but it still can be verified, even if it is a circular argument, that if we take a strict linear ordering and that we define our two relations on the set of intervals of this ordering, the structure obtained will satisfy the seven postulates. A1 intuitively says that if an event precedes another, it cannot be preceded by this other event; an event always overlaps itself (A3); A4 is the reflexivity of the overlap relation; if an event precedes another, then they don't overlap (A5); A7 says that of two events, one should precede the other, or they should overlap, i.e. it forces linearity of time (this is a postulate that is difficult to justify when your "data" is not the observed events of the world but only a segment of text, for then it will not always be clear which relation holds between any pair of events). A6 is a stronger version of A2, which intuitively says not only that the relation is transitive but also that the events considered are not located on different time lines.
Now we can give a definition of our instants.

Definition 1 *Let E be an event structure. An instant of E is a maximal subset of W of pairwise overlapping events. Then*

(i) i is an instant of E iff

(a) $i \subseteq W$

(b) for any $e_1, e_2 \in i$, $e_1 \bigcirc e_2$

(c) for any $e_1 \in W \setminus i$ *there is an* $e_2 \in i$ *such that* $\neg\, e_1 \bigcirc e_2$.

(ii) $I(E)$ *be the set of instants of* E

(iii) An event e *occurs at an instant* i *iff* $e \in i$

(iv) for $i_1, i_2 \in I(E)$, $i_1 <_E i_2$ *iff there are* $e_1 \in i_1$ *and* $e_2 \in i_2$ *such that* $e_1 \propto e_2$.

(c) can also be formulated as follows, if $H \subseteq E$, $i \subseteq H$ and for all e_1, $e_2 \in H$, $e_1 \bigcirc e_2$, then $H \subseteq i$. That is, if a set of events includes an instant, and all events in the set are pairwise overlapping, then this set is actually an instant.

Example 1 *Assume we have four events* $e_1, ..., e_4$, *with the following relations,* $e_1 \propto e_2, e_3, e_4$; $e_2 \bigcirc e_4$; $e_3 \bigcirc e_4$; $e_2 \propto e_3$, *then, the Russell-Wiener construction yields the instants structure of figure 2.1, with the obvious or-*

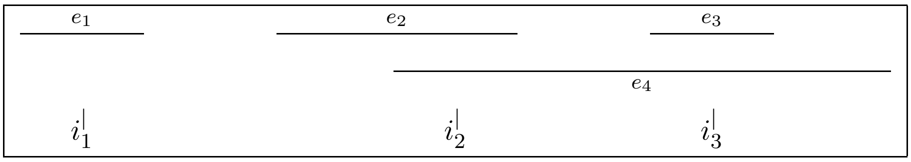


Figure 1.1: instants obtained with the Russell-Wiener construction.

der, $i_1 < i_2 < i_3$, *i.e.* $i_1 = \{e_1\}$, $i_2 = \{e_2, e_4\}$, *and* $i_3 = \{e_3, e_4\}$.

Theorem 1 $\mathcal{I}(E) = (I(E), <_E)$ *is a strict linear ordering.*[4]

Further we can define intervals from instants as the *convex* subsets of instants, i.e. as the subsets X such that if $i_1, i_2 \in X$ and $i_1 <_E i_3 <_E i_2$, then $i_3 \in X$, and for any instant structure $\mathcal{I}(E)$ we can derive an interval structure $\mathcal{I}nt(\mathcal{I}(E)) = (Int, <_{Int}, \bigcirc_{Int})$ as follows[5]

[4]For details of the proof, see [8, p. 378-379]. Strict linear ordering :

i) $x < y \rightarrow \neg\, y < x$

ii) $x < y \wedge y < z \rightarrow x < z$

iii) $x \neq y \rightarrow x < y \vee y < x$

[5]See [10, p. 668].

Definition 2 *Let X, Y be intervals of an instant structure $\mathcal{I} = (I, <)$. Then*

i) $X <_{Int} Y$ *iff for all* $i_1 \in X$ *and* $i_2 \in Y$, $i_1 < i_2$,

ii) $X \bigcirc_{Int} Y$ *iff* $X \cap Y \neq \{\}$,

iii) $X \subseteq_{Int} Y$ *iff for every instant* $i \in X$, $i \in Y$.

We can now associate with each event e of E a corresponding interval $p(e) = \{i \in \mathcal{I}(E) | e \text{ } occurs \text{ } at \text{ } i\}$ in the structure $\mathcal{P}(E) = \mathcal{I}nt(\mathcal{I}(E))$, then for any e_1, e_2 of E, we have

i) $e_1 < e_2$ iff $p(e_1) <_{\mathcal{P}(E)} p(e_2)$,

ii) $e_1 \bigcirc e_2$ iff $p(e_1) \bigcirc_{\mathcal{P}(E)} p(e_2)$.

Hence, p is a homomorphism from E to $\mathcal{P}(E)$.
From example 1 we get the following intervals corresponding to the events $e_1, ..., e_4$:
$p(e_1) = [i_1, i_1]$, $p(e_2) = [i_2, i_2]$, $p(e_3) = [i_3, i_3]$, $p(e_4) = [i_2, i_3]$. Furthermore we get the following ordering between the intervals:
$[i_1, i_1] <_{\mathcal{P}(E)} [i_2, i_2], [i_3, i_3], [i_2, i_3]$,
$[i_2, i_2] <_{\mathcal{P}(E)} [i_3, i_3]$,
$[i_2, i_3] \bigcirc_{\mathcal{P}(E)} [i_2, i_2], [i_3, i_3]$.

The main problem of this construction is that, were we to have the event structure of example 1 with only the events e_3 and e_4 (with $e_3 \subset e_4$), we would only get one instant and therefore both events would be mapped to the interval made of this single instant (here $[i_3, i_3]$).

1.3 Thomason's construction of time

1.3.1 Introduction

Thomason, in [20], looks back on the attempt of Russell of constructing instants from events, but quickly turns to a different method due to A. G. Walker. Walker was motivated by the same idea as Russell, that instants should not be postulated but constructed. He took as primitive for his construction a partially ordered (by the relation of complete precedence) set of events ("durées") [24]. Both Walker and Russell use for their constructions a single (partial) event ordering which is possibly infinite. In this article Walker wants to show that the instants obtained from the partially ordered set form a complete linear order (that is, the temporal experience of an observer in physics). He defined the relation of overlap in function of the precedence relation, i.e if two events a and b are such that $a < b$ and $b < a$ are false, then we say that $a \bigcirc b$, and give two axioms for those relations, (i) an event always overlaps itself, (ii) axiom A6 of Russell's construction. The real new step in the construction is to define an instant as cut of the set of events in three parts, (P, C, F), which corresponds to a partition of the set into "past", "current" and "future".

Walker concludes that a complete linear order is the only satisfactory structure of time, if you see time as representing the primitive temporal experiences. However the temporal continuum can only be obtained via additional conditions. In [25], he discusses the problem of obtaining a structure of instants similar to the continuum, but it is studied in a very different context, that is, in the context of the theory of relativity (his article is a proof of the assumption that the ordered set of instants of a particle is similar to the continuum of the real numbers).

Improving the previous attempts of Walker, Thomason shows in [20] that in order to get an instant structure isomorphic to the continuum, we need a non-empty set of events, which is dense and denumerable, and concludes that Walker's theory offers a "plausible explanation of time as a continuum" as it doesn't seem that strange to consider that the events happening in the "real world" form a non-empty, denumerable, dense event ordering.

In [21], Thomason addresses a somehow different problem; to use his words, [21, p. 43], "... what is the mathematical connection between the way events are perceived to be ordered (on the one hand) and linear orderings (on the other) which permits, or even compels, observers to regard events as occupying intervals of some linear ordering?". There is a change in perspective here. This new point of view is already present in the conclusion of [20]. The focus isn't anymore on the conditions to obtain a continuum (which we exposed above) but on how we could as "finite information-processors come to think of time as a continuum" (see [20, p. 95]). We won't say anything further in this chapter about the problem of granularity of time (and the possibility to construct increasing chain of event structures) even if we realize that it would benefit our analysis of some tense phenomena. We will now describe Walker's and Thomason's construction of instants (referring often verbatim to [21]).

1.3.2 Walker's construction

We will first introduce some new relations to refine our event structures.

Definition 3 *The predicate $B(c, d)$ ('c begins before d') is introduced by* *putting* $B(c,d) \leftrightarrow \exists b(P(b,d) \wedge \neg P(b,c))$. *Similarly,* $E(c,d)$ *('c ends before d') is introduced by* $E(c,d) \leftrightarrow \exists b(P(c,b) \wedge \neg P(d,b))$.

From now on, $< W; P, O, B, E >$ will be the event structure, where W is a set of events, and P, O, B, E are the predicates introduced by the axioms and definitions above. Notice that in case of an event beginning before another there must be a witness.

As we just said the main difference with Russell's construction is the way of seeing the instants.

Definition 4 *An* instant *of an event structure* $< E, P, O >$[6] *is a triple* (P, C, F) *such that*

1. $P \cup C \cup F = E$
2. P, F *are non-empty*
3. $a \in P,\ b \in F$ *implies* $P(a,b)$ [7]
4. *if* $c \in C$*, there exist* $a \in P$*,* $b \in F$ *such that* $O(a,c),\ O(b,c)$.

The instants are now directed, with a past part and a future part. The condition 4 of the definition gives a kind of continuity: there is no gap between the present and the past, and likewise for the present and the future. If we now compare Walker's instants to Russell's, we see that a Walker instant always occurs in the empty gap between two events; if there are no such gaps, i.e. if all events overlap, then the event structure has no Walker instant. Clearly in this case there is a Russell instant. It will be seen that Walker's construction gives vastly more insight than Russell's into the relations between past, present and future, and in the continuity of time. In fact, in Walker's setup events need not correspond to sets of points, rather, instants serve to separate events, because instants mark change. If nothing happens inside a given event, there will not be an instant inside that event. We will soon explain how to construct intervals from instants.

Example 2 *We refine the event structure of example 1 with the new relations. That is, we introduce two new events* e_5 *and* e_6*. The instants obtained with Walker's method are defined as follows,* $i_1 = (\{e_1\}, \emptyset, \{e_2, e_3, e_4, e_5, e_6\}$*,* $i_2 = (\{e_1, e_5\}, \{e_2\}, \{e_3, e_4, e_6\})$*,* $i_3 = (\{e_1, e_2, e_5\}, \{e_4\}, \{e_3, e_6\})$*,*

[6] E is the set of events, P the precedence relation and O the overlap relation.

[7] P thus stands for 'past', C for 'current' and F for 'future'. The relation of precedence P shouldn't be confused with the Past P in the sense that the relation is always written with its argument.

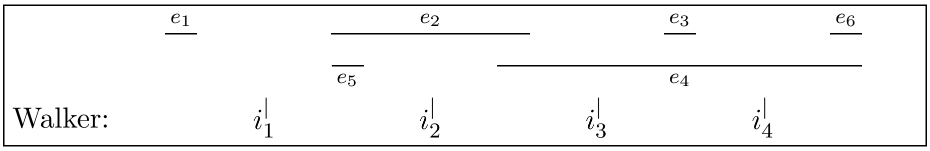


Figure 1.2: instants obtained with Walker's construction.

$i_4 = (\{e_1, e_2, e_3, e_5\}, \{e_4\}, \{e_6\})$ and of course, we have $i_1 < i_2 < i_3 < i_4$. There cannot be any other instant, otherwise it would have an empty past or future. Notice that the instants are traces of changes in the event structure.

Lemma 1 *(Walker [24], as modified by Thomason [20, p. 89]) Every instant is completely determined by its past. That is,*

(a) if $< W; P, O, B, E >$ is an event structure, and (P, C, F) an instant, then

- *(1) P is a nonempty proper subset of W*
- *(2) if $\exists a \in P : \neg E(a, d)$ then $d \in P$*
- *(3) if for all $a \in P$: $E(a, d)$, then $\exists b \forall a \in P : \ (P(a, b) \wedge O(d, b))$.*

(b) Conversely, if the set $P \subseteq W$ satisfies the preceding three conditions, then an instant (P, C, F) is defined by putting $F = \{b \in W \mid \forall a \in P : P(a, b)\}$ and $C = \{c \in W \mid \exists b \in P : \ O(b, c) \wedge \forall a \in P : \ E(a, c)\}$. This instant is the only one whose past equals P.

It should be noted that the fact that the past can alone determine the current and the future is possible because the past determines an instant only in the context of a given event structure. Although the three conditions on P only mention P and (implicitly) E, it is precisely the quantification over all of E in conditions 2 and 3 that does the trick. For proof, see [20, p. 89].

Let $\mathcal{I}(W)$ be the set of instants constructed with Walker's method from the event structure $< W; P, O, B, E >$.

Definition 5 *Let (P, C, F) and (P', C', F') be two instants of $\mathcal{I}(W)$, then $(P, C, F) < (P', C', F')$ if and only if P is properly contained in P'.*

We can now state the following theorem

Theorem 2 *If W is an event ordering then $\langle \mathcal{I}(W), < \rangle$ is a complete linear order.*[8]

Therefore we obtain a complete linear order from the event ordering. We have now to explain how to relate events in the event ordering to intervals in the linear ordering. In order to do so we must first give the following definition

Definition 6 *If L is a linear order then a* formal open interval *is a pair $(x,\ y)$ such that $x,\ y\ \in\ L \cup \{-\infty,\ +\infty\}$ and $x\ <\ y$. Let $\mathcal{I}nt(\mathcal{I}(W))$ consists of all* formal open intervals. *To make $\mathcal{I}nt(\mathcal{I}(W))$ into an event ordering we define the predicates on the formal open intervals by*[9]

1. $P((x,y),(u,v))$ *iff* $y \leq u$
2. $O((x,y),(u,v))$ *iff* $P((x,y),(u,v))$ *and* $P((u,v),(x,y))$
3. $B((x,y),(u,v))$ *iff* $x < u$
4. $E((x,y),(u,v))$ *iff* $y < v$.

We give now the mapping from events in W to formal open intervals.

Definition 7 *If $a \in W$, define $\eta_W(a)\ =\ (x_a, y_a)$,*[10] *where x_a is determined by the conditions*

1. *if a is P-minimal, $x_a\ =\ -\infty$; and if not $x_a\ =\ (P, C, F)$ where*
2. $P\ =\ \{c \mid P(c,a)\}$
3. $F\ =\ \{c \mid \neg B(c,a)\}$
4. $C\ =\ W - (P \cup F)$

Dually, y_a is determined by the conditions

1. *if a is P-maximal, $y_a\ =\ \infty$; and if not $y_a\ =\ (P, C, F)$ where*
2. $P\ =\ \{c \mid \neg E(a,c)\}$
3. $F\ =\ \{c \mid P(a,c)\}$

[8] For proof see [20, p. 91].

[9] Here we count $-\infty\ <\ u\ <\ +\infty$, for all $u\ \in\ L$.

[10] Here we use Thomason's notation $\eta_W(a)$ which comes from category theory. $\eta_W(a)$ is an *arrow* in the category of event orderings from W to $\mathcal{I}nt(\mathcal{I}(W))$ which preserves the relation P, O, B and E.

4. $C \ = \ W - (P \cup F)$

Hence, we obtain from example 2 the following intervals corresponding to the events $e_1, ..., e_4$.
$\eta_W(e_1) \ = \ (x_{e_1}, y_{e_1}) \ = (-\infty, i_1)$,
$\eta_W(e_2) \ = \ (x_{e_2}, y_{e_2}) \ = (i_1, i_3)$,
$\eta_W(e_3) \ = \ (x_{e_3}, y_{e_3}) \ = (i_3, i_4)$,
$\eta_W(e_4) \ = \ (x_{e_4}, y_{e_4}) \ = (i_2, +\infty)$,
$\eta_W(e_5) \ = \ (x_{e_4}, y_{e_4}) \ = (i_1, i_2)$ and
$\eta_W(e_6) \ = \ (x_{e_4}, y_{e_4}) \ = (i_4, +\infty)$.

1.3.3 Thomason's construction

There are two important differences with respect to Russell's construction. The first one is that Russell used two relations on his events structure, namely the complete precedence $\propto$ and the relation of overlap $\bigcirc$, whereas Thomason considers the following four relations,

1) P, which is to represent complete precedence,

2) B, which stands for "begins before",

3) E, for the relation "ends before", and,

4) A, which is for "abuts (from the left)".

The second difference is that Russell defines instants as maximal subsets of pairwise overlapping events, where Thomason (following Walker) defines instants as a *cut* (P, C, F) which partitions the set of events into "past", "current" and "future", which will allow to create new instants between some particular events.
Let $\mathcal{W} = (W, P, B, E, A)$ be an event ordering with W a finite set of events and P, B, E, A binary relations on W satisfying,

A1: $\neg P(a, a)$,

A2: $P(a, b) \wedge P(c, d) \Rightarrow P(a, d) \vee P(c, b)$,

A3: $B(a, b) \Rightarrow \neg B(b, a)$,

A4: $E(a, b) \Rightarrow \neg E(b, a)$,

A5: $B(a, b) \Rightarrow B(c, b) \vee B(a, c)$,

A6: $E(a, b) \Rightarrow E(c, b) \vee E(a, c)$, A7: $P(c,b) \wedge \neg P(c,a) \Rightarrow B(a,b)$,

A8: $P(a,c) \wedge \neg P(b,c) \Rightarrow E(a,b)$,

A9: $A(a,b) \Rightarrow P(a,b)$,

A10: $A(a,b) \wedge P(a,c) \Rightarrow \neg B(c,b)$,

A11: $A(a,b) \wedge P(d,b) \Rightarrow \neg E(a,d)$,

A12: $\neg E(a,c) \wedge \neg E(c,a) \wedge \neg B(b,d) \wedge \neg B(d,b) \Rightarrow (A(a,b) \Leftrightarrow A(c,d))$.

To explain a bit more what the relation A is about, we can look at the postulates (A9-A12) in more detail. (A9) just says that if a abuts b, then a totally precedes b; (A10) says that if a abuts b, then b is B-minimal among the set $\{d|P(a,d)\}$; (A11) says that if a abuts b, then a is E-maximal among the set $\{c|P(c,b)\}$ and finally (A12) "says that whether a abuts b depends only upon when a ends and when b begins" [21, p. 59].
Now we can define our instants as a *cut* in $\mathcal{W}$, that is a triple (P,C,F) of subsets of W.

Definition 8 *Let $\mathcal{W} = (W,P,B,E,A)$ be an event structure, a* cut *in $\mathcal{W}$ is a triple (P,C,F) of subsets of $\mathcal{W}$ satisfying*

1. $C = W \setminus (P \cup F)$,
2. $a \in P \wedge b \in F \Rightarrow P(a,b) \wedge \neg A(a,b)$,
3. $P(a,b) \Rightarrow a \in P \vee b \in F$,
4. $a \in P \wedge b \notin P \Rightarrow E(a,b)$,
5. $a \in F \wedge b \notin F \Rightarrow B(b,a)$,
6. $C = \emptyset \Rightarrow P \neq \emptyset \neq F$.

All those conditions are quite easy to understand. As we said a *cut* gives a partition of W into "past", "current" and "future", and we will say that a cut (P,C,F) *separates* the events a and b if $a \in P$ and $b \in F$. Now we can define the relation $<$ on the set of cuts $\mathcal{I}(\mathcal{W})$ by $(P,C,F) < (P',C',F') \Leftrightarrow P \subset P' \vee F' \subset F$.
Finally we can give a method to construct the instants directly from each event, see [21, p. 62], if $\mathcal{W}$ is an event ordering defined as above and $c \in \mathcal{W}$, define $\kappa_0(c) = (P_0(c), C_0(c), F_0(c))$, where

$P_0(c) = \{a \in \mathcal{W} | P(a, c)\}$,

$F_0(c) = \{b \in \mathcal{W} | B(c, b)\}$,

$C_0(c) = W \setminus (P_0(c) \cup F_0(c))$.

κ_0 is the least element of $\mathcal{I}(\mathcal{W})$ which doesn't have c in its "future". Dually, define $\kappa_1(c) = (P_1(c), C_1(c), F_1(c))$, where

$P_1(c) = \{a \in \mathcal{W} | E(a, c)\}$,

$F_1(c) = \{b \in \mathcal{W} | P(c, b)\}$,

$C_1(c) = W \setminus (P_1(c) \cup F_1(c))$.

κ_1 is the greatest element of $\mathcal{I}(\mathcal{W})$ which doesn't have c in its "past". Finally, if $a,\ b \in \mathcal{W}$, a is E-maximal among $\{c | P(c, b)\}$, b is B-minimal among $\{a | P(a, c)\}$, and $\neg A(a, b)$, define $\lambda(a, b) = (P(a, b), C(a, b), F(a, b))$, where

$P(a, b) = \{c | \neg E(a, c)\}$,

$F(a, b) = \{c | \neg B(c, b)\}$,

$C(a, b) = W \setminus (P(a, b) \cup F(a, b))$.

$\lambda(a, b)$ is the only element of $\mathcal{I}(\mathcal{W})$ having a in its "past" and b in its future. It can be proved that those triples are exactly the elements of $\mathcal{I}(\mathcal{W})$, see Lemma 3 [21, p. 62].

Example 3 *If we consider the same events structure as in Example 1 (notice that we have $\neg A(e_1, e_2)$ and $\neg A(e_2, e_3)$), we now get a richer instants structure, where $s = \kappa_0(e_1) = \kappa_1(e_1) = (\emptyset, \{e_1\}, \{e_2, e_3, e_4\})$, $t = \lambda(e_1, e_2) =$*

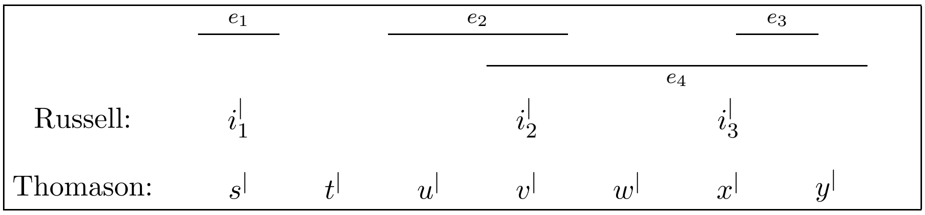


Figure 1.3: instants obtained with Thomason's construction.

$(\{e_1\}, \emptyset, \{e_2, e_3, e_4\})$, $u = \kappa_0(e_2) = (\{e_1\}, \{e_2\}, \{e_3, e_4\})$, $v = \kappa_1(e_2) = \kappa_0(e_4) = (\{e_1\}, \{e_2, e_4\}, \{e_3\})$, $w = \lambda(e_2, e_3) = (\{e_1, e_2\}, \{e_4\}, \{e_3\})$, $x = \kappa_0(e_3) = \kappa_1(e_3) = (\{e_1, e_2\}, \{e_3, e_4\}, \emptyset)$ and $y = \kappa_1(e_4) = (\{e_1, e_2, e_3\}, \{e_4\}, \emptyset)$.

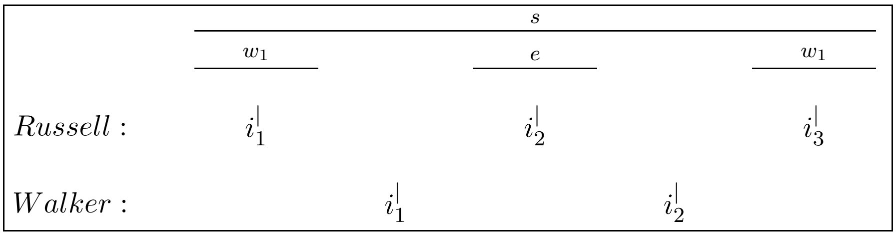
1.4 Conclusion

The three constructions yield very different instants structures. However we can oppose two styles: the Russell/Wiener method and the Walker/Thomason method. But why choose one above the other? What could be the reason to opt for one of those constructions?

We think that Walker's method has some big advantages compared to Russell's construction. In order to explain this statement we want to give a preview on what will follow in the next chapters. Consider the following sentence

(1) Il faisait chaud. Jean ôta sa veste.

The first sentence describe a state, say s, and use an Imparfait, it is usually said to give background information, whereas the second sentence with a Passé Simple describes an event, say e, that happens in this background information. The situation could be rendered by the following picture (the events w_1 and w_2 are witness of s beginning before e and s finishing after e). Furthermore it usually advocated that the event will be seen as a whole



without internal structure. If we follow Russell's construction, the listener trying to represent himself the information conveyed by these two sentences should come up with a mapping of the event into the interval $[i_2, i_2]$, the state into $[i_1, i_3]$. If we follow Walker we will obtain the interval (i_1, i_2) for e and $(-\infty, +\infty)$ for s. At first sight it seems that Russell's construction, with three instants, should give us more information. However we think that the reason why the event can be seen as a whole is not so much because it is mapped into a point, $[i_2, i_2]$, but because it has no instants in its interval, (i_1, i_2). Furthermore it is known that the Passé Simple sometimes emphasizes the beginning of the event (inchoative reading). This cannot be explained if the event is mapped into $[i_2, i_2]$, but is well-rendered by (i_1, i_2).

We have to say that there is a common problem with Russell and Walker's constructions which Thomason's method doesn't have. In both methods we cannot express that one event "abuts" another. Intuitively an event abuts another if these events are contiguous, i.e. there cannot be another event in between. This may not seem of importance but this is a feature that is relevant in analyzing some tense phenomena, witness the following sentence

(2) Quand Jean eut ouvert les yeux il vit sa femme. (PA, PS)

In this sentence the first tense is a Passé Antérieur (PA) and the second is a Passé Simple and the event described by the subordinate with the Passé Antérieur is usually understood as being contiguous to the Passé Simple event.

To conclude this chapter, we want to say that the choice for Walker's construction is also motivated by our choice of the event calculus formalism to treat some problems of tense and aspect in French. We will only give a better explanation for this choice in chapter 5 but we can already say that there will be a strong resemblance between the role played respectively by the events and the instants in Walker's construction and the role played by the fluents and the events in the event calculus.

Walker		Event Calculus
events	$\leftrightsquigarrow$	fluents
instants	$\leftrightsquigarrow$	events

Chapter 2

Tense and Aspect in French: some data

2.1 Introduction

We will here discuss the common views on the use of some French tenses and their contribution to the tense and aspectual information at the sentence and discourse level. But tenses are not the only elements that give rise to aspectual and tense information. Following Gosselin [4], we will describe the influence of some of those elements which play an important role:

a) lexical properties of the verb and the NP's (object and subject) which determine the aspectual class at the VP or sentence level.

b) (indicative) tenses. The following indicative tenses will have our attention the Passé Simple (PS for short), The Imparfait (Imp), the Passé Antérieur (PA) and the Plus-que-Parfait (PqP).

c) temporal adverbs like *pendant*, *depuis*, etc...

d) adverbs of a more aspectual nature; iterative adverbs like *souvent* and *parfois*; numerative adverbs like *deux fois*, *à trois reprises*.

2.2 Traditional linguistic approach to the data

In the literature about tense and aspect in French, the aspectual difference between the PS and the Imp is usually the one which is stressed most. It is probably because aspect doesn't seem to play a prominent role in French grammar, i.e. aspectual information isn't marked in an explicit manner (by progressive verb form, for instance). It is quite interesting to remark that the word *aspect* is usually absent from grammar books for French students. We will now discuss some traditional examples, first with PS sentences and then with Imp sentences. Finally we will look at some examples where coercion plays an important role. Further we will often refer to states, activities, achievements and accomplishments, referring by this to Vendler's famous classification of verb phrases.[1] This is clearly to emphasize the importance of (lexical) aspectual information in the interpretation of sentences. This chapter must be seen as a short introduction to sentences (mostly) in the PS and the Imp where we will give some of the most common ideas about the interpretation of those tenses. However this isn't a commitment to the traditional linguistic approach and we reserve ourselves the right to revise some ideas that we will expose here.

2.2.1 The Passé Simple.

The PS is typically used to express temporal succession of events in a narrative discourse as in

(1) Pierre se leva et monta dans sa chambre. (PS, PS)

In this example the PS conveys the information that both events are located in the past. Further it is usually claimed that these two events are to be viewed as punctual (a closed interval is probably a better picture of a PS sentence) in the sense that there are no other events which could partition them (this is true because the sentence is a succession of events that forms a sequence in the narrative[2]). The constituency of the events is not important. As we already said, the PS imposes a view of the events 'from outside' and from a distance. The other typical effect of the PS is the temporal succession of the events. It is not the only tense that can create this effect[3] but it is particularly well-suited to do so and this is explained by the preceding remarks. As the events are seen as punctual, 'irreducible' and viewed from outside, it is quite normal to expect that two events in the PS are not simultaneous, and so that one is happening before the other. Then the

[1] See [22].

[2] This sequence is usually constructed using several verb phrases and placing the last one after an *et*.

[3] It is a matter of fact that we don't have to use a new tense every time we introduce an event posterior to another in a segment of text; the order of the sentences and adverbs are in general enough to determine the temporal structure.

normal choice is to place first things first unless explicitly stated otherwise. Hence, in (1), the getting up of Pierre precedes his going up in his room. It could be objected that the succession is not only due to the PS but also to the use of the conjunction *et*. However we think that the conjunction is used more for stylistic reasons than for expressing temporal order, witness (2) where *et* appears only between the two last events.

(2) Pierre se leva, monta dans sa chambre, ferma la porte et alluma sa radio. (PS $\times 4$)

The order of the three first events is isomorphic to the order of utterance and the fourth event, introduced by *et*, is also preserving this order, i.e. it is understood as being posterior to the third. The conjunction *et* in a succession is typically used to announce the last relevant event of this particular succession (it would be quite strange to place the conjunction between the second and third events in (2)).
However the PS doesn't always imply succession and punctual event. There can also be no specific relationship between several sentences in the PS except that they all happen at a certain period, as shown in Kamp's example (3), see [9]. This example shows that an event can be partitioned in certain contexts.

(3) L'été de cette année-là vit plusieurs changements dans la vie de nos héros. François épousa Adèle, Jean partit pour le Brésil et Paul s'acheta une maison à la campagne.

The first sentence introduces an event which gets divided in the following sentence. But how this first event is divided cannot be told from the following PS sentences. In a way this first sentence 'asks' for an enumeration afterwards, and so the next verb phrases enumerate the list of changes in the life of the heroes, but in the absence of adverbs or ordering conjunctions (like *puis*) we cannot give the precise temporal relationship between those events. There are still other cases of this particular relationship between a sentence and some of its successors (usually called relation of *elaboration*) where the following sentences are in narrative succession ((4) is also taken from [9]).

(4) Pierre dîna chez "Madame Gilbert". D'abord il y eut un hors-d'oeuvre, puis *(il y eut)* une bouchée à la reine. Après cela le patron apporta une sole meunière. Le repas se termina par un dessert flambé. (PS $\times 5$)

In this example of elaboration, the first sentence says that Pierre had diner at "Madame Gilbert", the next ones describe what was eaten and reflect the order of succession of the dishes. Hence, in this narrative text, we have a first event e_1 which gets further subdivided into well-ordered events $e_2 < e_3 < e_4 < e_5$. We think however that this ordering cannot only be attributed to the use of the PS but is mainly due to the different ordering adverbs like *d'abord*, *puis*, *après cela*. On the one hand, if we replace e_2,e_3 and e_4 by *il y eut un hors-d'oeuvre, il y eut une bouchée à la reine et il y eut une sole meunière*, we are more in a configuration like (3) where we cannot really tell the precise relationships between events, even if our world knowledge would surely place at least e_4 after e_2 and e_3. And on the other hand the adverbs *d'abord*, *puis* and *après cela* imply the use of point-like events (the events cannot overlap in the structure *First..., then...*) like in a narrative succession (hence the PS fits well in this setting); the Imp for instance doesn't fit well in this single event reading setting because the adverbs are in conflict with its properties (unboudedness, seen from inside) (it could only be used to give an habitual reading if we add *comme d'habitude* (*as usual*) in the first enumeration sentence: *Comme d'habitude, il y avait un hors d'oeuvre, puis...*).
The Plus-que-Parfait (PqP) would also be a correct tense[4] in the elaboration of (4)

(5) (Ce soir-là) Pierre dîna chez "Madame Gilbert". D'abord il y avait eu un hors-d'oeuvre, puis *(il y avait eu)* une bouchée à la reine. Après cela le patron avait apporté une sole meunière. Le repas s'était terminé par un dessert flambé. (PS, PqP $\times$4)

Now, the question is, what difference is there between (4) and (5) (if any)? First we have to remark that it is not because we can use two different tenses in this sentence that there must be a completely different meaning for each. Nevertheless, the fact that both possibilities exist and that none has disappeared from the French language should account for a particular use in both cases. This brings us to a point on which we remained silent until now: we focussed on how the elaboration is made, but didn't say anything about the elaborated sentence *Pierre dîna chez "Madame Gilbert"*. The untensed sentence is an accomplishment[5] and we said until now that events (achieve-

[4] Notice that even if the sentence seems correct it would be better if the first sentence was with a PC.

[5] We think that *dîner chez "Madame Gilbert"* should be seen as an accomplishment. However one could argue against this point of view. This verb phrase doesn't combine in

ments, accomplishments) are usually seen as a whole and that the internal constituency of the event isn't important. However we think that this is not the correct picture here and to clarify this point we will also discuss the use of the PS with stative and activity verbs.
In sentences like (1) and (2) all the verb phrases are eventualities (achievements, accomplishments) and as such those verb phrases don't conflict with the PS: they can both be represented as closed intervals (bounded entities). It is usually claimed that the PS just imposes to see the event as a whole without reference to its internal structure

(6) Pierre traversa la rue lentement. (PS)

Hence, in the case of an accomplishment like (6), the use of the PS implies that the street was crossed, i.e. the culmination point is reached. The modifier *lentement* (slowly) shows that (6) cannot be considered as a punctual event but it definitely took time to cross the street. There is however no focus on the preparatory phase or the culmination point, the whole event happened slowly.
But the PS, used with stative and activity verbs, behaves quite differently. It coerces an activity or state into an event by usually giving it an inchoative reading like in (7) and (8) (it can also get this meaning with eventualities, i.e it is not a property of the PS with stative and activity verbs alone)

(7) Il fut président. (PS)

(8) Et la lumière fut. (PS)

The correct translation of (7) would be: he became president, and not he was president. The PS gives this inchoative reading except if the domain is bounded explicitly (*Il fut président de 1981 à 1995*). In (8), the stative verb with the PS obviously doesn't refer to an event corresponding to the state with a beginning and a termination point. It refers to the moment when the light first appeared (or was created). As Kamp says in [9], sentences like (7) and (8) are usually interpreted as denoting an event that is the onset of a

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a nice way with *en + explicit duration* which is one of the tests to differentiate between accomplishments and activities. Actually it can combine with *pendant + explicit duration*, hence we should, following this test, say that it is an activity. The probably most correct view would be to consider it as an activity with explicit boundaries, i.e. a beginning and a culmination point, or an accomplishment with no resulting state (other than the obvious and not really informative one: having stopped the activity phase). Hence our choice of an accomplishment is somehow arbitrary. It should become clearer why this isn't a real problem when we will deal with chapter 4 and 5.

state of the kind reported by the untensed verb phrase. The activity verbs can also get this interpretation[6]

(9) a. Il chercha. (=”Il se mit à chercher.”)(PS)
    b. Il écrivit. (=”Il se mit à écrire.”)(PS)

The PS can also put the emphasis on the end of the event (even if it is quite rare),

(10) Il dîna vite. (PS)

like in (10) which can have the meaning: *Il acheva vite de dîner*. We claim that a PS sentence (without temporal adverbials) is usually seen as a whole without reference to its internal constituency if it is a stand-alone sentence with an achievement/accomplishment verb phrase (and possibly some Imp sentences), otherwise, for instance in (4) and (5), we have the three different possibilities to interpret the first sentence, *Pierre dîna chez ”Madame Gilbert”* (this independently of the kind of eventuality the verb phrase describes). It could refer to the beginning of the accomplishment (≈*Pierre alla dîner chez ”Madame Gilbert”*), to the whole event with beginning and termination point or to the end of accomplishment (culmination point). Let us first examine sentence (5). In this example all sentences except the first one use a PqP which is often called the past of the past. It places the PqP event in the past of another event (or state or activity) which is already located in the past. Hence, in order to use it grammatically we should expect to have first an event in the past to which we can refer. This is the role of the first sentence in the PS. However, as the PqP sentences describe the succession of dishes in this particular dinner, the emphasis of the PS sentence (reference point) should be on the end of the event, otherwise it wouldn't make sense to use the PqP. We don't get an inchoative meaning of the accomplishment, but instead the emphasis is put on the culmination point of the accomplishment and the PqP sentences describe the preparatory phase. In a way the use of the PqP forces this interpretation as it is in need for a reference point to make sense. If there is no such constraint on the PS sentence for the interpretation, we think that it won't put the emphasis on the end of the event but that the inchoative or the ”whole event” interpretation is a lot more natural.
Now we have to see what happens in (4) as we have ruled out the possibility that the end of the sentence serves as reference point. Our objection to this

[6]The following three examples are taken from [19, p. 101].

representation should probably have more arguments, but we think that it is not abusive to consider that if there is no explicit evidence for such a possibility (as in the use of the PqP), we should keep things simple and just rule it out. Further, as we will see later on, there is a strong belief that, in a succession of PS sentences, the inverse temporal order is blocked (however, we will mention the few exceptions to this "rule") which confirms our objection. We just have two other possibilities, either the first PS sentence gets an inchoative reading, or the PS coerces the activity in an accomplishment. Let's suppose that the first sentence e_1 gets an inchoative reading, then we could paraphrase e_1 by *Pierre alla dîner chez "Madame Gilbert"*. Consequently the other events just rapport the order of the dishes after e_1. Hence we don't really have any elaboration at all but just a simple succession of events in a narrative. If the PS imposes to see the accomplishment "from outside" then we can only appeal to the relation of elaboration to explain how the following PS sentences are related to the first one. We are inclined no to choose between the two views. There is no evidence that the simple succession reading is less plausible than the elaboration reading.

We mentioned before that the PS blocks any inverse temporal reading. A PS sentence following another PS sentence is never understood as being anterior to the first, that is why it is usually said that the PS drives the narrative forward. However there are some counterexamples to this point. It is possible to obtain an inverse temporal order with a PS sentence introduced by *car* or *parce que*. In this case the sentence introduced by *car* or *parce que* has an explicative meaning (see [3])

(11) Le singe s'échappa. Nous ne le retrouvâmes plus, car il disparut dans la forêt épaisse. (PS $\times 3$)

Here, the third sentence is introduced by *car*, and cannot be understood as being posterior to *nous ne le retrouvâmes plus*; the not-finding cannot be preceding the disappearance, the right order of the sentences would be without *car*

(12) Le singe s'échappa. Il disparut dans la forêt épaisse. Nous ne le retrouvâmes plus. (PS $\times 3$)

In order to deal with example (11), De Swart introduces the rhetorical relation of causality (between e_2 and e_3) and explains that (as seen in (12)) e_3 stands in relation of narrative succession with e_1 which serves as reference point for e_3. However, this reading cannot be achieved without the use of *car* or some other conjunction, as we can see in those examples inspired from

Lascarides and Asher [12]

(13) a. Guillaume poussa un cri de douleur. Pierre lui donna un coup de pied. (PS, PS)
b. Guillaume poussa un cri de douleur car Pierre lui donna un coup de pied. (PS, PS)
c. Guillaume poussa un cri de douleur. Pierre lui avait donné un coup de pied. (PS, PqP)
d. Pierre donna un coup de pied à Guillaume. Il poussa un cri de douleur. (PS, PS)

Here (13-b), (13-c) and (13-d) all describe the same happening in different manners (Guillaume screamed because he got hit by Pierre). (13-b) is an example of the rhetorical relation of causality, (13-c) shows a typical use of PS/PqP and (13-d) is simple narrative succession. This reading is impossible for (13-a)[7], the PS blocks this possibility and the only interpretation possible is that Guillaume screamed and that, because he screamed, he gets hit by Pierre, i.e. we have a simple narrative succession.

We will, as concluding remarks on the PS, give some examples of sentences with subordinate and relative clauses and adverbials and look at how they influence the interpretation.

(14) Le général attaqua l'ennemi, qui se retira. (PS, PS)

In (14) the main clause introduces an event which serves as reference point for the relative clause. This is due to the fact that the relative clause is linked to the object of the sentence *l'ennemi*. If the subject of the sentence has a relative clause then the effect can be the opposite.

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[7] It is allowed in its English version, where we can have an inverse temporal order reading, see [12].

(i) Guillaume screamed. Pierre hit him.

Further, we want to say that the inverse temporal order seems to be achieved in the following example of Gosselin, [4, p. 117], without the use of *car*

(ii) Pierre brisa le vase. Il le laissa tomber. (PS $\times 2$)

It seems that we can derive the explanation reading for two reasons: first, the achievement of the first sentence is irreversible in the way that the object of the sentence is changed for good after the achievement(this doesn't happen in the first sentence of (13-a)), second, the anaphoric pronoun *le* in the second sentence refers to the the vase, not to the broken vase which is the result of the first sentence, hence, we expect that the second sentence applies to the not-yet-broken vase.

(15) Le gendarme qui m'arrêta repartit en direction de Bordeaux. (PS, PS)

In (15), it is the relative clause which serves as reference point for the main clause, however in these two examples (and we think in all the examples of this style) the order of the PS sentences reflects the order of the events, hence, there is no difficulty for the interpretation. This is different when we look at temporal subordinates like (16)

(16) a. Quand Alain ouvrit les yeux, il vit sa femme. (PS,PS)
b. Alain vit sa femme quand il ouvrit les yeux. (PS,PS)

It is often said that the usual construction in this case places the temporal subordinate in front of the sentence[8] as in (16-a), however, an example like (16-b) seems completely grammatical. In both sentences the obvious explanation is that Alain has to have the eyes open in order to see his wife. The subordinate is anterior to the main clause but there may be some partial overlap: *Alain ouvrit les yeux* is an accomplishment (it takes some time to reach the culmination point even if this time can be very short) and we think that the main clause represents an event that starts when the accomplishment still is in the preparatory phase. To express the fact that the main clause is strictly posterior to the subordinate, one would use the PA instead.

(17) Quand il eut ouvert les yeux, Alain vit sa femme. (PA, PS)

Somehow it seems that the PS in the subordinate introduced by *quand* often gets an inchoative meaning (especially for stative verbs). The explanation could be that,

- The *quand* subordinate provides the reference point for the main clause.
- In a PS+PS sequence, the main clause is often seen as "beginning" before the end of the subordinate (if this subordinate takes some time).
- The PS doesn't license inverse temporal order reading. Hence, the reference point has to be before the event introduced by the main clause.

It is also interesting to notice that *finir* doesn't fit in this setting

(18) a. # Quand il finit son travail, il rentra. (PS, PS)

[8]See [13, p. 57].

b. Quand il eut fini son travail, il rentra. (PA, PS)

In this example of Olsson [13], (18-a) is not grammatical whereas (18-b) is. That (18-b) is grammatical is not a surprise, the PA is a past in the past and forces the event of the main clause to be strictly after it. In this setting, *il finit son travail* (PS) describes an accomplishment; in particular, the last moments before the culmination point is reached, that is why it doesn't fit with another event which should happen after this culmination point. We saw in (16-a) and (17) that it is usually possible to have the subordinate with a PS or a PA and that it just results in two different interpretations. Kamp noticed these kind of problems ([9, p. 116]) and gave as example the following sentences

(19) a. # Quand il mangea, Jean partit pour la gare. (PS, PS)
b. Quand il eut mangé, Jean partit pour la gare. (PS, PS)

The first sentence is hardly making any sense; we think it is not so much a tense or aspect problem than a world knowledge problem. In (19-a), we expect to find in the main clause an event *compatible* with the event in the subordinate (as they have to be at least partly overlapping), which is obviously not the case in (19-a) whereas in (19-b) the PA imposes the event denoted by the main clause to be after the subordinate, hence, there is no such conflict of *compatibility.* We want to conclude this overview of the PS by some examples taken from [4].

(20) Marie but du café pendant dix ans. (PS)

Boire du café is surely an activity, so the PS coerces it into an event. However the temporal information is in conflict with the expected duration of such an activity. Therefore, the sentence gets an iterative reading, the PS+*pendant dix ans* coerce the sentence into an activity that has taken place for "precisely" ten years. Hence, if the PS verb phrase conflicts with the temporal adverbial, then the PS limits the event or process of the verb phrase to the period denoted by the temporal adverb and gives an iterative reading to this event or process (the process is not anymore coerced into an event) in this period.

(21) Marie but du café pendant dix minutes. (PS)

Here, the adverbial doesn't conflict with the activity in the sense that it is conceivable to drink coffee for ten minutes. The PS imposes boundaries for this activity. However this doesn't mean that the activity took place during the whole ten minutes but that it was begun at some time in the past and that it was stopped ten minutes later.

(22) Marie but son café pendant dix minutes. (PS)

Now the verb phrase is an accomplishment, hence following de Swart we couldn't have a single event reading of this sentence as *pendant* needs an homogeneous eventuality to apply to. We think that this sentence has a single event reading. The problem is that the adverbial forces a termination after ten minutes. The only part of an accomplishment that can be terminated is the preparatory phase, hence the underlying activity. That is why we obtain the meaning that Marie drunk her coffee during ten minutes but didn't finished it. That the coffee isn't finished is a pragmatic inference. If it was finished after ten minutes of drinking at the same time the activity stopped, then we should use the *en + explicit duration* construction as it is precisely what this construction describes.

Conclusion

In this section, we have seen that the PS presents the event it describes from a distance and as temporally closed. It is commonly used in narrative text to describe a succession of events. However, we saw that almost any relation between two PS sentences can be obtained under certain conditions (there are strict constraints, for instance, to get an inverse temporal order). Further, the PS is by nature in conflict with activities and states. In those cases, the PS usually forces an inchoative reading. Still, as the PS represents the eventuality it describes as closed, it can put the emphasis also on the end, or on the whole event.

2.2.2 The Imparfait.

We've already said that the Imp is better understood with reference to the PS and vice-versa, see (38) and (39). However, different authors give usually different comments on how it is to be interpreted and which of its properties is the most important. De Swart says in [3, p. 57], "sentences in the Imparfait are traditionally taken to describe background information that does not move the story forward". It follows Kamp's view which is motivated by the study of the tenses in narrative context and where the fact that the Imp doesn't move the narration forward is directly opposed to the fact that the PS does. Gosselin, in [4, p. 199], doesn't put the emphasis on background or moving the story line forward, but notices that "the Imp refers to a moment in the past during which the process is going on, without precision about the situation of the beginning and the end of the process."[9] He notices the anaphoric nature of this tense, in the sense that it cannot be used alone but only in reference to another sentence or with temporal adverbials (Kamp also has this insight in [9, p. 35]). Even if he recognizes the background use of the Imp, Sten, in [19], focusses on its use as "present in the past": "L'imparfait sert à indiquer une action qui serait du présent pour un observateur du passé,...", (the Imp serves to indicate an action which would be present for an observator in the past). We're going to explain these different positions by some examples. Let us extend example (16-a) (like [9, p. 12]) and rename it (23).

(23) Quand Alain ouvrit les yeux, il vit sa femme. (PS, PS)
  a. Elle lui souriait. (Imp)
  b. Elle lui sourit. (PS)

Here, we have a good example of the contrast between the Imp and the PS. The PS of (23-b) refers to an event which happens after Alain has opened his eyes and seen his wife, and, as we usually direct our smile to someone, it would certainly be interpreted as saying that his wife smiled because she noticed that he was looking at her. Hence this event "introduces a new temporal element into the story, the time of the smile",[10] i.e. it moves the story forward. Let's explain (23-a) in the light of the different ideas on the Imp. If we follow De Swart, this sentence does not move the story forward but gives some background information. The first point is for sure true, the Imp refers to an activity (extended in time) which begun at least before Alain saw his wife, and therefore doesn't move the story forward (it doesn't introduce a new time like the PS would do because we have no reference to when she begun to smile; the only thing we know is that she is smiling at the time that he opened his eyes). In this context, De Swart would probably call *elle lui souriait*, a "background information relevant to the situation at hand" (see [3, p. 57]). If *background* is referring to the anaphoric nature of the Imp, as in Gosselin or Sten, we surely agree. The Imp places a part of the process in the past at the same time as another event, and (23-b) alone does not itself constitute a correct sentence. However, here the Imp plays

[9] p. 199, [4]: "L'imparfait renvoie donc typiquement à un moment du passé pendant lequel le procès se déroule, sans préciser la situation temporelle du début et de la fin du procès. Ce temps apparaît non autonome (anaphorique) et situe le procès comme simultané par rapport à d'autres procès du contexte, et comme se déroulant en un même lieu.

[10] See [9, p. 13]

more the role of the past progressive in English and as such it doesn't only refer to background information but it is the only way to express that kind of relation between two events: an event happens (PS) and another one is going on at the same time (without having to specify when it begun).

A typical example of background information is when the Imp is used for descriptions as in (24)[11]. The first sentence uses a PS which introduces a new event (that of meeting someone's friend called Jean), the following Imp sentences just give background information about this person (young, blue eyes).

(24) Je rencontrai son ami Jean. Il avait 20 ans. Il avait les yeux bleus. (PS, Imp $\times 2$)

However the Imp in (24) and the one in (23) offer a different kind of background. Whereas we can expect that Alain's wife stops smiling after 5 minutes in (23), we certainly don't expect that the friend in (24) will have brown eyes after 5 minutes (nor will he be old). That is why De Swart speaks about stage-level predicates (for the situation at hand as in (23)) and individual-level predicates (information of a more permanent nature).

We saw that Gosselin (probably more than the other authors discussed here) insists on the anaphoric nature of the Imp. A stand-alone Imp is not grammatical, but is always linked to a temporal adverbial or another sentence to which it can refer. (23) and (24) are representative of this anaphoric use of the Imp (linked to a PS sentence). We also cite here some of Gosselin's examples to illustrate some other ways of reference (see [4, p. 195]).

(25) a. Mercredi, il pleuvait. Jeudi, il faisait soleil. (Imp, Imp)
b. Le grand-père de Marie était noir. (Imp)

In (25-a), the Imp is bounded by the day it refers to. The processes are included in the periods (intervals) delimited by *mercredi* and *jeudi*. In (25-b), the noun phrase *le grand-père de Marie* plays the role of reference point (here we should better say reference interval) for the Imp. Here the state gives us a description of some properties of the subject.[12] It should be noted that it is considered (by Kamp and De Swart among others) that the Imp contains the reference point it is attached to, and this takes the form in DRT of the conditions $t \subseteq s$, $t \subset s$ or $s \circ t$. However, we have here a quite different

[11] See [3, p. 57]

[12] We cite Gosselin's original formulation in [4, p. 127]: "...le procès ainsi exprimé sert à caractériser cette entité en en décrivant des propriétés stables."

condition as the state referred to by the Imp is itself included in its reference point, i.e. $s(il\ pleuvait) \subseteq t(mercredi)$.
The Imp, like the PS, can be interpreted as an explanation reading when coming after a PS sentence. Then it couldn't be said that it includes its reference point (if we consider that it has tobe the previous sentence).

(26) Max rentra. Le soleil lui brûlait les épaules.[13] (PS, Imp)

(27) Jean attrapa une contravention. Il roulait trop vite.[14] (PS, Imp)

We could introduce the conjunction *car* for both sentences (26) and (27) to emphasize the relation of explanation, but it is also correct without. In both cases the sentence in Imp is understood as leading to the event of the first sentence, i.e. it is because Jean drove too fast that he got a ticket afterwards.

(28) Jean tourna l'interrupteur. La lumière éclatante l'éblouissait.[15] (PS, Imp)

On the other hand, the Imp sentence in (28) is seen as a consequence of the first sentence in the PS, and the light cannot blind Jean before he switched on the light. De Swart, in [3, p. 59-61], considers that the reference point for the Imp sentence is not the PS sentence but its consequent state (the light is switched on). Then we have simultaneity between the Imp sentence and its reference point. She calls this notion *temporal implication* and she gives quite the same explanation for (26) and (27), introducing the notion of *temporal presupposition* (in (26), the sun is burning Max's shoulders while he is not yet back in : presupposition of the PS sentence).[16]

Now we want to look at how the Imp behaves in presence of temporal adverbs like *en*, *depuis* or indications of time.[17] We will use some of Gosselin's

[13]See [3, p. 59]
[14]See [3, p. 59]
[15]See [3, p. 58], adapted from Kamp's example.
[16]Gosselin describes this phenomenon similarly by a shift to the state before or consequent to the event in the PS. His example for (26) and (28) are respectively (see [4, p. 202])

(i) Marie se leva à 5 heures du matin. Elle dormait seulement depuis une heure. (PS, Imp)

(ii) Marie ouvrit la fenêtre. La lumière de l'aube inondait la pièce. (PS, Imp)

[17]Notice that most of those sentences should have a reference point to be "attached to", for instance, a PS sentence placed before.

examples [4, p. 11, 31-36].

(29) Luc mangeait depuis cinq minutes. (Imp)

This sentence describes a process that is going on in the past. The Imp places the process in the past and the adverb *depuis cinq minutes* imposes a left boundary on the process, i.e the beginning of the process. The process of eating is compatible with the temporal adverb in a single event reading and there is no coercion going on. This is quite different in

(30) Luc dessinait depuis dix ans. (Imp)

Here the activity of drawing is not compatible with "since ten years" in a single event reading. The conflict is resolved by giving to the activity an iterative or habitual reading. We have already said that *en* combines with accomplishments so we should expect a conflict in the following sentence

(31) Luc mangeait en cinq minutes. (Imp)

Here we have the same problem as in (4). We should consider the verb phrase with temporal adverbial either as an accomplishment without resulting state or as an activity with explicit boundaries. Fortunately we don't really need to choose because either way it conflicts with the Imp which should denote the process going on in the past and viewed from inside. The conflict is resolved by giving an habitual reading to the sentence that could be paraphrased by "Luc used to eat in 5 minutes". The coercion mechanism can also be more complicated as in

(32) Pierre mangeait sa soupe en cinq minutes. (Imp)

where the verb phrase is an accomplishment. The sentence can be interpreted as describing an accomplishment that occurred in the past repeatedly within a certain period for which we do not know the boundaries, but that is now (at the time of speech) over. This example also poses the problem of how the coercion effectively functions. Do we have to treat the conflict as 1)(VP+Imp)+TA or 2)(VP+TA)+Imp?

1) (VP+Imp)+TA: The VP denoting an accomplishment is coerced into an activity $VP_{activity}$ by the use of the Imp (as we said before, we should then be in the preparatory phase). Then the TA, which needs an accomplishment to apply to, coerces the $VP_{activity}$ into a $VP_{accomplishment}$ which then needs to be iterated in a period around the reference point. This doesn't seem to be very convincing!

2) (VP+TA)+Imp: The accomplishment (untensed VP) gets a completed meaning by the use of the TA (which records the length of the accomplishment with the termination point). Then the Imp coerces this completed accomplishment in an iteration of it (without boundaries) which includes the reference point.

We actually think that the correct coercion is 2). It can also be seen if we look back at example (31), where the untensed VP is an activity. With 2), the untensed VP is coerced into an accomplishment by TA and then the Imp gives the iteration as in 2). With 1), the TA would have to coerce the activity (VP+Imp) to an accomplishment and then in an unbounded iterated accomplishment. It seems to be asking a lot of the TA *en cinq minutes* to do all these transformations. Further, if the correct interpretation of the coercion mechanism was 1), we could expect to put the temporal adverb infront of the sentence and to get the same meaning. However, *en cinq minutes* cannot be detached in front of the sentence which supports that 2) should be the good representation.

(33) A huit heures, Pierre se reposait. (Imp)

In the preceding sentence the temporal adverb is put at the beginning of the sentence and plays the role of reference point. This leads to the interpretation that Pierre was sleeping (single event reading) at 8.00 and, as in the common use of the Imp, the reference point is included in the activity denoted by the VP. However, we don't get this interpretation if the temporal adverb is included in the VP as in

(34) Pierre se reposait à huit heures. (Imp)

Here we get an habitual reading, i.e. "Pierre used to rest at 8.00". The reference point must be some sentence preceding (34) or some detached temporal adverb as *(En période de travail)*, *(A cette époque)*. The untensed VP denoting an activity gets an inchoative meaning in the presence of the temporal adverb. The Imp cannot coerce it in an uncompleted process, hence, it has to give an uncompleted iterative reading.

(35) A huit heures trente cinq, Pierre mangeait sa soupe. (Imp)

(36) Pierre mangeait sa soupe à huit heures trente cinq. (Imp)

We get approximatively the same result if the VP denote an accomplishment. Sentence (35) gets the same interpretation as (33), the only difference is that the VP is an accomplishment which is coerced into an activity by the

Imp (preparatory phase). Hence, at the time of the reference point Pierre was still in the preparatory phase of the accomplishment. However, sentence (36) doesn't yield the same interpretation as (34). Here, the untensed VP denoting an accomplishment is coerced by the temporal adverb into a punctual event. It gets an inchoative meaning, i.e. Pierre begins to eat his soup at 8.35. Further, the Imp coerces this event in an unbounded habitual because it cannot transform it in an unfinished single event.

The Imp can also have the effect of increasing the size of an achievement, as in

(37) Luc ouvrait la porte, quand il reçut une balle en plein front.[18] (Imp, PS)

The temporal subordinate (with PS) is included in the main clause. The Imp doesn't coerce the achievement in an activity (for "opening the door" couldn't be called an activity), and we don't get an habitual reading because of the subordinate. Hence we must either consider that the event "opening the door" is extended in time or that it is viewed as an accomplishment. We will consider it becomes an accomplishment. This is a common problem with some achievements; they can be considered at different levels of granularity. We should actually always consider that kind of verb phrases as accomplishments, that is, "opening the door" can be decomposed in different phases. It is actually seen as an achievement in those cases where the resulting state (the door is opened) and not the whole accomplishment is of importance.

2.2.3 Aspect and coercion.

We want to treat some examples involving coercion with temporal adverbials which are less straight-forward than what we have seen until now. It is nice to notice that the rare encounters one can have with the word *aspect* in French grammar books are for sentences as the following

(38) Chantal écrivit une lettre. (PS)

(39) Chantal écrivait une lettre. (Imp)

where (38) will usually be regarded as a point-like event happening in the past (this due to the use of the PS). Here we don't mean that the event is seen as taking no time but just that the internal constituency of the event

[18] See [4, p. 200]

has no importance[19], i.e. the event is seen as an irreducible entity. (39) is also located in the past but is seen as the activity of writing a letter; the Imp places us inside the untensed event, to be more precise in the preparatory phase of the accomplishment *Chantal écrire une lettre*. That is why in [9], Hans Kamp claims that the PS and the Imp overrule the aspectual information of the verb phrase; the PS by zooming out of the internal constituency of the accomplishment, putting the reader or hearer 'outside' the event and the Imp by zooming on this structure, putting the reader in the preparatory phase. It should however be noted that the internal structure of the accomplishment doesn't vanish when we use a PS. The use of the temporal adverbial in

(40) Chantal écrivit une lettre en une heure. (PS)

gives us information on the preparatory phase of the event; *en* records that it lasted for one hour before the letter was finished. It is a property of this adverbial to combine with telic events and to record their duration. This test is often used to distinguish between activities and accomplishments, the latter combine with *en*, the former with *pendant*. Hence, as we have seen that the Imp coerces the accomplishment *Chantal écrire une lettre* into the activity corresponding to the preparatory phase, it should combine correctly with *pendant* as in

(41) ? Chantal écrivait une lettre pendant une heure. (Imp)

resulting in the single event reading of Chantal being in the process of writing a letter for one hour. However (41) doesn't seem to be felicitous. De Swart claims in [3, p.47-48] that it is because *pendant* as eventuality description modifier needs as input an homogeneous eventuality (state or process) and that (41) doesn't satisfy this constraint. We agree with de Swart that the adverbial applies first to the untensed verb phrase and that the tense is applied as last in the interpretation. However we will argue for a somewhat different explanation of the problem. The adverbial does conflict with the accomplishment in the following manner. *Pendant*, citing De Swart, imposes boundedness on the state or process it applies to but the accomplishment refers already to a culmination point(at least implicitly), that of the letter being written. Thus, it is actually the right-boundary imposed by *pendant* that is in conflict with the culmination point of the accomplishment. We would like to stress that it is only the right-boundary that is in conflict with

[19] Here we follow Comrie. See [1].

the culmination point, as we can see in (42), the activity corresponding to the preparation phase can be attributed a left-boundary with *depuis*

(42) Chantal écrivait une lettre depuis une heure. (Imp)

Suppose that in (41) the culmination point is reached before the end of the duration. In that case the sentence doesn't make any sense as the activity is stopped before one hour. Suppose the culmination point is reached precisely after one hour, then we must use (40)[20] to express it, or the paraphrase [mettre (duration) à/pour (verb phrase)] as in

(43) Chantal mit une heure pour écrire une lettre. (PS)

Hence using *pendant* could be understood as stressing the fact that the activity part of the accomplishment has the duration of one hour and that the letter is not finished. The reader must realize that this meaning is the result of a complex reasoning and should not be mistaken for a default implicature. This is due to the fact that this sentence is actually quite odd and that, in order to express the same meaning, a normal French speaker would probably not use this construction but would use two sentences instead.
On top of this comes the Imp. In the classical interpretation, the Imp denotes imperfectivity of the event or state referred to. Here, it would mean that we are in the activity phase of the accomplishment. Why this interpretation cannot be achieved is because we partially resolved the conflict of the untensed sentence, i.e. saying that the most probable interpretation is that the letter is not finished after one hour, and that now the Imp would "put" us in the activity phase, i.e before the one hour is finished (viewing the situation from inside) but it should still imply that the letter won't be finished! In order not to conflict with the fragile interpretation of the untensed sentence, the Imp would have to denote an habitual reading. The situation is seen from inside, that is at a time in the past this accomplishment was an habitude for Chantal, see (45). We understand however that we had to make a lot of coercions to get a possible meaning, and that this sentence could still remain odd for some readers.[21]

[20]We are not sure if it is at all possible to make reference to the whole preparation phase of an accomplishment without the culmination point, but we doubt it seriously!

[21]As Comrie remarks in [1, p. 33-34], the progressive and non-progressive forms are not obligatorily distinguished in French, and the Imp can eventually take a progressive meaning (especially if there is no direct evidence for an habitual reading, as for instance with *chaque jour*).

The habitual reading seems a lot more natural with *en une heure*, as shown in

(44) (A cette époque,) Chantal écrivait une lettre en une heure. (Imp)

Here the untensed sentence is clearly an accomplishment and *en* doesn't conflict with it in any way (*en* combines with telic durative events). However, this combination of an accomplishment with *en + duration* doesn't seem to be an accomplishment anymore, but looks more like an achievement. It tells us something about the culmination point, i.e. that it is reached after one hour. In this example the Imp cannot get a progressive meaning without a complicated coercion, but it can easily coerce the sentence into an habitual one. This achievement was at that time something habitual.
We don't want to say that (41) could never be used, indeed there is a possible context where the sentence could make sense. If we force an habitual reading of the sentence by putting in front of it, for instance *Tous les matins*, as in

(45) Tous les matins, Chantal écrivait cette lettre pendant une heure. (Imp)

then we could interpret it as an habitual activity (Chantal has to write this letter to someone) that is doomed to fail as she never manages to finish this letter. Now that we have an example of use of this sentence, we can remark that *pendant* is obviously not limited to states and activities (for a single event reading) as it also can denote simultaneity with another event in the form of *pendant ce temps(-là)* (which is perfectly fine with the Imp but also with the PS).

(46) Chantal écrivait une lettre pendant ce temps. (Imp)
Chantal écrivit une lettre pendant ce temps. (PS)

To conclude these examples, we can say that the aspectual class of the untensed verb form is of particular importance even if the sentence is coerced into another class by the use of an Imp or PS. We would have spared some paper if our example was *Chantal écrivait <u>des</u> lettres*, where the untensed form of the sentence is an activity which can correctly combine with *pendant*. Those examples show clearly that the phenomenon of coercion can be quite complex and before we go further in this direction we will give some examples of the 'normal' use of the PS and Imp.

2.2.4 The Passé Antérieur.

In the literature, the PA is usually considered as a past in the past that denotes an event directly preceding another one (usually in the PS), i.e it is used for succession. In [19, see footnote 2 p. 214], Sten gives a definition from M. Dauzat (Phonétique et grammaire historiques de la langue française) which could be translated as follows. The PA denotes an "immediate or precise anteriority". It is also said that the PA makes reference to the end of the event it denotes. Finally, as compound tense, it is in the category of the perfect tenses.
A typical use of the PA is in a subordinate introduced by *quand*, *lorsque*, *dès que* among others, and where the main clause is in the PS.

(47) Après qu'il eut mangé, Jean partit pour la gare.[22] (PA, PS)

It is often said in those cases as (47) that the subordinate+PA structure denotes "the initial phase of the consequent state" of the subordinate[23] (i.e. an inchoative meaning). To use Kamp's words in [9, p. 113], it denotes "the onset of state which results from his having eaten: It is the time of the beginning of the result state that serves as an anchor point for the location of the main clause event".
Sten's definition applied to (47) says that the two events are in the relation of immediate or precise anteriority, i.e. PA event < PS event. In this case we shouldn't expect an immediate anteriority but precise anteriority. What we mean by precise anteriority is that the interpretation of the sentence doesn't allow any relevant event in between the two clauses. The emphasis is on the relation between this two clauses independently of what could happen in between.[24] This aspect of the PA is best seen in comparison with the PS.

(48) Dès qu'il mangea, il se sentit mieux. (PS, PS)

(49) Dès qu'il eut mangé, il se sentit mieux.[25] (PA, PS)

[22]See [9, p. 113].

[23]See Gosselin [4, p. 213].

[24]We cite this example from Michelet given by Sten, [19, p. 214]

(i) La république romaine ne tomba que 500 ans après qu'elle eut été fondée par Brutus. (PS, PA)

In this example we cannot speak about immediate anteriority, however, there is a precise anteriority between the two events. The period of 500 years refers to the time between the completed foundation of the Roman republic by Brutus (initial phase of the resulting state) and its fall.

[25]See [4, p. 212].

Sentence (48) says that as soon as he began to eat he felt better, whereas (49) says that once he had eaten he felt better. In (48), the PS clause gets an inchoative meaning, i.e. *Dès qu'il mangea* denotes the starting point of the underlying activity. In (49), we have to consider the initial phase of the resulting state of the completed activity, i.e. having eaten.

Chapter 3

Formal methods

In this section we will introduce some methods used to deal with the semantics of temporality and aspect in French. The goal is to tackle the problems we've seen in the previous section. Our attention will go to the work of Hans Kamp, Henriëtte de Swart *et al.* and Laurent Gosselin.

3.1 Kamp's method

Kamp's approach is based on the study of narrative text and especially the effect of the PS and Imp on the representation of a segment of text [8]. His analysis of the tenses is then used to make a Discourse Representation Structure (DRS) of a sentence (or text). It was initiated by the remark about the PS and Imp in [8, p. 400], that "what distinguishes the Imp and the PS does not lie in the contribution they make to the truth condition of the sentences in which they occur, but rather in the different directives they convey to the adressee concerning how he is to represent to himself the contents of the sentences which these tenses mark".

3.1.1 Reichenbach's analysis.

Kamp's analysis of the French tenses [9], and in particular of the PS and Imp, involves the use of a *reference point.* This concept is due to Reichenbach [14], who introduced it to account for the problems of temporal anaphora in natural language. He characterized the meaning of tenses of a verb by a pair of temporal relations. The relata of these relations are the speech time, the reference time and the event time. The speech time corresponds to the time at which the sentence is uttered and the event time is the time of the event (or state) the sentence describes. The reference time is a sort of "vantage point" (Kamp's expression) from which the event or state is looked at. The two temporal relations then are between the speech time and the reference time, and the other between reference time and event time. However, Kamp uses a variant of Reichenbach's analysis, introducing new elements in the picture. He uses an improved version of Reichenbach's reference point. His argument is that only one reference time is not always enough and that it should therefore be replaced by a pair of notions. We can explain it better with the following example (an *extended flashback* taken from [9])

(1) Alain arriva au sommet vers midi. Il s' était levé à cinq heures et demie, avait préparé son lunch, s'était mis en route et avait passé la station de base avant sept heures.
Alain reached (PS) the top around noon. He had woke (PqP) up at 5.30am, prepared (PqP) his lunch, begun to walk (PqP) and had passed (PqP) the base camp before 7am.

The first sentence is a PS clause, and all the other clauses use a plus-que-parfait. The role of reference point is attributed to the first sentence and all the PqP clauses "lie" before "Alain's arrival at the top". However the

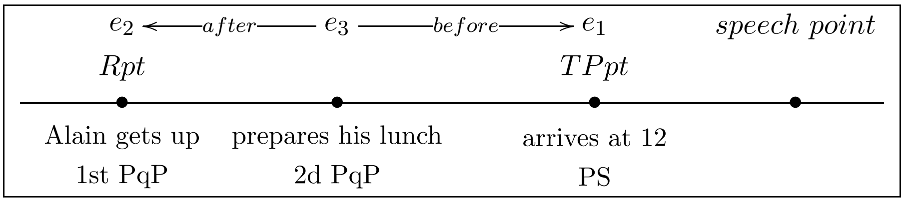


Figure 3.1: Interpretation of the second PqP clause of (2.1)

second PqP clause, "Alain preparing his lunch", is not only before the first clause, but is also understood as being after "Alain's getting up". To solve this problem, Kamp splits the notion of reference time in two, and uses the notions of Reference point, Rpt, and Temporal Perspective point, TPpt. In the example, we will refer to the role played by the clause "Alain gets up" in the interpretation of the second PqP clause as Rpt, and the TPpt will be illustrated by the role of the PS clause in relation to "Alain prepared his lunch". Furthermore the TPpt is closer to the reference point of Reichenbach than the RPt and it will be used in the interpretation of every sentence. Hence, Kamp uses four ingredients: TPpt, the temporal perspective point; Rpt, the reference point (only used for some tenses as the PqP); Spt, the speech point or speech time (when a sentence is uttered or read) and the TL time, the temporal location time (when the event or state is happening).

3.1.2 The features system.

Kamp considers that tense and aspect are "modes of classifying properties" [10, p. 556]. Tense and aspect are categories of properties with somehow different domains, for instance, tense is a category of properties applicable to complete sentences. In particular, the relation between the TPpt and the Spt is one of those properties. On the other hand, aspect is applicable to verbs, verb phrases and complete sentences and one of its properties is represented by the feature PROG that we will describe afterwards. The properties of tense are for instance represented by the means of the features *TENSE* and *Temporal Perspective* (TP for short), defined for certain types of expressions (complete sentences). First we have to explain what is really meant by the word *feature*. The purpose of a feature is to collect properties into families, that is to distinguish among the members of a class by giving to these members one of its feature value. Features will therefore be considered as functions which assign to each member of a class one of its value. For instance, the feature TENSE will have the three values *past*, *pres* and *fut* and will account for the different orders of the Temporal Location time with respect to the Temporal Perspective point in the obvious way. The Feature TP has two values, +PAST and -PAST, that will account for the relation between the TP point and the Speech point. +PAST means that the TP point lies before the S point, -PAST that TP point and S point coincide. The third feature Kamp introduces, and which serves among other things to distinguish between PS and Imp, might be described as an *aspectual feature*. Kamp considers that as temporal operators PS and Imp coincide but that, as aspectual operators, they are diametrically opposed. The feature serves to mark the contrast between punctual and durative. It will be this feature that decides whether the sentence is to be interpreted as introducing an event or state and as part of this decision, how this new element must be temporally related to the TL time (i.e. whether it should include the TL time or be included in it). It will be called PROG and will have two values, +PROG and -PROG. In English these would be assigned to the progressive and non-progressive forms, respectively, of non-stative verbs or verb phrases. In French the PROG-value of Imp is +PROG and that of the PS is -PROG. PS and Imp are now distinguished in that the former determines the feature value combination ⟨-PAST, past, -PROG⟩ and the latter either ⟨-PAST, past, +PROG⟩ or ⟨+PAST, pres, +PROG⟩.

Tense Form	TP	TENSE	PROG	PERF
present	−PAST	pres	±	−
PS	−PAST	past	−	−
Imp	+PAST	pres	+	−
futur	−PAST	fut	±	−
PC	−PAST	past	−	−
	−PAST	pres	+	+
PqP	+PAST	past	−	−
PA	−PAST	past	−	+
FA	−PAST	fut	+	+

Figure 3.2: Some possible feature values of the most common tenses

The last feature used by Kamp is called PERF and is used to make the distinction between perfects and non-perfects. Kamp sees the perfect as an operation on the untensed verb phrase such that:
"if the underlying VP is one typically used to describe events, then the new VP serves to describe the kind of state that results from the event having obtained; and if the underlying VP is itself stative the new VP serves to describe the state resulting from having been, but being no longer in the kind of state described by the underlying VP", [9, p. 107].
To illustrate the use of this feature, we can have a look at the following examples

(2) a. Jean mange une pomme.
Jean is eating (present) an apple.
b. Jean a mangé une pomme.
Jean has eaten (PC) an apple.

The feature values for Tense, TP and PROG of examples (2-a) and (2-b) are the same, i.e. ⟨-PAST, pres, +PROG⟩, the difference is that the underlying event in (13b) has been "perfected" whereas (13a) hasn't. Hence (13a) gets the following feature value combination ⟨-PAST, pres, +PROG, -PERF⟩, and (13b) gets ⟨-PAST, pres, +PROG, +PERF⟩.

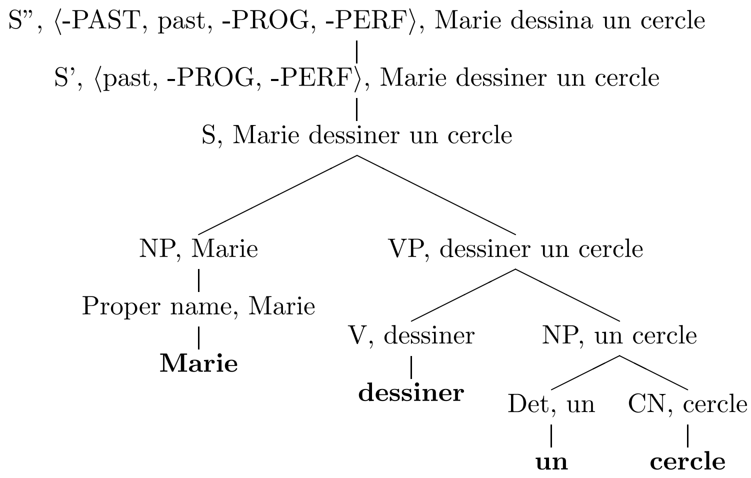
3.1.3 The system of construction rules.

It is not our aim to review the method for constructing a DRS, neither to state all the rules we' ll have to use to do so; for a comprehensive overview the reader should look at [11] and [10]. Further we will not detail the mechanisms for constructing structural descriptions, but will assume we can get those descriptions from modern generative syntax. Hence, following Kamp's method, we take it for granted that

(3) Marie dessina un cercle.
Marie drew a circle.

has the following syntactic tree

(4)



This syntactic description will serve as input to the rules for constructing the DRS. But one could legitimately ask where this structure comes from. To "clear" this point we can cite Kamp in [10, p. 512] where he says that, "the syntactic structures that we will make use of are motivated in large part by the role they have to play as inputs for the construction algorithm", i.e. these descriptions are "a means to an end". Kamp recognizes in [9, p. 226] that those syntactic descriptions will have to be replaced by "something more respectable" as they "undoubtedly evoke in any educated syntactician a mixture of horror and derision". However our aim is not to find a more respectable description and we will therefore use Kamp's descriptions without complaining further but we will give an example of how this description is used as input in the construction algorithm.
First we will "define in an informal manner" a (on purpose) narrow fragment of French. We will only allow simple tensed sentences without temporal adverbs (we don't use any perfect tense either in order to keep it simple). Then the phrase structure rules are as follows,

R1	NP	$\longrightarrow$	Proper name
R2	NP	$\longrightarrow$	Det CN
R3	VP	$\longrightarrow$	TV NP
R4	VP' (PROG value)	$\longrightarrow$	VP
R5	S	$\longrightarrow$	NP VP'
R6	S' (TENSE)	$\longrightarrow$	S
R7	S" (TP)	$\longrightarrow$	S'

and, for our example, we will just have the following lexicon,

Det	un
CN	cercle
Proper name	Marie
TV	dessiner +obj

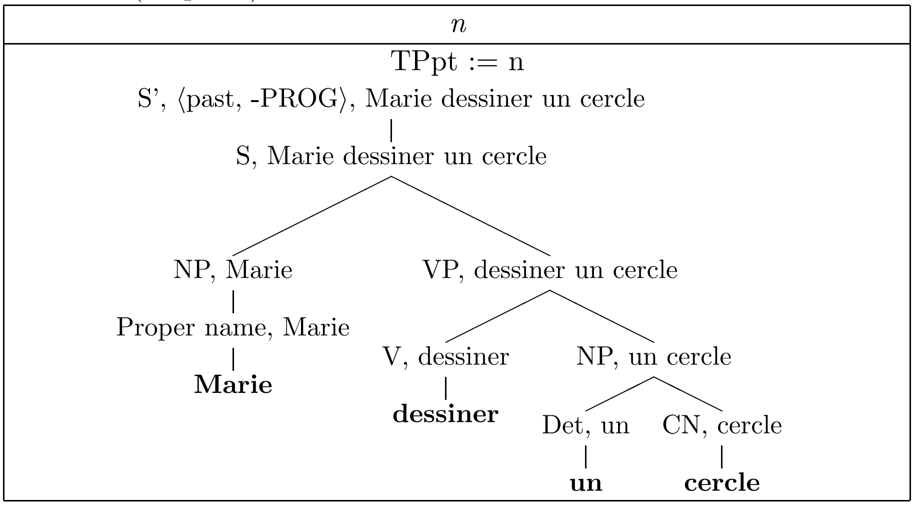
We can first make a link with what we said in the previous section, that is, the TP feature is only applicable to the whole sentence (actually at the level S"), whereas the TENSE feature applies to S" and S' and the PROG feature applies to VP', S, S' and S". We stress one more time that Kamp uses that kind of phrase structure rules (with the introduction of different features at different levels) to get syntactic descriptions well-suited for the construction algorithm; that is their main justification. In example (4) we didn't put any node for VP' and wrote the PROG information only at the S' level. Nevertheless the PROG information is available at level VP'; we just don't write it in the tree because the construction rule for the PROG feature is triggered before the (missing) VP' node.

The processing of a new sentence begins with the introduction of a discourse referent for the Spt in U_k (called n), the construction algorithm then proceeds from the top node S" to the bottom nodes using construction rules for the processing of the features information and the syntactic information (Proper name, NP, etc...). We don't want to give all rules and prefer to show the result of their application on (4), however we give as example (a simplification of) the rule for the processing of the TP feature on the top node S" (see [9, p. 188]). The function of this rule is "to choose a TPpt in accordance with the TP-feature". It reduces the conditions expressed by S" to the one expressed at node S'.

- If the TP value is -PAST, add to Con_k the condition (TPpt := n) and replace S" by subsequent information (S').
- If the TP value is +PAST, introduce a new discourse referent t to U_k add to Con_k the conditions (t < n) and (TPpt := t) and replace S" by subsequent information (S').

Each phrase structure rule gets a construction rule associated with, but instead of summing up all the rules we now turn to an example. For instance the "temporal" and "aspectual" part of the construction of (4) (without the PERF feature) proceeds as follows:

i) We first introduce a new time discourse referent n for the Speech time, and the feature value −PAST of the feature TP introduces in Con_k the condition (TPpt=n).



ii) There is no need for a Rpt (we saw that the Rpt is only needed in constructions involving verb phrases in relation with other verb phrases).

iii) There is no temporal adverbial in the sentence.

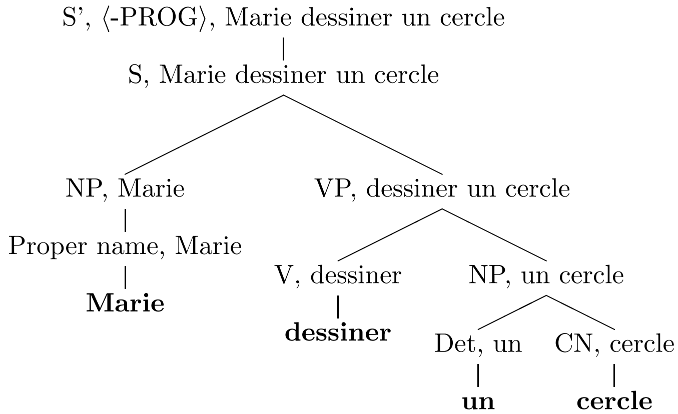
iv) The TL time is determined by the feature TENSE = past, which means that the TL time is strictly before the TPpt. The rule triggered ([9, see rule FR8.1]) introduces a new time discourse referent t in U_k and add the conditions (TLt = t), and (TLt < TPpt) to Con_k.

n t

TPpt := n

TLt := t

TLt < TPpt



v) Then as the PROG-feature has the value −, we introduce a new event discourse referent e in U_k,

vi) and add to Con_k the following conditions, a DRS with empty discourse referents, (e: (sentence with infinitive verb)), and (e ⊆ TLt).

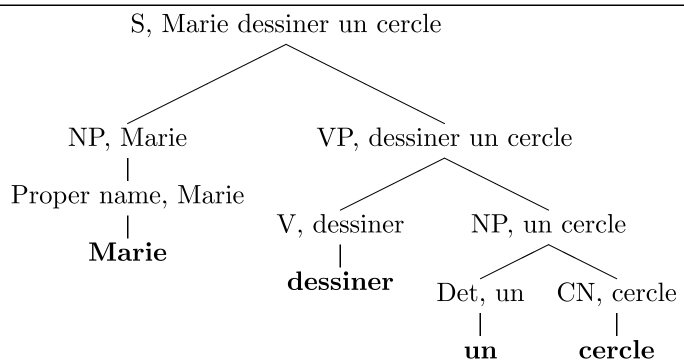
n t e

TPpt := n

TLt := t

TLt < TPpt

e:



e ⊆ TLt

Hence, after processing of the syntactic structure in e and erasing the informations about the construction's steps, we get the following DRSs

(5)

$$\begin{array}{|c|}\hline n\ t\ e\ x\ y \\ \hline \text{t} < \text{n} \\ \text{Marie(x)} \\ \text{cercle(y)} \\ \text{e: } \boxed{\text{x dessiner y}} \\ \text{e} \subseteq \text{t} \\ \hline \end{array}$$

We can notice that in this example the verb phrase denotes an accomplishment but that the discourse referent introduced is an event. We can also give an example with a stative verb (example taken from [3, p. 44]).

(6) Jeanne savait la réponse.(Imp)

$$\begin{array}{|c|}\hline n\ s\ t\ x\ y \\ \hline \text{t} < \text{n} \\ \text{Jeanne(x)} \\ \text{Réponse(y)} \\ \text{s: } \boxed{\text{x savoir y}} \\ \text{s} \circ \text{t} \\ \hline \end{array}$$

Hence the construction of the DRS is determined by the features values. However it can be noticed that we haven't spoken about lexical aspectual information at all, but only about the aspectual information given by the tense form (remember one of Kamp's main ideas that the PS and Imp "overrule" the aspectual information of the verb phrase).

3.1.4 Problems in Kamp's analysis

First of all we want to comment a technical part of DRT as expressed in [10]. Kamp uses an event structure as described in 1.2.2 in the definition of a model. Hence there are no "begins before" and "ends before" (or abut) relations which is a problem if one wants to obtain an instructive instant structure. We acknowledge that he doesn't use the instants construction in order to define time (he uses an independent time structure) but should this construction at least be relevant from a cognitive point of view, then the event structure should include the other predicates. Furthermore, the reader should remark (see [9]) that the relations used in the DRSs to express how an event or state is related to a discourse referent for time are precisely the relations of the event structures of Kamp's construction with the addition of the abut and the inclusion relation. However the abut relation isn't define in [9]. It is used in an ad-hoc manner and no new postulates are added on the event structure.

Kamp's work is focussed on the analysis of tenses (in particular the difference between the PS and the Imp) and all the features he uses reflect this choice. In his analysis the features values for a given tense do overrule the aspectual information one could have about a verb phrase. Hence, it becomes difficult to make a distinction between an [achievement verb + PS] and a [stative verb + PS] (inchoative reading). Kamp does realize this problem in [9, p .341] where he says, "we should have preferred to leave them *(i.e. aspectual distinctions)* aside altogether, reserving a serious attempt at their analysis for a subsequent study. Unfortunately this isn't quite feasible, for even in French the phenomena of tense and aspect are so intricately interwoven that one cannot hope to give a systematic account of the one without talking about the other at all." The problem of coercion is clearly not a priority in [9]. However, Kamp introduces in [10, p. 579] new "functors" on event and states, *end()* and *beg()*, to treat the problem of the perfects of stative verbs in English. This method doesn't seem very satisfactory to account for the inchoative meaning of a stative verb in the PS. As a matter of fact, the DRS still contains a state for the untensed verb phrase and not an event which seems very counter-intuitive as in one of our previous examples (augmented here with what the features values should give us for DRS and with what we think the DRS would be with the beg() functor[1])

(7) a. Il fut président.

b.
$$\begin{array}{|c|}\hline n\ t\ e\ x\ y \\ \hline \mathrm{t} < \mathrm{n} \\ \mathrm{Il(x)} \\ \mathrm{President(y)} \\ \mathrm{e:} \ \boxed{\text{x être y}} \\ \mathrm{e} \subseteq \mathrm{t} \\ \hline \end{array}$$

[1] $\supset\subset$ stands for the abut relation.

c.

$$\begin{array}{|c|}\hline n\ s\ t\ x\ y \\ \hline \text{t} <\text{n} \\ \text{Il(x)} \\ \text{President(y)} \\ \text{s} \circ \text{t} \\ \text{e} := \text{beg(s)} \\ \text{s: } \boxed{\text{x être y}} \\ \text{e} \supset\subset \text{s} \\ \hline \end{array}$$

where the stative verb in the PS interpreted inchoatively is translated not by *He was president* but by *He became president* which is obviously an event and not a state. As we said the DRSs don't seem to be correct. On the one hand (7-b) the typical stative verb *être* gets the label *event*, and on the other hand, in (7-c) the label of the verb is a state but we want to describe an event!

Another problem with the DRS representation is that the DRS resulting of the construction's steps (as in, say (3) and (6)) is often a lot less instructive than the construction's steps themselves. For instance, in the DRSs (5) and (6), we have two discourse referents t and n which correspond to the same referents, i.e. t is the temporal location time and n is the speech time. However they play a completely different role in the two DRSs. In (5) repeated here as

(8)

$$\begin{array}{|c|}\hline n\ t\ e\ x\ y \\ \hline \textbf{TLtime=}\ \text{t} < \text{n}\textbf{=Spt=TPpt} \\ \text{Marie(x)} \\ \text{cercle(y)} \\ \text{e: } \boxed{\text{x dessiner y}} \\ \text{e} \subseteq \text{t} \\ \hline \end{array}$$

n is the Speech point but also the TPpt as the feature TP has value -, hence the relation $t < n$ corresponds to the feature value *past* of TENSE, that is the relation between location time and TPpt. In example (6) repeated here as

(9)

$$\begin{array}{|c|} \hline n\ s\ t\ x\ y \\ \hline \textbf{TLtime}=\textbf{TPpt}=\text{t} < \text{n}=\textbf{Spt} \\ \text{Jeanne(x)} \\ \text{Réponse(y)} \\ \text{s: } \boxed{\text{x savoir y}} \\ \text{s} \circ \text{t} \\ \hline \end{array}$$

n is only the Speech time as the value of PAST is +, and it is t which plays the role of the TPpt, hence the value of the feature TENSE, *pres*, is not represented by any relation in the DRS as TPpt = TLtime.

Further we saw that the Imp and the PS can almost express all the possible relations with respect to the temporal perspective point. For instance, two events in the PS are usually represented as following themselves but we saw examples where the second PS sentence could coincide with the first, could precede it (explanation) or even could be in no particular relation with it. The Imp can also have those undesired effects and the DRT framework used by Kamp in [9] cannot deal with that kind of problems and is only efficient with the typical occurrences of an Imp or PS sentence. Hence Kamp's analysis is not well-suited to account for coercion problems or unusual occurrences of sentences with an Imp or PS.

3.2 De Swart's method

We will now introduce de Swart's method as related in [3] and [2]. As stated in [3, p.42], the aim of this method is "to develop a compositional analysis of predicational aspect and grammatical aspect which preserves insight from the two approaches described, and which can serve to describe the discourse semantics of the French past tenses". The two approaches she refers to are Kamp's method which we described previously and where grammatical aspect is prominent (and predicational aspect almost left aside) and the approach which states that "aspectual classes and grammatical aspect are essentially different notions, which involve distinct analytical tools".[2]It should be noted that de Swart's method stays in the DRT framework, hence we will only focus on the differences with Kamp's work.

[2]see [2] on the method of Smith (1991, The Parameter of Aspect) and Depaetere (1995, On the Necessity of Distinguishing Between (Un)boundedness and (A)telicity, *Linguistics and Philosophy* 18).

3.2.1 Formal setting

Predicational aspect and aspectual classes

De Swart uses a compositional analysis where all the elements of a predication play a role to describe the aspectual information of a sentence. This classification distinguishes between states, processes and events, in function of the nature of the verb and the nature of its NP arguments. We have two binary features, *ADD TO* and *SQA*, the first one has the two values [+ADD TO] and [-ADD TO] and the Verb determines the value of the feature: [+ADD TO] refers to nonstativity or dynamicity of the verb (walk, run, win), [-ADD TO] refers to stativity (know, exist, possess). The feature values [±SQA] distinguish NPs pertaining to a Specified Quantity of A (where A is a set of sandwiches or persons in the domain of interpretation), for instance "une lettre" or "trois lettres"(a letter, three letters), from NPs which express an Unspecified Quantity of A, "des lettres": letters (see Verkuyl [23]). The feature SQA applies to the internal as well as external argument of the verb (subject and complement). The two features then determine the value of the binary feature [T] (for terminative, telic), where [+T] refers to terminative and [-T] refers to non-terminative, i.e. durative. The value is determined by the so-called Plus-Principle: on minus-value is enough to make a sentence durative.

(10) a. Pierre écrire une lettre.
Pierre 'write' a letter.
$[_{NP}$ +SQA$]+[_{V}$ +ADD TO$]+[_{NP}$ +SQA$] \Rightarrow$ terminative

b. Pierre ecrire des lettres.
Pierre 'write' letters.
$[_{NP}$ +SQA$]+[_{V}$ +ADD TO$]+[_{NP}$ -SQA$] \Rightarrow$ durative

c. Pierre tenir cette lettre.
Pierre 'hold' this letter.
$[_{NP}$ +SQA$]+[_{V}$ -ADD TO$]+[_{NP}$ +SQA$] \Rightarrow$ durative

Finally states, processes and events are predicted on the basis of the feature combinations in figure 3, where the feature value of SQA represents the value of all NPs in the sentence in accordance with the Plus-Principle. So, looking back at (10), we now get (11)

(11) a. Pierre écrire une lettre.
Pierre 'write' a letter.
$[_{NP}$ +SQA$]+[_{V}$ +ADD TO$]+[_{NP}$ +SQA$] \Rightarrow$ Event

[−ADD TO]	+	[−SQA]	⇒	**State**
[−ADD TO]	+	[+SQA]	⇒	**State**
[+ADD TO]	+	[−SQA]	⇒	**Process**
[+ADD TO]	+	[+SQA]	⇒	**Event**

Figure 3.3: Construal of the three aspectual classes

b. Pierre ecrire des lettres.
Pierre 'write' letters.
$[_{NP}$ +SQA]+$[_V$ +ADD TO]+$[_{NP}$ -SQA] ⇒ Process

c. Pierre tenir cette lettre.
Pierre 'hold' this letter.
$[_{NP}$ +SQA]+$[_V$ -ADD TO]+$[_{NP}$ +SQA] ⇒ State

We have to remark that this analysis doesn't have to be restricted to the sentence level; it can also take the VP as unit.

Aspectual operators

Whereas Kamp focusses on the effect of the different tenses on the interpretation of sentences, de Swart introduces aspect (grammatical and predicational) in the picture in terms of "*sensitive aspectual operators*". She uses the following temporal-aspectual structure

(12) [Tense [Aspect* [eventuality description]]]

where the eventuality description corresponds to the classification above. The aspectual operators take as input the eventuality description and return an expression of the correct class. The tense operator maps the event onto the time axis via its location time in relation to the speech time".[3] The aspectual operators she introduces are C_{eh}, C_{he} and C_{se}. C_{eh} coerces an event to an homogeneous description (state or process), C_{he} coerces an homogeneous description into an event and C_{se} coerces a stative description in an event. We will now give two examples of coercion as treated by de Swart.

(13) Jeanne sut la réponse.(PS)[4]

[3] see [3, p. 40].
[4] [3, p. 45]

$$
\begin{array}{|c|}
\hline
n\ e\ t\ x\ y \\
\hline
\mathrm{t} < \mathrm{n} \\
\mathrm{Jeanne(x)} \\
\mathrm{Réponse(x)} \\
\mathrm{e} \subseteq \mathrm{t} \\
\mathrm{e:} \boxed{C_{se}: \begin{array}{|c|} \hline \mathrm{s} \\ \mathrm{s:} \boxed{\mathrm{x\ savoir\ y}} \\ \hline \end{array}} \\
\hline
\end{array}
$$

Example (13) corresponds to a stative verb phrase with the PS. It is usually interpreted inchoatively. The coercion takes place because the PS introduces an event[5] and that the verb phrase is a state. Therefore the coercion operator C_{se} coerces the state into an event to which the PS can apply.

(14) Jeanne écrivait une lettre.(Imp)[6]

$$
\begin{array}{|c|}
\hline
n\ h\ t\ x \\
\hline
\mathrm{t} < \mathrm{n} \\
\mathrm{h} \circ \mathrm{t} \\
\mathrm{Jeanne(x)} \\
\mathrm{h:} \boxed{C_{eh}: \begin{array}{|c|} \hline e\ y \\ \hline \mathrm{Lettre(y)} \\ \mathrm{e:} \boxed{\mathrm{x\ écrire\ y}} \\ \hline \end{array}} \\
\hline
\end{array}
$$

In (14) the verb phrase is an accomplishment (we should actually only speak about an event as the difference between achievements and accomplishments is not made in this framework), and the tense is an Imp. We have therefore a conflict between the Imp which gives the directive to introduce a state and the event nature of the verb phrase. The coercion operator C_{eh} coerces the event into an homogeneous eventuality which doesn't conflict with the Imp.

3.2.2 Rhetorical relations

When we are listening to a piece of discourse, we usually don't interpret a new sentence in abstraction of the precedent discourse. What is said is in fact rarely independent of what has been previously uttered, so any new

[5] In the DRT framework.

[6] [3, p. 46]

sentence (say describing an event) will be in some kind of relation to some preceding sentence or group of sentences. De Swart uses those relations in the context of SDRT (Segmented Discourse Representation theory) to treat the problems Kamp encoutered.

(15) Ils restèrent au Cap de Bonne Espérance jusqu'au 15 octobre. D' abord ils s'occupèrent du navire qui avait souffert beaucoup pendant la tempête. Puis ils se rendirent à l'intérieur pour se procurer, par achat ou par pillage, les ravitaillements nécessaires. (in [8])

For instance, example (15) contains a first sentence which is described in greater detail in the following sentence(s). That kind of rhetorical relation will be referred to as *elaboration*. The relation of elaboration holds between a sentence and the following "subordinated" sentence(s) if these *elaborate* (describe in greater detail) the first sentence. Further the two sentences which compose the "describing" clauses of elaboration, are also in relation with each other. This time we have also some flashing markers of temporal relation with *"D'abord ... Puis"*. That is, the second clause (Puis ils se rendirent...) is understood as being the successor of the first one; it is the next relevant event in the narration after "D'abord ils s'occupèrent". There seems to be no commonly agreed term for this relation[7], so we will use the term *narration* as in [3]. It is obvious that these two relations are not the only rhetorical relations one should take into account. Another well-known relation is that of *explanation*.

(16)
a. John fell. Max pushed him. (taken from [3], example from Lascarides and Asher [12])
b. John tomba. Max le poussa.(PS, PS)
c. John est tombé. Max l'a poussé.(PC, PC).
d. John tomba. Max l'avait poussé.(PS, PqP)

The English sentence (16-a) illustrates the relation of explanation, the second sentence is understood as preceding the first one: John fell because Max pushed him first. The two sentences use a simple past and it has been remarked that the French counterpart with PS (16-b) doesn't allow this causal explanation. John's fall is understood as being before the pushing. In our opinion the correct translation is (16-d) where the first sentence is a PS and the second a PqP which places the event "Max pushed him" before John's

[7]Kamp uses in [9] *temporal continuation* (or *narrative continuation* in [10]) and Uwe Reyle in a study of "puis" and "alors" as enumeration relations refers to this kind of example as *chronological enumeration* [15].

fall. Thus, in this example, the discourse relies more on the tenses to determine the order of the events than on the relation of explanation as such. Further it should be noted that de Swart et al. consider that it is possible to express an explanation with a sequence of sentences in PC [3, p. 106], as in (16-c). It seems to us that it is not quite correct for the same reasons stated in [3, section (2.3.1)]. The insertion of *parce que* (because) or *car* (for) allows occasionally a relation of explanation that inverse the temporal order (with PS/PS or PC/PC), but the example (16-c) without causal conjunction behaves in our idea just like (16-b). The reason why it could be thought as correct is probably that, in spoken language, it is current to make that kind of inferences with a PC, i.e. describe the situation to someone, "John est tombé", and then give the explanation (pointing at Max in some way) saying "Max l'a poussé". But it doesn't seem to us that, in the written language, the use of a conjunction is optional (for that example) to express explanation if the tenses are not coordinated to clarify the temporal order.

A relation that also interests us in the study of the PS and Imp is the relation of *background* which is based on the common idea that a PS sentence introduces a new event while an Imp sentence provides background information about the described situation.

(17) Paul entra. Marie faisait la vaisselle.

The first sentence (PS) introduces the event "Paul enters". The second sentence is an Imp which introduces a state, that of "Marie doing the dishes". The correct interpretation is that when Paul enters Marie is already doing the dishes, and (without further information) she continues to wash the dishes once Paul is entered. That is, the event is included in the background state.

3.2.3 SDRT

SDRT is an extension of DRT that takes into account the rhetorical relations we just mentioned. A piece of discourse is represented by a SDRS, that is, "a recursive structure consisting of elementary DRSs and sub-SDRSs linked together by discourse relations. These elementary DRSs and sub-SDRSs corresponding to complex discourse segments are the constituents of the SDRS representing the discourse".[8] De Swart turns back to an ontology with only states and events, see [3, p. 99]. Then the only possibility is to let the Imp introduce state referents and the PS introduce event referents

[8]see [3, p. 97]

in the SDRS.

A new constituent is integrated in a context (already constructed SDRS) by an "Update function" and a "Glue Logic".[9] I don't want to go into detail here but want to focus on the use of the discourse relations. In this framework the discourse relations have "axioms specifying their semantic effects" (see [3, p. 99]). To be more precise we will focus on two of those relations, namely *Narration* and *Elaboration*. Following de Swart Narration is the discourse relation that is inferred by default if no other relation can be inferred. Narration is a coordinating relation (it doesn't introduces a new SDRS) and implies succession of the constituents. Elaboration is a subordinating relation that gets "triggered when some event type is a subtype of another event type".[10] Let's look back at example (3), here renamed

(18) L'été de cette année-là vit plusieurs changements dans la vie de nos héros. François épousa Adèle, Jean partit pour le Brésil et Paul s'acheta une maison à la campagne.

In this example the relation of elaboration holds between the first constituent and the three others. Elaboration implies that the elaboration constituents are included in the first sentence. The problem comes with the possible relation between the other three constituents. As Narration is inferred if no other relation can be inferred, de Swart has to introduce a new relation, the so-called *Continuation*, to get the intuitive meaning that those constituents are in no particular order.

3.2.4 Problems in de Swart's analysis

First we want to come back on a problem with the coercion example. In particular an example with an inchoative reading as

(19) Il fut président.

The coercion operator coerces the state into an event to which the PS is applied. We however think that it is not so much that the state becomes an event but more that the event initiating the state is introduced reflecting the translation *He became president* and not *he was president*. But here the coercion operator doesn't give us a *becoming president* event but a *being president* event.

On the problem of rhetorical relations we have two remarks. First we don't

[9] See [3, p. 99]. The Glue Logic exploits monotonic and non-monotonic conditionals.
[10] See [3, p. 107].

really support de Swart's analysis of the relation of explanation. De Swart claims that the PS doesn't allow to express explanation without an explanation connective whereas the PC does. We cite here two examples, the first one taken from de Swart, the second from Gosselin

(20) a. Jean est tombé. Paul l'a poussé.
b. Pierre brisa le vase. Il le laissa tomber.

De Swart claims thus that the first sentence allows an explanation reading whereas the second doesn't. We think actually quite the opposite. We think that the trigger for the explanation reading is the pronoun anaphora, that is the two sentences of each example are linked in what de Swart would call a *topic* (they speak about the same situation). The first sentence in both cases introduces an event, in (20-a) the PC emphasizes the consequent state, and in (20-b) the PS describes the event itself. Therefore the question now is to explain to which entity the pronoun refers. Here we have to argue from a common-sense perspective, in (20-a) the pronoun can refer to the "not-yet-fallen" Jean but also to the "yet-fallen" Jean (either way it refers clearly to Jean). In (20-b) we think that the pronoun can only refer to the "not-yet-fallen" vase and therefore places the event of the second sentence before the first one. After the first sentence the vase is not a vase anymore but pieces of a vase and it seems quite odd to refer anaphorically to the pieces of the vase with the singular pronoun *le*. Hence even if we agree that the interpretation for (20-a) could be that Jean fell because Paul pushed him, it could also be understood as a succession. However for (20-b) we don't doubt that the correct interpretation is given by an explanation reading.

This discussion about the correctness of the axioms for the discourse relations brings us to a more important issue. In our idea the discourse relations shouldn't be a primitive notion in the theory. We think that what makes us interpret (20-b) correctly is a sort of world knowledge of the things we speak about. We will develop this idea in the last chapter. Furthermore de Swart introduces also a relation called *Background*, this relation holds for instance between a PS sentence and an Imp sentence, as in

(21) Paul entra. Marie faisait la vaisselle.

Here the Imp sentence is the background for the PS sentence. In this case we think that introducing this relation is actually superfluous. In (21), the PS and the Imp have precisely the effect of creating a background relation and we shouldn't need to relate the two sentences by *Background* but we think we should get it for free.

All in all, we think that the introduction of the discourse relations is not necessary. The important idea behind those discourse relations is that they are triggered by *clues*[11] (what de Swart calls "linguistics and common knowledge clues"). We think that those clues are all that is needed and that we can infer the correct order of the events of a discourse from them and from the tense information.

3.3 Gosselin's method

Gosselin takes the same starting point as Kamp in the sense that he wants to predict the meaning of segments of text by looking at the instructions given by the aspectual and temporal information for the construction of a representation of the text.[12] The fact that he incorporates aspectual information in his system is deviant from what Kamp did (he precisely tried to avoid to use any aspectual information). The aim of his analysis is to provide a system of rules able to assign representations (aspectual and temporal at the same time) to texts. We will from now on summarize Gosselin's method as explained in Chapter 1 of [4], sometimes verbatim.

3.3.1 Formal setting

Representation by intervals

Gosselin claims that the representations of sentences or segments of text involve four types of intervals:

1) interval [P1,P2] corresponds to the process itself. It represents the interval on the temporal axis denoting the aspectual information (class) of the verb phrase.[13]

2) interval [S1,S2] corresponds to the time of speech (beginning to end) and reflects the moment from which the process is considered.

[11] See [3, p. 99]. Such clues are axioms of the form (informally): if there is a push and a fall event then the push is possibly a cause of the fall event.

[12] In [4, p. 13]: "élaborer ... un système qui puisse prédire les significations temporelles globales des énoncés (et des séquences d'énoncés) à partir des significations des marqueurs qui les composent, mais aussi les significations que prennent ces marqueurs en contexte en fonction des significations globales des énonés qui les contiennent. ... Au lieu de décrire la signification hors contexte des différents marqueurs, on admet qu'ils codent des instructions pour la construction d'éléments de représentation ..."

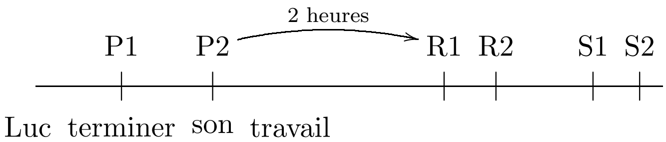
[13] Gosselin recognizes the arbitrary of this representation, see [4, p. 70-71].

3) interval [R1,R2] is the reference interval. It plays the same role as Reichenbach's reference point.

4) interval [ct1,ct2] which corresponds to the temporal complement like *hier*, *samedi dernier*. They are used to localize the process interval and/or the reference interval.

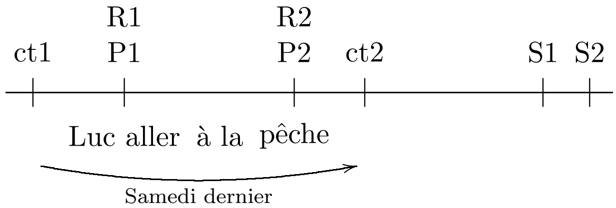
We can give some examples of representation from [4, p. 15-17] to show informally how these components will be used subsequently

(22) Luc avait terminé son travail depuis deux heures. (PqP)



This sentence has a reference interval in the past (here [R1,R2]), and the event denoted by the verb phrase is placed before this interval because of the use of the PqP. Further the PqP expresses that the event is completed, so the right boundary of the process interval is linked to the beginning of the reference interval (it would have been different if the verb used would have been *commencer* (to begin) in place of *terminer* (to finish).

(23) Samedi dernier, Luc a été à la pêche. (PC)



Sentence (23) has a temporal complement, hence we also get an interval [ct1,ct2].

Rules for these intervals

Further Gosselin gives the following principles for the attribution of those intervals for a sentence, or segment of text:

a) every sequence of sentences (coherent segment of text) uttered gets one and only one speech interval.

b) every clause (main, subordinate or independent) is associated to at least one process interval and at least one reference interval.

c) every temporal complement is associated with at least one complement interval.

Hence, every representation of a sentence has a process interval, a reference interval and a speech interval. Then Gosselin defines three relations between two boundaries i and j of those intervals (the same interval or two boundaries of two different intervals):

a) $i = j$, when the two boundaries coincide.

b) $i \propto j$, when i precedes j but is infinitely close (used to refer to punctual processes like achievements).

c) $i \langle j$, when i precedes j but is not close to it.

From those basic relations he defines more complex relations between boundaries and between intervals,

1. $i < j =_{df} (i \propto j) \vee (i \langle j)$.
2. $i \leq j =_{df} (i < j) \vee (i = j)$.
3. anteriority: $[i,j]ANT[k,l] =_{df} j < k$.
4. posteriority: $[i,j]POST[k,l] =_{df} l < i$.
5. simultaneity: $[i,j]SIMUL[k,l] =_{df} (i \leq l) \wedge (k \leq j)$.
6. cover: $[i,j]RE[k,l] =_{df} (i < l) \wedge (l < j)$.
7. coincidence: $[i,j]CO[k,l] =_{df} (i = k) \wedge (j = l)$.
8. accessibility: $[i,j]ACCESS[k,l] =_{df} (i \leq k) \wedge (l \leq j)$.
9. succession: $[i,j]SUCC[k,l] =_{df} k < i$.
10. precedence: $[i,j]PREC[k,l] =_{df} i < k$.

3.3.2 Aspect and tense

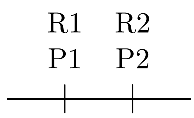
Aspect

Gosselin holds that aspect can be decomposed in two categories, lexical aspect and grammatical aspect. The former corresponds to Vendler's classification of verbs, that is the different aspectual classes: states, activities, achievements and accomplishments, the latter corresponds to the way the process is viewed (completed or not, etc..).

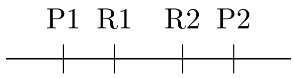
Grammatical aspect

This is characterized by the relation between the reference and process intervals, [R1,R2]/[P1,P2]. He considers four basic notions of aspect, perfective, imperfective, completed and prospective, defined as follows,

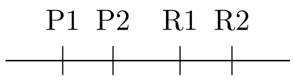
perfective[14]: [R1,R2]CO[P1,P2].



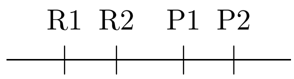
imperfective: [P1,P2]RE[R1,R2].



completed: [R1,R2]POST[P1,P2].



prospective: [R1,R2]ANT[P1,P2].



The perfective gives a global view of the process, i.e. with beginning and end but without reference to the internal constituency of the process (we should have probably called it as Gosselin, aoristic, but we decided to change the author's terminology in order to avoid as much as possible confusions with the English terminology). The imperfective just gives a partial view of the process, we see the process from inside. The completed aspect corresponds to viewing the resulting state of the process, whereas the prospective shows the preparatory state.

[14]The author calls it *aoristique* and the other respectively *inaccompli*, *accompli* and *prospectif*, see [4, p. 22].

Features system for lexical aspect

Gosselin considers the following three features for lexical aspect [4, p.25,41]: boundedness, dynamicity and punctuality. They determine the shape of the process interval.
Boundedness has two feature values, extrinsic (value -) and intrinsic (value +), determined respectively by the compatibility in the PC with *pendant* or *en*(similar with the English test with *for* and *in*).
Punctuality is defined by the relation between the boundaries of the process interval, where by definition $P1 < P2$. The boundaries can be infinitely close, $P1 \propto P2$, and then the process is punctual (value -), or they are not, $P1 \langle P2$, and the process is not punctual.
Dynamicity is determined by the compatibility with [*être en train de*+Infinitive] (comparable to the English test with the progressive).
The four aspectual classes are then defined as follows,

States: [− dynamic], [− bounded], [− punctual].

Activities: [+ dynamic], [− bounded], [− punctual].

Accomplishments: [+ dynamic], [+ bounded], [− punctual].

Achievements: [+ dynamic], [+ bounded], [+ punctual].

This analysis gives a two-dimensional view of the four aspectual classes which is problematic when it comes to consider achievements as punctual/dynamic processes.

Tense

Absolute time is defined by the relation between reference and speech interval,

past: [R1,R2]ANT[S1,S2].

present: [R1,R2]SIMUL[S1,S2].

future: [R1,R2]POST[S1,S2].

and the relative time is determined by the relation between the reference time of the main clause ([R1,R2]) and the reference time of the relative clause ([R1',R2']),

anterior: [R1',R2']ANT[R1,R2].

simultaneous: [R1',R2']SIMUL[R1,R2].

posterior: [R1',R2']POST[R1,R2].

3.3.3 General principles of construction

The construction of representations is based on some principles.[15] First, all the aspectual and temporal features have a unique value in the form of one or more instructions for the construction. Further, the representation of a segment of text results from the gathering of these instructions under the following principles,

1. Contextual dependency of the reference interval. This principle given by Gosselin states that the reference interval must coincide with an antecedent interval in the context. However, the word antecedent doesn't mean that this interval must always be taken from an antecedent sentence, i.e it can also be taken from the other intervals of the sentence itself. For instance, in a typical PS sentence (say with an accomplishment), the reference interval coincides with the process interval (perfective), [R1,R2]CO[P1,P2], which makes it a perfect stand-alone sentence. This is also an explanation of the fact that a stand-alone Imp sentence like *Il pleuvait* isn't correct.[16] The only intervals here are [R1,R2], [P1,P2] and [S1,S2], the Imp "is" imperfective, hence [P1,P2]RE[R1,R2] and it puts the reference interval in the past of the speech interval, hence [R1,R2]PAST[S1,S2]. The reference interval is already related to all the other intervals, therefore we cannot anchor it to anything.

2. Text cohesion. This principle states that there are often special relations between processes. For instance, perfective processes (as with a PS) usually belong to a same chain of changes, i.e. we get succession of the processes. Those relations are the rhetorical relations used by de Swart (elaboration, narrativity, causality, etc..)

When following the instructions and those principles, either we get a plausible representation, or we try to resolve the conflicts if possible.

3.3.4 Normal use of the PS and Imp

PS

As the PS is a past time the first instruction it gives is: [R1,R2]ANT[S1,S2] (i.e. $R2 < S1$). From the point of view of aspect, it presents the process as

[15] See [4, p189].
[16] For more examples see [4, p. 122].

perfective: [R1,R2]CO[P1,P2].
Let's give some examples of representations

(24) Pierre ouvrit la fenêtre et regarda dehors. (PS, PS)
$P1 = R1 \propto R2 = P2 < P'1 = R1' \propto R2' = P'2 \langle S1 \propto S2$.[17]

P1=R1/R2=P2 P'1=R1'/R2'=P'2 S1/S2

In sentence (24), we have a succession of PS sentences where the two events are seen as punctual. The first event is an achievement and therefore the boundaries of the event are infinitely close. The other event is an activity; the PS "deforms" it into a punctual process.

(25) Pierre mangea sa soupe en cinq minutes. (PS)
$ct1 = P1 = R1 \langle ct2 = P2 = R2 \langle S1 \propto S2$.[18]

ct1 ct2
R1 R2
P1 P2 S1/S2

Following Gosselin's analysis, *manger sa soupe* corresponds to an accomplishment, hence the boundaries of the process are intrinsic and the process is not punctual, [Pi1,Pi2] and $P1 \langle P2$. *en cinq minutes* is not punctual, $ct1 \langle ct2$, and it implies the directives [ct1,ct2]CO[P1,P2], i.e. ct1=P1 and ct2=P2 and [R1,R2]ACCESS[P1,P2], i.e. $R1 \leq P1$, $P2 \leq R2$ which means that the boundaries must be accessible from the reference interval. All this with the instructions given by the PS gives us the structure given in (25).

Imp

The Imp gives the following instructions for the representation, [R1,R2]ANT[S1,S2] (in the past), and the uncompleted aspect [P1,P2]RE[R1,R2] The typical use of the Imp is to give background information, as in

(26) Il faisait chaud. Jean ôta sa veste. (Imp, PS)
$P1 < R1 \propto R2 < P2$, $R2 < S1 \propto S2$, $R1 = R1' = P'1 \propto P'2 = R2' = R1$.

[17] See [4, p. 197]
[18] See [4, p. 36].

P1 R1=R1'=P'1/P'2=R2'=R2 P2 S1/S2

Here [P'1,P'2] corresponds to the achievement interval *ôter sa veste.*

3.3.5 Conflict resolution

Gosselin proposes to resolve the conflicts by "deformations" in the representation [4, p. 170]. The zones that can be deformed are, the process interval, and the reference interval associated, the speech interval and the relation between the reference interval and its antecedent (in discourse). Those zones can be deformed in four different ways; they can be moved, contracted, dilated and duplicated. Furthermore in conflict resolution these deformations can be combined.

PS

(27) Pierre mangea sa soupe à 8h 35. (PS)
ct1 = P1 = R1 $\propto$ ct2 = P2 = R2 $\langle$ S1 $\propto$ S2.[19]

ct1/ct2
R1/R2
P1/P2 S1/S2

Here we have a conflict. The event is interpreted inchoatively. This happens because the temporal adverb gives the instruction ct1 $\propto$ ct2 and [ct1,ct2]CO[P1,P2], hence ct1 = P1 $\propto$ P2 = ct2, whereas *manger sa soupe* gives P1 $\langle$ P2. Gosselin says that this conflict is resolved by giving an inchoative reading.

(28) # Pierre mangea sa soupe depuis cinq minutes.[20] (PS)

5 minutes
ct1=P1 ct2=R1
depuis cinq minutes:
P2 R2

Here the temporal adverb gives the instructions ct1 $\langle$ ct2 and ct1 = P1, ct2 = R1. However the PS imposes P1 = R1 and P2 = R2, and it seems to be impossible to resolve this conflict.

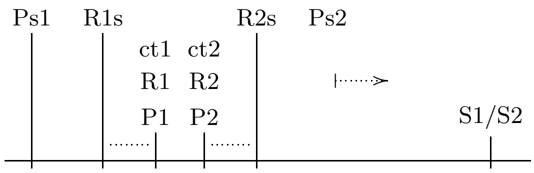
[19] See [4, p. 38].
[20] See [4, p. 37].

Imp

(29) Pierre mangeait sa soupe en cinq minutes.[21] (Imp)

Here the Imp gives the instructions [P1,P2]RE[R1,R2] (i.e. uncompleted, $P1 < R1 < R2 < P2$), and $R2 < S1$ (i.e. it is in the past). As we said before, the temporal adverb imposes the following conditions, ct1 $\langle$ ct2, [ct1,ct2]CO[P1,P2] and [R1,R2]ACCESS[P1,P2] ($R1 \leq P1$, $P2 \leq R2$). This last condition makes a conflict with the Imp's directives: $P1 < R1 \leq P1$ and $P2 \leq R2 < P2$!
Gosselin proposes that the conflict should be resolved by iteration. We get an iteration of events (compatible with *en*) seen from inside (Imp), that is, we get the following representation:

(30) $Ps1 < R1s < R2s < Ps2$ (uncompleted aspect of the iteration).
$R2s < S1$ (past tense).
$ct1 = P1 = R1 \langle ct2 = P2 = R2$ (effect of *en* on the process).



3.3.6 Conclusion

The problems with Gosselin's approach come from the general principle of construction. It is unclear how and when those principles should be applied, especially the principles concerned with "text cohesion" (like the rhetorical relations of de Swart). In a way, we can do too much with his method. Think for instance of Kamp's example

(31) Cette année-là vit la fin des relations intimes qui avaient lié jusqu'alors les héros de notre histoire. Paul épousa Francine, Jean-Luc partit pour l'Afrique. Et Alain s'acheta une Porsche. (PS, PqP, PS $\times 3$)

where the sentences following the first one all belong to the same view but are not ordered. In Gosselin's method there is no special reason to let those

[21] See [4, p. 37-38].

events unordered, nor is there any special reason to order them. We have the choice to drop (or not) the principle that perfective processes usually belong to the chain of changes from which we get the succession.

However, we have to say that our method will resemble what Gosselin did. For instance, we will also have a minimal influence of the tenses features on the interpretation. In Gosselin's approach the PS gives the following instructions: [R1,R2]ANT[S1,S2], [R1,R2]CO[P1,P2]. The process is in the past and is seen as perfective. We will have instructions of the form: an event happens; it happens in the past.

Chapter 4

Event Calculus

The Event Calculus is a formalism that comes from the AI field and was introduced by Kowalski and Sergot.[1] It is based on first-order predicate calculus and can for instance represent events and their effects and continuous change. The version we will describe is due to Fritz Hamm and Michiel van Lambalgen[2] and was mainly influenced by work of Murray Shanahan.[3] We will outline the mechanisms and techniques of the event calculus as described in [7] and then explain how it can be used to solve some problems of the semantics of the French past tenses.

4.1 Event calculus

We will now outline the theory of event calculus, beginning with the underlying ontology and the basic predicates. Then we will give the axioms relating those predicates and introduce the notion of scenario used to treat specific problems, that is for us linguistic problems.

4.1.1 Event Calculus ontology

In the event calculus formalism, i.e. many-sorted first order logic, events begin or finish time-dependent properties, hence the following ontology seems well-suited for our purpose,

1. individual objects.

[1] In R.A. Kowalski and M.J. Sergot, A Logic-Based Calculus of Events, *New Generation Computing*, vol. 4 (1986), pp. 67-95.

[2] See [7] and [5].

[3] See [18].

2. real numbers, to represent time and variable quantities.
3. time-dependent properties, such as states and activities.
4. changing partial objects.
5. event types, marking the beginning and end of time-dependent properties.

We follow [7] in representing time by the real numbers. The time-dependent properties and changing partial objects will be called *fluents*. Those fluents can change their value over time and can have variables for individuals and reals. The event types have also variables for time, and when given a time point they give an event token. Now that we have a basic ontology we can turn to the predicates for the event calculus.

4.1.2 Predicates

As we already said, we want to be able to express that an event begins or terminates a fluent, that an event happens, that a fluent is true at the beginning. That is done with the following predicates,

1. Initially(f).
2. Happens(e, t).
3. Initiates(e, f, t).
4. Terminates(e, f, t).

The meaning of the predicates is that a fluent holds from time 0, that an event e happens at time t, that a fluent f starts to hold after event e took place at time t and that fluent f ceases to hold after event e took place at time t.

One basic principle of the event calculus (actually of any formalism to reason about actions and their effects) is the so-called "principle of inertia" which says that unless explicitly stated, events do not affect fluents. To express this principle we need two predicates,

5. Clipped(t_1, f, t_2).
6. Declipped(t_1, f, t_2).

Those predicates mean that if there is no f-relevant event between t_1 and t_2 then the truth value of f remains the same. A part of the meaning of Clipped is that there is an event that terminates f, and for Declipped that there is an event that initiates f.

However, we said that the event calculus can represent continuous change but sofar we don't have any predicate suited to express continuous change with changing partial objects. We therefore have to introduce special predicates,

7. Trajectory(f_1, t, f_2, d).

8. Releases(e, f, t).

The Trajectory predicate has two fluent arguments, f_1 represents an activity or "force" under which the second fluent f_2 (changing partial object) may vary over time. The predicate Releases expresses that a fluent stops obeying the principle of inertia and thus can vary over time. The meaning of Releases is thus that the fluent f is not subject to inertia anymore after the event e at time t. We want to come back on the meaning of Clipped and Declipped. We said that Clipped means that there is an f-relevant event that terminates the fluent f. We also want the possibility that this f-relevant event releases the fluent f. Hence Clipped means that there is an event that terminates or releases f, and likely Declipped means that there is an event e that initiates or releases f.
Finally we have the truth predicate,

9. HoldsAt(f, t).

This means intuitively that the fluent f holds at time t. We will consider that HoldsAt belong to the truth theory. We now need some axioms to relate the different predicates.

4.1.3 The axioms of the event calculus

All variables are assumed to be universally quantified,

Axiom 1: Initially(f) $\wedge$ $\neg$Clipped(0, f, t) $\rightarrow$ HoldsAt(f, t)

Axiom 2: HoldsAt(f, r) $\wedge$ r $<$ t $\wedge$ $\neg\exists$ s $<$ r HoldsAt(f, s) $\wedge$ $\neg$ Clipped(r, f, t) $\rightarrow$ HoldsAt(f, t)

Axiom 3: Happens(e, t) $\wedge$ Initiates(e, f, t) $\wedge$ t $<$ t' $\wedge$ $\neg$Clipped(t, f, t') $\rightarrow$ HoldsAt(f, t')

Axiom 4: Happens(e, t) $\wedge$ Terminates(e, f, t) $\wedge$ t < t' $\wedge$ $\neg$Declipped(t, f, t') $\rightarrow$ $\neg$HoldsAt(f, t')

Axiom 5: Happens(e, t) $\wedge$ Initiates(e, f_1, t) $\wedge$ t < t' $\wedge$ t' = t + d $\wedge$ Trajectory(f_1, t, f_2, d) $\wedge$ $\neg$Clipped(t, f_1, t') $\rightarrow$ HoldsAt(f_2, t')

Axiom 6: Happens(e, s) $\wedge$ t < s < t' $\wedge$ (Terminates(e, f, s) $\vee$ Releases(e, f, s)) $\rightarrow$ Clipped(t, f, t')

Axiom 7: Happens(e, s) $\wedge$ t < s < t' $\wedge$ (Initiates(e, f, s) $\vee$ Releases(e, f, s)) $\rightarrow$ Declipped(t, f, t')[4]

Those axioms describe the intuitive meaning we gave for the predicates HoldsAt, Clipped and Declipped. In axiom 6, a fluent is clipped between time t and t' if there is an event e happening between t and t' such that this event terminates f or releases f. There are further four different ways for a fluent to hold, i.e. axioms 1 to 5, but the typical axiom is 3. In this case a fluent f holds at a time t' if there was an event initiating f strictly before t' and that f is not clipped between t and t' (i.e. there are no f-relevant events between t and t'). We will use the abbreviation EC for the set of axioms.

4.1.4 Scenario

We have now a general theory which would be useless if we didn't had information about a specific situation. This is the purpose of the scenario. It has to describe the situation by saying what happens, which fluents are to be considered and by which events those fluents are initiated (or terminated).

Definition 9 *A state S(t) at time t is a conjunct of literals involving only*

1. *literals of the form ($\neg$)HoldsAt(f, t), for t fixed and possibly different f,*
2. *equalities between fluent terms, and between event terms*
3. *formulas in the language of the structure* $(\mathbb{R}, <; +, \times, 0, 1)$.

Definition 10 *A scenario is a conjunction of statements of the form*

1. *Initially(f), or*

[4]Actually axioms 4 and 7 shouldn't be included in our list because we will use constraint logic programming with (a version of) negation as failure in order to make inferences. Hence we shouldn't allow negative atoms in the head of the formula. However we allow ourselves (for the sake of simplicity of the computation tree) to use those rules if needed.

2. *HoldsAt(f, t), or*

3. *$\forall t$ (S(t) $\rightarrow$ Initiates(e, f, t)), or*

4. *$\forall t$ (S(t) $\rightarrow$ Terminates(e, f, t)), or*

5. *$\forall t$ (S(t) $\rightarrow$ Releases(e, f, t)), or*

6. *$\forall t$ (S(t) $\rightarrow$ Happens(e, t)), or*

7. *S(f_1, f_2, t, d) $\rightarrow$ Trajectory(f_1, t, f_2, d).*

where S(t) (and S(f_1, f_2, t, d)) is a statement in the sense of the definition above. These formulas may contain additional constants for objects, reals or time points and can be prefixed by universal quantifiers over time points, reals and objects.

We will see in section 4.2 how some elements of the scenario serve to describe eventualities by introducing statements as in definition 10.

4.1.5 Minimal models

So far we exposed the version of the event calculus as presented in [7] by Fritz Hamm and Michiel van Lambalgen, but the differences with Shanahan's version are still minimal (somewhat different axioms and a more constraining notion of scenario). The difference between [7] and Shanahan's approach is in the way of obtaining a minimal model. That is a model in which the interpretation of the predicates are "as small as consistent with those premises" and which allows us to model common sense reasoning and overcome the frame problem. If the scenario only contains *Initially(sunny-weather)*, saying that at the beginning of the scenario there is a sunny weather, we want to be able to derive that at all time in the scenario there is a sunny weather. This isn't guaranteed in all models but a minimal model allows us to make this inference.
Shanahan chose circumscription to solve this problem. We will continue to follow [7] and opt for constraint logic programming with (a version of) negation as failure. We don't want to go in all detail (for this the reader should better have a look at [7] and [6]) but just want to briefly describe the tools we will be using and the important results that make this approach appealing.

Definition 11 *A* (general) query *is a finite sequence of literals.*

Definition 12 *A* (general) rule *is an expression $M \to A$, where A is an atom (the* head*) and M is a (general) query (the* body*). A* (general) program *is a finite set of such rules.*

Given a program $\mathcal{P}$ the sets of sentences $IF(\mathcal{P})$ and $IFF(\mathcal{P})$ are constructed from $\mathcal{P}$ by means of the following steps. Fix a sequence of new variables $x_1, x_2, \ldots$.

Step 1. *Remove terms from rule heads.*
Replace every rule of the form $B_1 \wedge \ldots \wedge B_m \to r(t_1, \ldots, t_k)$ by $B_1 \wedge \ldots \wedge B_m \wedge x_1 = t_1 \wedge \ldots x_k = t_k \to r(x_1, \ldots, x_k)$.

Step 2. *Introduce existential quantifiers.*
Transform each formula $F \to r(x_1, \ldots, x_k)$ obtained in the previous step into $\exists y_1 \ldots \exists y_n F \to r(x_1, \ldots, x_k)$, where the $y_1, \ldots, y_n$ are all the free variables of F minus $x_1, \ldots, x_k$.

Step 3. *Group formulas with the same head.*
If $F_1 \to r$, $\ldots$, $F_l \to r$ are all the formulas with head r, replace them by a single formula $F_1 \vee \ldots \vee F_l \to r$. This formula will be called the *definition* of r.

Step 4. *Handle undefined relation symbols.*
If a relation symbol $r(x_1, \ldots, x_i)$ does not occur as head of a rule in P, replace r by $\mathcal{A}x_1 \ldots \mathcal{A}x_i \neg r(x_1, \ldots, x_i)$.

Step 5. *Replace each formula by its universal closure.*
This gives us the set $IF(P)$.

Step 6. To obtain $IFF(P)$ from $IF(P)$, replace each $\to$ by $\leftrightarrow$.

Lastly, to obtain the completion *comp*(P) from $IFF(P)$, we have to add *uniqueness of names* assumptions UNA. This is the following set of statements for function symbols f, g and terms t of the language:

1. $f(y_1, \ldots, y_n) = f(z_1, \ldots, z_n) \;\to\; y_1 = z_1 \wedge \ldots \wedge y_n = z_n$
2. $f(y_1, \ldots, y_n) \neq g(z_1, \ldots, z_m)$, where f, g are different
3. if y occurs in t, $y \neq t$.

Definition 13 *If P is a (general) program,* comp(P) *is the conjunction of $IFF(P)$ and UNA.*

Then we have the following result stating soundness of negation as failure.

Theorem 3 *Let P be a general logic program, A a positive literal. If for some substitution σ, $A\sigma$ can be derived from P by means of negation as failure, then comp(P)$\models \forall A\sigma$, where $\forall$ denotes the universal closure. If for some substitution σ, $\neg A\sigma$ can be derived from P using negation as failure, then comp(P)$\models \neg\exists A\sigma$*

Further we want to refer the reader to [6] for the completeness result.

4.2 Aspectual classes and eventualities

Before we discuss the representation of eventualities in the event calculus we have to say something about the process of *reification*. That is, the process that turns formulas into object or terms. This problem is usually left out the formal system of event calculus. We won't say much more about it and assume that we have an interpreter that can provide us with the fluents and event types. However this isn't just an easy way out and we refer to [5] for the reader who would like to know how to incorporate reification in the formal system.

4.2.1 Eventualities

We will now explain how the lexical meaning of an expression can be expressed in the event calculus formalism. Here we still follow [7] influenced by the work of Moens and Steedman,[5] and of Dowty.[6] An eventuality will be described as a structure of the form

1. activity,
2. changing partial object,
3. culminating event,
4. consequent state.

A verb phrase will now be described by a quadruple of the form (f_1, f_2, e, f_3) with possibly empty slots as shown in the table below.

[5]See M. Steedman. Temporality. In J. van Benthem and A. ter Meulen editors, *Handbook of Logic and Language*. Elsevier, Amsterdam, 1997.

[6]See D. Dowty. Thematic proto-roles and argument selection. *Language*, 67:547-619, 1991.

State	$(-,-,-,+)$
Activity (strict)	$(+,-,-,-)$
Activity (wide)	$(+,+,-,-)$
Accomplishment	$(+,+,+,+)$
Achievement	$(-,-,+,+)$
Point	$(-,-,+,-)$

This must be understood as follows: a state will be a quadruple of the form $(-,-,-,+)$, i.e. the only element available is the fluent f_3. An accomplishment will be the "full" quadruple (f_1, f_2, e, f_3), where f_1 corresponds to an activity and f_2 to a changing partial object (both corresponding to the common idea of the preparatory phase of an accomplishment). The event e will be the culminating event of the accomplishment and f_3 the resulting state. In the case of an accomplishment the fluent f_3 will actually be the "finished" changing partial object, that is some $f_2(r)$. Notice that the difference between a state and a strict activity is due to the fact that they don't occur in the same predicates. For instance the fluent for an activity cannot be in *Releases* or in third position in the *Trajectory* predicate (both are a place for the second element of a wide activity, i.e. the changing partial object or for a consequent state fluent). Hence the activity and the state fluents have a different syntactic role.

	Releases	$\text{Trajectory}_{\text{1st argument}}$	$\text{Trajectory}_{\text{3d argument}}$
States	$+$	$-$	$+$
Activity (strict)	$-$	$+$	$-$

4.2.2 Aspectual classes and scenario

We know what elements compose an accomplishment or a state but we have to say at least informally which statements are introduced in a scenario for those different aspectual classes. It is obvious that each component of an eventuality should appear in a statement in the scenario.

Accomplishment

We first begin with accomplishments because it is the more complicated eventuality, as all the slots of the quadruple are filled, $(+,+,+,+)$. Note that, as the accomplishment also has an activity part, we need a starting event for this activity. We will call it *start*. The accomplishment introduces the following statements in the scenario

1. $\forall$t (S(t) $\rightarrow$ Initiates(start, f_1, t)), and
2. $\forall$t (S(t) $\rightarrow$ Terminates(e, f_1, t)), and
3. $\forall$t (S(t) $\rightarrow$ Happens(e, t)), and
4. $\forall$t (S(t) $\rightarrow$ Releases(start, f_2, t)),[7] and
5. S(f_1, f_2, t, d) $\rightarrow$ Trajectory(f_1, t, f_2, d).

Statements 5 and 6 are the dynamics of the accomplishment. Statements 2, 3 and 4 are the statements about the culminating event and its effects. The accomplishment is a good example of how the event calculus can be used to model continuous change.

States

The quadruple for a state is as follows $(-,-,-,+)$, hence we have only one fluent f_3. Furthermore a state has to be initiated somehow by an event e or has to be true at the beginning of the scenario considered. Hence a state can introduce some of the following statements in the scenario

1. Initially(f_3), or
2. $\forall$t (S(t) $\rightarrow$ Initiates(e, f_3, t)).[8]

Notice that a state doesn't mandatorily introduce something in the scenario.

Strict activity

Here we have also only one fluent f_1 but this time corresponding to the configuration $(+,-,-,-)$. Hence we need at least in the scenario

1. Initially(f_1), or
2. $\forall$t (S(t) $\rightarrow$ Initiates(e, f_1, t)).

It could be confusing for the reader to notice that we have written the same statements here and in the "state part" above. We repeat therefore that those two fluents play a different syntactic role in the scenario. They can both appear in Initially or Initiates but an activity fluent cannot appear in Releases whereas a state fluent can. This has to do with our description of eventualities. An activity changes only value over time in the sense that it is going on or not at some time t. However it remains the same activity.

[7] The S(t) in those statements need not to be the same state.

[8] S(t) is a state in the sense of definition 9 and may of course be empty.

Wide activity

We have to notice that a stand-alone activity sentence can always be considered as a strict activity.[9] A wide activity is of the form $(+, +, -, -)$. We have a strict activity f_1 and a changing partial object f_2, and we still need an intiating event. Hence we need at least the following elements in the scenario

1. $\forall$t (S(t) $\rightarrow$ Initiates(e, f_1, t)), and
2. $\forall$t (S(t) $\rightarrow$ Releases(e, f_2, t)), and
3. S(f_1, f_2, t, d) $\rightarrow$ Trajectory(f_1, t, f_2, d).

Statements 2 and 3 are called the dynamics.

Achievement

The achievement is composed of a culminating event *e* and a resulting state f_3 which are obviously linked together. Hence the achievement introduces at least one statement

1. $\forall$t (S(t) $\rightarrow$ Initiates(e, f_3, t)).

We said *at least* because it is not evident that an event has only one resulting state (except if we consider it to be the uninteresting one stating that the event has happened). Notice that where an accomplishment describes continuous change, an achievement describes a discrete change.

Points

A point verb phrase is only an event e, hence it doesn't introduce anything in the scenario as long as we don't have tense information.

4.3 Event calculus and Walker's construction

In Walker's construction the instants serve to separate eventualities of the eventuality structure.[10] In the event calculus the events initiate or terminate

[9] What Dowty calls the "incremental theme" of a wide activity as *push a cart* (i.e. the changing position of the cart) makes sense only if the changing position of the cart is relevant for some other sentence. If the sentence is a stand-alone we can speak of a strict activity as this information doesn't serve any purpose.

[10] We use here "eventuality" in the sense of event in chapter 1, in order to be able to speak about events of the event calculus.

fluents (activity fluents, state fluents). This is a nice parallel that we already mentioned in 1.4 with the following picture. However if we want to let

Walker		Event Calculus
events	$\leftrightsquigarrow$	fluents
instants	$\leftrightsquigarrow$	events

correspond an eventuality structure to a scenario not only the fluents will have to be included in the set of eventualities but also the events.

It still would be attractive if the instants corresponding to those events were the place of changes with respect to the fluents they act on. Let's have a look at one example.

(1) Il faisait chaud. Jean ôta sa veste.

The first sentence is an Imp and describes a state, hence we have one fluent *warm*, the second sentence describes an achievement, hence we have an event *undress* and a fluent *no-jacket*. Our event structure then looks like figure (1) (with the added events for "begins before" and "ends before"). Hence

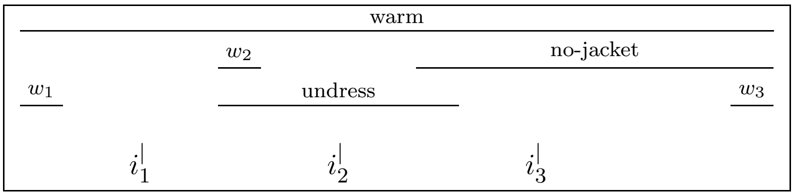


Figure 4.1: Events and Walker's instants.

the event *undress* is mapped into the interval (i_1, i_3) and the resulting state *no-jacket* is mapped into the interval $(i_2, +\infty)$. We can therefore regard the instant i_2 which belong to the interval of *undress* as the place of change. Notice also that the fluent warm is mapped into the interval $(-\infty, +\infty)$. It is nice to notice that, should we idealize the event as being punctual, the pattern of the intervals we get from the fluents somehow match the minimal model we will get for this scenario (see page 87).

Chapter 5

Event calculus, PS, Imp and coercion

First of all we have to say that we won't treat habitual or iterative readings. This is left as future work.

5.1 Scenario

We have to say what elements we incorporate in the scenario when we deal with a PS or an Imp sentence. We propose to analyze PS and Imp as aspectual sensitive "operators", following the idea of de Swart. That is, an Imp with a stative or activity verb doesn't add anything to the scenario except that the state considered is in the past. The Imp is aspectually neutral with stative and activity verbs; those verbs conserve their properties. In the same manner, the PS with an achievement only introduces the event of the quadruple $(-,-,e,f)$ with a new time, say $t_0 <$ now, at which the event of the achievement happens, that is, it introduces Happens(e, t_0), t_0 $<$ now. We assume the following order for the scenario construction,

1. lexical information from the verb phrase.
2. episodic and time information from the tense used.
3. incorporate both parts to form the scenario.

As the reader will notice, these rules just say what to do with a one verb phrase sentence. Hence we need to broaden these construction steps for more complex sentences or segments of text. However, what has to be done in a more complex setting is closely linked to our treatment of temporal information, therefore we will only treat this problem after our proposal for treating the PS and the Imp.

5.1.1 Proposal for the PS

The PS adds the following episodic information in the scenario to the lexical information

- a new time t_i such that $t_i <$ now (where *now* is the utterance time).
- the statement Happens(e, t_i), where e is an event that can be unified with one of the possible events described by the lexical information. In the case of an achievement, there is only one event $e_{achievement}$ in the lexical information. We can therefore directly merge both information in the scenario by writing Happens($e_{achievement}$, t_i). In the case of a stative verb phrase there is no event from the lexical information, hence e is the event that happens.

5.1.2 Proposal for the Imp

The Imp adds the following episodic information in the scenario to the lexical information. We have two possibilities here

- If the Imp verb phrase is in front of the text (with possibly other Imp sentences) or if the statements concerning the first component of the activity (i.e. f_1) don't have any preconditions (in the form of a *S(t)* formula) then the statement Initially(f) is introduced, where f is a fluent that can be unified with one of the possible fluents described by the lexical information.
- Otherwise the statement [HoldsAt(f, t_i), $t_i <$ now] is introduced where f is a fluent that can be unified with one of the possible fluents described by the lexical information and *now* is the utterance time. We choose to constraint the choice of the fluent to unify with f. We will choose the first positive component in the quadruple describing the eventuality.

5.1.3 Conclusion

The reader will notice that, contrary to Kamp and de Swart, we don't introduce anything to say how a newly introduced PS verb phrase interacts with the preceding PS sentence. If we wouldn't go further we would surely come into trouble, but our way to deal with this problem is to use previous lexical information about fluents and events in the construction of the lexical information of a new sentence.

The important notion here is the notion of scenario. The scenario is constructed in such a way that it has to describe what happens to a fluent or event by means of the definitions 9 and 10. In the case of a newly introduced PS achievement, the role of the event (i.e. (-,-,$\underline{+}$,-)) is decisive. This event initiates the resulting state fluent but may also have an effect on the previous fluent(s). We saw in 4.2.2 which statements have at least to be introduced in the scenario for an achievement. It was some thing of the form

$$\mathrm{S(t)} \rightarrow \mathrm{Initiates(e, f_3, t)}$$ [1]

but it might be the case that this event also terminates some other fluents. Then we have to introduce in the scenario some statement of the form

$$\mathrm{S'(t)} \rightarrow \mathrm{Terminates(e, f', t).}$$

To improve readability we use the following convention for the scenarios. For a text with multiple sentences, each sentence gets numbered in the obvious order, and for each sentence we first give the lexical information and then the episodic (tense) information

1. first sentence
    - lexical information
    - episodic information
2. ...

5.2 Event Calculus applied

5.2.1 Stand-alone Imp

(1) Il faisait chaud. (Imp)

We saw in the previous section that a stand-alone sentence in the Imp like (1) is odd. This is explained in Kamp's and Gosselin's theories by the fact that there is no previous "reference point" to anchor the sentence and that an Imp sentence such as (1) doesn't introduce its own reference point (notice

[1] From now on we will leave out the universal quantifier $\forall t$ for readability reasons.

that a sentence like (25-b) doesn't encounter this problem even though it is an Imp sentence).
Faire chaud is obviously a state, hence in our representation of aspectual classes it has the form (−,−,−,+), that is only one fluent. Let's call this fluent *warm*.[2]
The scenario is as follows. The Imp sentence is the first and only sentence; hence it introduces the following statement: Initially(f). The only fluent available is *warm*, therefore the complete description is:

- Initially(warm).

The question that can be asked is: when does HoldsAt(warm, t) hold for some t? It seems that we can derive the empty clause in the computation

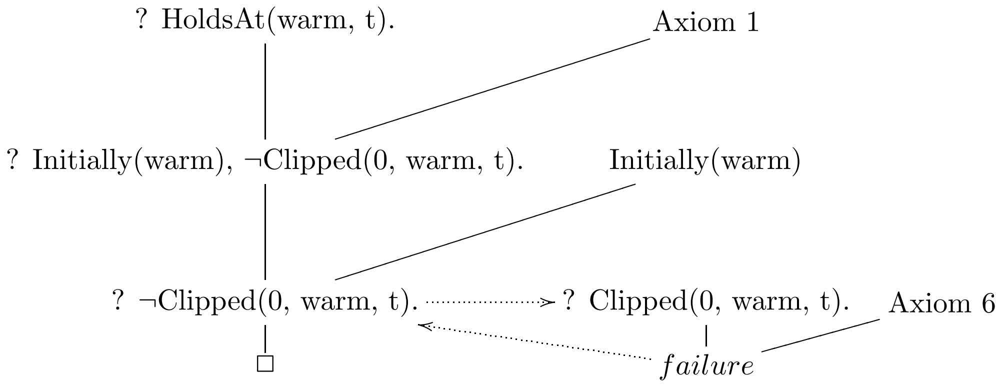


Figure 5.1: Computation tree of example (1).

for any time. That means that the sentence should make sense and be true at all times. The problem is that no other time than the implicit beginning of the state is introduced in the scenario, i.e. nothing happens. In a way, we only have a background.

We will now treat a stand-alone Imp sentence with an accomplishment verb phrase but in order to make this example more interesting we would like the reader to assume with us that there is a context (for instance a PS sentence we just heard) and let us introduce the Imp sentence as if it was in a segment of text.

(2) Marie écrivait une lettre. (Imp)

[2] We use the following convention for readability reason: in a sentence we write fluents in italic, in a statement or derivation tree we don't.

The verb phrase is an accomplishment, hence we need a fluent for the activity, the changing partial object, the event and the resulting state. We use respectively *writing*, *letter(x)*, *finish* and *letter(m)* as components of the eventuality (*letter(m)* denoting that the letter is finished). We then have the following scenario for the lexical information

- Initiates(start, writing, t).[3]
- Terminates(finish, writing, t).
- Releases(start, letter(0), t).
- Initially(letter(0)).
- HoldsAt(writing, t) $\wedge$ HoldsAt(letter(m), t) $\rightarrow$ Happens(finish, t).
- HoldsAt(letter(x), t) $\rightarrow$ Trajectory(walking, t, letter(g(x+d)), d).

The Imp introduces in the scenario

- HoldsAt(f, t_0), $t_0 <$ now.

The fluent f will be unified with *writing* (we specified that we first try to unify with the first positive component of the quadruple (writing, letter(x), finish, letter(m))). In the minimal model for this scenario the event *start* will have to happen before t_0. Furthermore the event *finish* will happen at some time after t_0.

5.2.2 PS with Imp

Now we reformulate sentence (1) by adding a PS sentence

(3) Il faisait chaud. Jean ôta sa veste. (Imp, PS)

The interpretation of the first sentence is unchanged. The new verb phrase describes an achievement, hence something of the form (−,−,+,+). We have to specify an event and a fluent for the achievement; we will call the event *undress*, and the fluent *no-jacket*. Now we have to specify their relation, that is done by the statement Initiates(undress, no-jacket, t). This is all the lexical information we get from the verb phrase. The PS introduces the following statements Happens(undress, t_0), $t_0 <$ now.[4] The complete scenario will then be,

[3]The event "start" is an event that has to happen in order to begin the accomplishment.

[4]We should actually write Happens(e, t_0), but the event e will be unified with the event undress as it is the only event.

1. Initially(warm).
2.
    - Initiates(undress, no-jacket, t).
    - Happens(undress, t_0), $t_0 <$ now.

We would expect that the PS event is included in the Imp state, that is that it was warm before, when and after that Jean undressed. The fluent *warm*

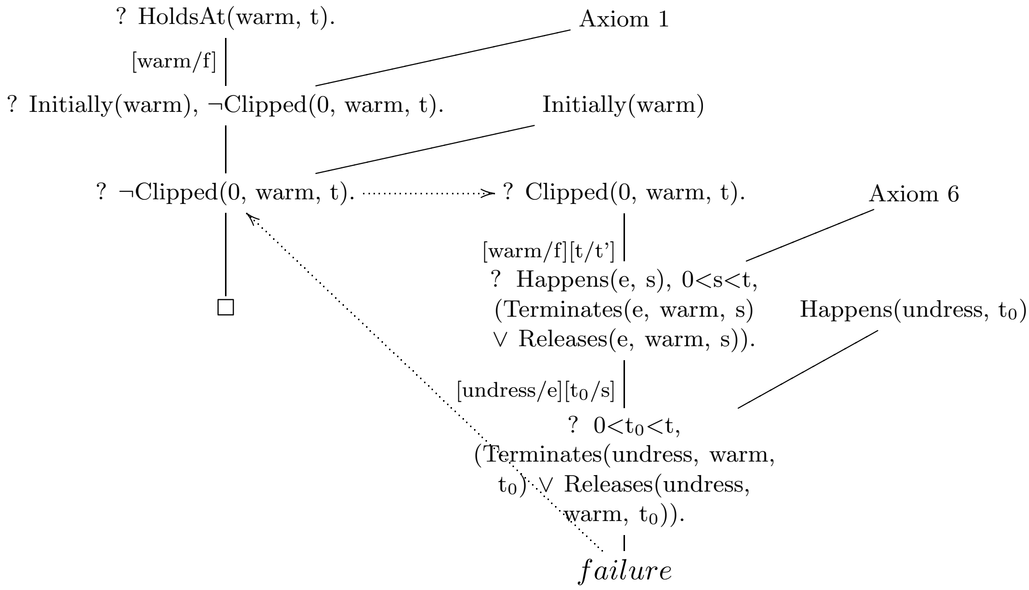


Figure 5.2: Computation tree of example (3).

is true during all the scenario, as the only event has no effect on it. This is shown by the Clipped predicate, action *undress* doesn't clip the fluent *warm*, see figure 6.2. We have now a good description of the scenario with respect to time, i.e. the PS event is surrounded by the Imp state. However, we should be able to get more than what we have now. The important point in (3) is that we expect that there is a link between the two sentences, that is, that Jean undressed because it was warm. Then we need a new fluent expressing the fact that it is warm for Jean, say *J-warm*. The following statements should then be introduced, Initially(J-warm) and

$$\text{HoldsAt(warm, t)} \rightarrow \text{Terminates(undress, J-warm, t)}.$$

The fluent warm is still true at all time in the scenario as no new event has been introduced in the scenario. The only difference is that at time t_0 the fluent J-warm is terminated.

We saw however that a sentence with a PS and an Imp can behave differently. In (3), the Imp precedes the PS sentence and we get the usual meaning PS/punctual, Imp/background information. We now want to investigate the following example

(4) Jean appuya sur l'interrupteur. La lumière l'éblouissait. (PS, Imp)

As we saw, the Imp sentence cannot surround the PS event but should be a consequence of this event. It is actually quite normal as the event and state should be linked by the Clipped predicate; they are related (at least in the scenario). In (3) we had a causality relation between two sentences without interaction between these (notice that it would have been different if the Imp sentence was, "*Il avait chaud.*"). By causality without interaction we mean that the state is understood as the cause of the following event (Jean undress because it is warm), but the event has no effect on the state. In (4) however, the action causes the state to be, hence they have to be related by Clipped.

The first verb phrase describes an achievement. We have three elements, two events *push-on* and *push-off* and a fluent *light-on.* This elements are ruled by the following two statements, Initiates(push-on, light-on, t) and Terminates(push-off, light-on, t). The second verb phrase describes a state, hence we have only one fluent *blinded.* Now we have to remark that the fluent *light-on* has an influence on *blinded.* That *light-on* holds or not is relevant to *blinded.* Thus we have the following two statements

$$\neg\text{HoldsAt(light-on, t)} \rightarrow \text{Initiates(push-on, blinded, t)}$$

$$\text{HoldsAt(light-on, t)} \rightarrow \text{Terminates(push-off, blinded, t).}$$

One might wonder why it is necessary to have such preconditions in the statements above. The idea is that the blinded fluent gets initiated by a *push-on* event (i.e. turn the light on), but that in order to make the blinded fluent true there must also be some change for the light-on fluent. We could have made it easier by introducing the statement

$$\text{HoldsAt(light-on, t)} \rightarrow \text{HoldsAt(blinded, t)}$$

but then we should have changed our definition of the scenario which would possibly lead to loops in the computations. The complete scenario is

1. • Initiates(push-on, light-on, t).
   Terminates(push-off, light-on, t).

- Happens(e, t_0), t_0 < now.

2. - ¬HoldsAt(light-on, t) → Initiates(push-on, blinded, t).
     HoldsAt(light-on, t) → Terminates(push-off, blinded, t).
   - HoldsAt(blinded, t_0'), t_0' < now.

We would expect that the *blinded* fluent would hold after the light is switched on, and that the computation of the query ?HoldsAt(blinded, t_1) should end with $t_1 > t_0$, and therefore that $t_0 < t_0$'. This is exactly what we get from the computation, see figure page 100.

It should be quite different if the order of the sentences is reversed as in

(5) La lumière l'éblouissait. Jean appuya sur l'interrupteur. (Imp, PS)

Here we expect the light to be turned off after the PS sentence, hence ?¬HoldsAt(light-on, t_1) should return an empty clause if $t_1 > t_0$; see page 101. Hence Jean shouldn't be blinded anymore at $t_1 > t_0$, see figure page 102. The complete scenario then is,

1. - ¬HoldsAt(light-on, t) → Initiates(push-on, blinded, t).
     HoldsAt(light-on, t) → Terminates(push-off, blinded, t).
   - Initially(light-on).
     Initially(blinded).

2. - Initiates(push-on, light-on, t).
     Terminates(push-off, light-on, t).
   - Happens(e, t_0), t_0 < now.

The event will now be *push-off* and as the Imp sentence is introduced first, Initially(light-on) should be incorporated in the scenario. This is not uncontroversial as, so far, we only introduced information based on the verb phrase in the scenario. Initially(light-on) is clearly based on the subject of the verb phrase and the statements concerning *blinded* are also induced by the subject. Therefore we would have to say more about the treatment of all components of the sentence.[5] In figure page 101, the branch for Clipped(0, light-on, t_0) fails because there are no events in the scenario happening before t_0.

[5]It doesn't come as a surprise that a proper treatment of all components of the sentences has to be done. However that we introduce this component in the scenario shouldn't be seen as a general shortcoming of our method but as an point that has to be clarified in future work. We hope that the reader will take our word on this point!

We will now give an example of the reverse temporal order in comparison with example (4).

(6) Jean attrapa une contravention. Il roulait trop vite. (PS, Imp)

Here the Imp sentence is understood as being before the PS event happens. This is obviously a situation where there is a lot more reasoning to be done than what the input sentences provide us with. To make sense of these two sentences a lot of world knowledge has to be applied. Let's first describe the bare situation with the event calculus to explain which problems occur. First scenario

1. we consider the first sentence event as a point, that is only an event *get-ticket*, Hence we only get episodic information of the form Happens(get-ticket, t_0), t_0 < now.
2.
   - Initiates(accelerate, drive-too-fast, t),
   - HoldsAt(drive-too-fast, t_1), t_1 < now.

From this scenario we get a minimal model where at a time before t_1, the event *accelerate* happens. However we cannot conclude anything about an ordering between the two sentences. We think that it is a common principle of interpretation that makes us introduce more information in the scenario until a sentence can be linked with at least another one in a text,[6] and that this information can only be some part of world knowledge. We actually claim that any theory that gets an intuitively correct order of the events has to use some world knowledge. We claim furthermore that a normal reader will introduce more information in the scenario until he gets a minimal model where the two sentences are related. The minimal scenario could be

1.
   - HoldsAt(drive-too-fast, t) $\rightarrow$ Happens(get-ticket-from-police, t), Terminates(get-ticket-from-police, driving).
   - Happens(get-ticket-from-police, t_0), t_0 < now.
2.
   - HoldsAt(driving, t) $\rightarrow$ Initiates(accelerate, drive-too-fast, t),
   - HoldsAt(drive-too-fast, t_1), t_1 < now. Initially(driving).

[6]This process of adding information to the scenario is comparable to extending an event structure by decomposing its elements into more elaborated components. It is therefore interesting to notice that it is possible with Thomason's method to construct a chain of event ordering.

In this scenario, the fluent *driving* holds from the beginning until t_0 where it gets terminated. The fluent *drive-too-fast* is initiated after time 0 and holds also until time t_0. Hence we get the intuitive order of the eventualities.

We now turn to an example with a temporal subordinate as in example (23) page 32 that we rename here

(7) Quand Alain ouvrit les yeux, il vit sa femme. Elle lui souriait. (PS, PS, Imp)

We will first give the lexical information of the three verb phrases and then discuss the influence of the construction and tenses.

1. Initiates(open-eyes(Alain), opened, t).[7]

2. Initiates(open-eyes(Alain), see(wife), t).

3. Initiates(begin, smile(wife), t).

We follow [7, p. 33] and consider that the *quand* clause "is always related to the first positive component of the quadruple expressed by the main clause". But in this case the events are actually the same, hence we get

1. Happens(open-eyes(Alain), t_0), t_0 < now.

2. Initially(smile(wife)).[8]

Hence in the minimal model the fluent *see(wife)* holds directly after he opens his eyes and the fluent *smile(wife)* holds during all the scenario and therefore it holds also when Alain opens his eyes.

5.2.3 PS alone

We will now turn to the classic sentence involving several verb phrases in the PS, i.e. a succession.

(8) Pierre se leva, monta dans sa chambre et ferma la porte. (PS $\times$3)

The usual interpretation is a succession of events in the order of speech. The first verb phrase describes an achievement, hence is represented by an event

[7] Notice that we said for example (16-a) page 29 that the first sentence is an accomplishment. Here, however, we treat it as an achievement for the sake of simplicity.

[8] We don't get here a HoldsAt() statement because the lexical statement for the fluent *smile(wife)* doesn't have any preconditions.

get-up and a fluent *upright* such that, Happens(get-up, t) and Initiates(get-up, upright, t). The second verb phrase describes also an achievement hence we get the following, an event *upstairs* and a fluent *being-upstairs* with the following statements Happens(upstairs, t) and

$$\text{HoldsAt(upright, t)} \rightarrow \text{Initiates(upstairs, being-upstairs, t).}$$

Finally the third verb phrase is also an achievement, hence we get the following event and fluent, *close* and *closed*, and the statements Happens(close, t),

$$\text{HoldsAt(being-upstairs, t)} \rightarrow \text{Initiates(close, closed, t).}$$

Thus we get the following scenario

1.
   - Initiates(get-up, upright, t).
   - Happens(get-up, t_0), t_0 < now.
2.
   - HoldsAt(upright, t) → Initiates(upstairs, being-upstairs, t).
   - Happens(upstairs, t_1), t_1 < now.
3.
   - HoldsAt(being-upstairs, t) → Initiates(close, closed, t).
   - Happens(close, t_2), t_2 < now.

The numbering of the different times (reflecting the expected order of the events) shouldn't confuse the reader on the fact that we don't assume this order at first, but expect to be able to derive it. Hence we should get the ordering $t_0 < t_1 < t_2 < t'$ as end-goal of the computation of the query ?HoldsAt(closed, t'), see example page 103.

However, we cheated somehow by saying that "monter dans sa chambre" is an achievement. It should be an accomplishment (quite the same could be said about "fermer la porte" as shown in example .., but for the sake of simplicity we let it be interpreted as an achievement). An accomplishment looks as follows (+,+,+,+), that is, we have three fluents, one event and the appropriate statements. The first fluent expresses the "activity" part of the accomplishment, let's call it *walking* as it is quite clear that it is the underlying activity that makes the subject change from position. The second fluent, say *distance(x)*, expresses the distance the subject has walked from downstairs to upstairs in his room. We assume that the distance from where the subject is to his room is *m*, i.e. at the beginning of the scenario we have *distance(0)* and the subject reaches his room if *x=m*. Furthermore we assume for the sake of simplicity that the subject is walking with uniform velocity and without interruption. The event represents the culmination point of the accomplishment, we will call it "finish". Hence, we have the following statements for the lexical information

- HoldsAt(upright, t) $\rightarrow$ Initiates(start, walking, t).[9]
- Releases(start, distance(0), t).
- Initially(distance(0)).
- Terminates(finish, walking, t).
- HoldsAt(walking, t) $\wedge$ HoldsAt(distance(m), t) $\rightarrow$ Happens(finish, t).
- HoldsAt(distance(x), t) $\rightarrow$ Trajectory(walking, t, distance(x+d), d).

The PS induces the following changes:

- Happens(e, t_1), $t_1 <$ now.

We said at the beginning of this section that the PS introduces a statement of the form Happens(e, t), with e, an event taken from the lexical description of the verb phrase. Therefore there should be no special treatment for the event *start* and one could introduce a *Happens(finish, t)* instead. Actually, both events can be used, the only difference being one of point in view. If the event e is unified with *start* we get an inchoative meaning and if e is unified with *finish* the perspective is put on the end of the accomplishment. That both events work in this situation is due to the fact that in the minimal model for this scenario both events will happen and result in the correct order of the sentences. It is however usually claimed that a PS sentence gets preferably an inchoative meaning, [4, p. 197]. Hence we will probably have to introduce a constraint in our proposal for the episodic information the PS provides: substitute first *start*, if a query is not evaluable then substitute *finish*. In the following we will unify the event *e* with *start*.

Furthermore the change from achievement to accomplishment for the second verb phrase changes also the representation of the third verb phrase.

- HoldsAt(distance(m), t) $\rightarrow$ Initiates(close-door(s), closed-door(s), t).

see page 104-106 for the details of the computation of the query ?HoldsAt(closed-door(s), t_2').

It has to be noticed that, in our resolution tree, the culmination point imposes the introduction of a new time t_1+m. However, this is due to

[9]The event "start" is an event that has to happen in order to begin the accomplishment.

the presence of the third verb phrase which cannot be activated before the accomplishment is finished and to our use of axiom 2. Notice further that in the minimal model the culmination point of the accomplishment must be such that $t_1 < t_1+m \leq t_2$. Hence the accomplishment could finish at the same time as the fluent *closed-door(s)* is initiated. This is due to the fact that in the completion of the program (EC+Scen+Dyn) the statement HoldsAt(distance(m), t') is "equivalent" to (Axiom $2_{[distance(m)/f]}$ $\vee$ Axiom $5_{[distance(m)/f]}$),[10] that is

$$\text{HoldsAt(distance(m), t')}$$
$$\updownarrow$$
$$(...\vee(\text{HoldsAt(distance(m), r)}\wedge r<t'\wedge\neg\exists s<r\ \text{HoldsAt(distance(m), s)}\wedge...))\vee$$
$$(\text{Happens(e, t)}\wedge...t'=t+d\wedge\text{Trajectory(walking, t, distance(m), d)}...)\vee...)$$

Should we remove the third verb phrase, reformulating example (8) in

(9) Pierre se leva et monta dans sa chambre. (PS, PS)

then, the accomplishment gets an inchoative meaning as we don't specify anything about when the resulting state of the accomplishment will hold (even if it is a fact that in the minimal model the culmination point will be reached).

Let's have a look at a PS sentence with a stative verb phrase as

(10) Il fut président. (PS)

We already said that this sentence is interpreted inchoatively, that is we interpret this sentence as representing the event of becoming president. The underlying verb phrase is stative, hence we have only one fluent *pres*, which comes in the predicate Initiates(e_{pres}, pres, t). The PS induces the following scenario, Happens(e_0, t_0) and $t_0 <$ now. Hence the whole scenario becomes

- Initiates(e_{pres}, pres, t).
- Happens(e_0, t_0), $t_0 <$ now.

Thus this scenario describes the following situation:

- Nothing happens until time t_0. It is important to notice that, as we use constraint logic programming with negation as failure, The fluent *pres* doesn't hold before t_0 because we don't specify anything about its initial situation.

[10]This isn't correctly expressed, but I just want to convey the informal idea.

- At time t_0, e_{pres} happens (after unification) and initiates *pres* which doesn't get clipped further as nothing else happens.

The important point is that the event e_0 gets unified with the event e_{pres}(see computation page 107), hence we get the description of the achievement *becoming president*.

We now turn to a variant of one of Kamp's famous examples

(11) Cet été-là, François épousa Adèle, Jean-Louis partit pour le Brésil et Paul s'acheta une maison à la campagne. (3x PS)

The problem in the interpretation of this sentence is that the three events are not understood as being ordered, but only as being located in the same period (cet été-là). The scenario will look as follows,

1. - Initiates(begin, this-summer, t).
     Terminates(end, this-summer, t).
   - HoldsAt(this-summer, t_1).
     HoldsAt(this-summer, t_2).
     HoldsAt(this-summer, t_3).
2. - Initiates(marry, married, t).
   - Happens(marry, t_1), t_1 < now.
3. - Initiates(leave, be-in-Brasil, t).
   - Happens(leave, t_2), t_2 < now.
4. - Initiates(buy-house, have-house, t).
   - Happens(buy-house, t_3), t_3 < now.

What it means for the fluents and events is that, for instance, the fluent *be-in-Brasil* is initiated when the fluent *this-summer* holds, hence the event *leave* takes place when *this-summer* holds. However we do not know anything about the other events, (see figure page 108). That the events are not ordered is due to the fact that they are not linked with each other. This is maybe not well rendered by the name of our fluents and events, but for instance the fluent *married* represents the resulting state of the event *marry* which stands for "François marry Adèle". Hence, if the sentence would be "... François épousa Adèle et partit pour le Brésil, Paul ...", we could then derive that the first event is before the second and that both are not in any particular relation to the third.

5.2.4 An approach for *pendant* and *en*

It is usually considered that *pendant* applies to activity verb phrases, and *en* applies to accomplishment verb phrases.

(12) Marie but du café pendant dix minutes. (PS)

(13) Marie but son café en dix minutes. (PS)

In (12), *boire du café* is an activity that gets bounded by applying *pendant dix ans*. That is, the intuitive meaning is that after ten minutes Marie is not drinking coffee anymore. In (13), *boire son café* is an accomplishment and the *en* adverbial tells us how long it took to reach the culmination point. Hence, both adverbials refer to a duration. *En* refers to a duration from a beginning point to a culmination point (already present in the scenario), whereas *pendant* induce the presence of a culmination point but doesn't imply the introduction of a resulting state. Therefore in our event calculus approach, *pendant* introduces in the scenario the relevant statements for the culmination point and its effect on the activity, whereas *en* only imposes constraints on the fluent f_2 of the Trajectory predicate.

Let's see what happens in example (12). The verb phrase is an activity, thus we get the following statements with the two fluents *drinking* (activity of drinking coffee) and *quantity(x)*,

- Initiates(start, drinking, t).
- Releases(start, quantity(0), t).
- HoldsAt(quantity(x), t) $\rightarrow$ Trajectory(drinking, t, quantity(g(x+d)), d).

Then *pendant dix minutes* introduces a culmination point *stop* (10 minutes after initiation of the activity) and the relevant statements for it,

- Terminates(stop, drinking, t).
- $\neg$Clipped(t$-$10, drinking, t) $\rightarrow$ Happens(stop, t).[11]

[11] We have to broaden our notion of scenario for this statement as we don't allow statements with a Clipped predicate. However this is only for the sake of simplicity that we use this precondition. Notice that we could have used something of the form
$\forall s$, t$-$10 $<$ s $<$ t HoldsAt(drinking, s) $\rightarrow$ ...
or the "clock" we will use in the following example.

It is important to notice that the culmination point doesn't depend on the changing partial object quantity(x) as in the lexical information for an accomplishment. Finally, the PS introduces the following elements in the scenario,

- Happens(e, t_0), t_0 < now.

Here we have the same problem as with the accomplishment in example (8), as we have two different events. We choose to substitute the *start* event for *e* for the same reason as before (precedence of the *start* event). However this doesn't mean that we couldn't substitute the *stop* event. In the minimal model for this scenario *start* will happen at t_0 and initiate the *drinking* fluent. After 10 minutes (units of time would probably be a more appropriate term) *stop* will happen and the drinking fluent will be terminated. Hence we should get a *failure* in the computation of the query ?HoldsAt(drinking, t_1), for a $t_1 > t_0+10$, see page 109.

We now turn to our last example. In (13), on the other hand, the scenario is as follows. The verb phrase is an accomplishment, hence we get the following statements with *drinking* as the activity of drinking coffee and quantity(t) representing the quantity of this particular coffee that Marie has drunk (we use quantity(c) to express the fact that all coffee has been drunk). We use in this example a "clock device" to measure time. It is actually more like a chronometer. If it gets initiated at time t and it doesn't get terminated until time t+5, then it says that 5 (units of time) have elapsed at time t+5. The lexical information introduces the following statements

- Initially(quantity(0)), representing that Marie hasn't drunk coffee yet.
- Initiates(start, drinking, t).
- Releases(start, quantity(0), t).
- HoldsAt(quantity(g(s)), t) $\rightarrow$ Trajectory(drinking, t, quantity(g(s+d)), d).
- HoldsAt(quantity(c), t) $\wedge$ HoldsAt(drinking, t) $\rightarrow$ Happens(stop, t).
- Terminates(stop, drinking, t).

Then the *en* adverbials introduces the following statements,

- Initially(f(0)).
- Initiates(start, ticking, t).

- Terminates(stop, ticking).
- Releases(start, f(0), t).
- HoldsAt(f(x), t) $\rightarrow$ Trajectory(ticking, t, f(x+d), d).
- we replace the statement about when *stop* happens by HoldsAt(quantity(c), t) $\wedge$ HoldsAt(drinking, t) $\wedge$ HoldsAt(f(10), t) $\rightarrow$ Happens(stop, t).

The main difference with *pendant* is that now the culmination point depends also on the changing partial object of the accomplishment. Finally the PS gives us the following statement

- Happens(e, t_0), t_0 < now.

Notice that in this scenario we assume that the function g is strictly increasing. This simplifying assumption is due to the fact that we consider that under the activity "drinking" the quantity of coffee that has been drunk should increase. It may seem a too simplifying assumption but our idea is that in order to drink the whole quantity of coffee there must be at least an interval of time where this g function is strictly increasing. Furthermore the fact that the duration that has to elapse before *stop* happens is precisely 10 minutes, may also seem too strong. The speaker of this sentence could know that it took 9 minutes and 50 seconds or 10 minutes and 23 seconds but approximate to 10 minutes, and as listener we are aware of that kind of approximations. However we think that it would be easy to built in this "clock device" that kind of approximation.

We still consider that e will be unified with *start* (first choice for unification). In the minimal model for this scenario the *drinking* activity will be initiated at t_0, hence the fluent *quantity(0)* gets released and the "clock" begins ticking. Furthermore at time t_0+10 *stop* will happen. Hence the *drinking* activity will be terminated and the cup will be empty, see page 110 for the derivation tree of the query ?HoldsAt(drinking, t_1), t_1 > t_0.[12]

[12] We use in this computation axioms 4 and 7 and we left out some Clipped derivation tree for the sake of simplicity.

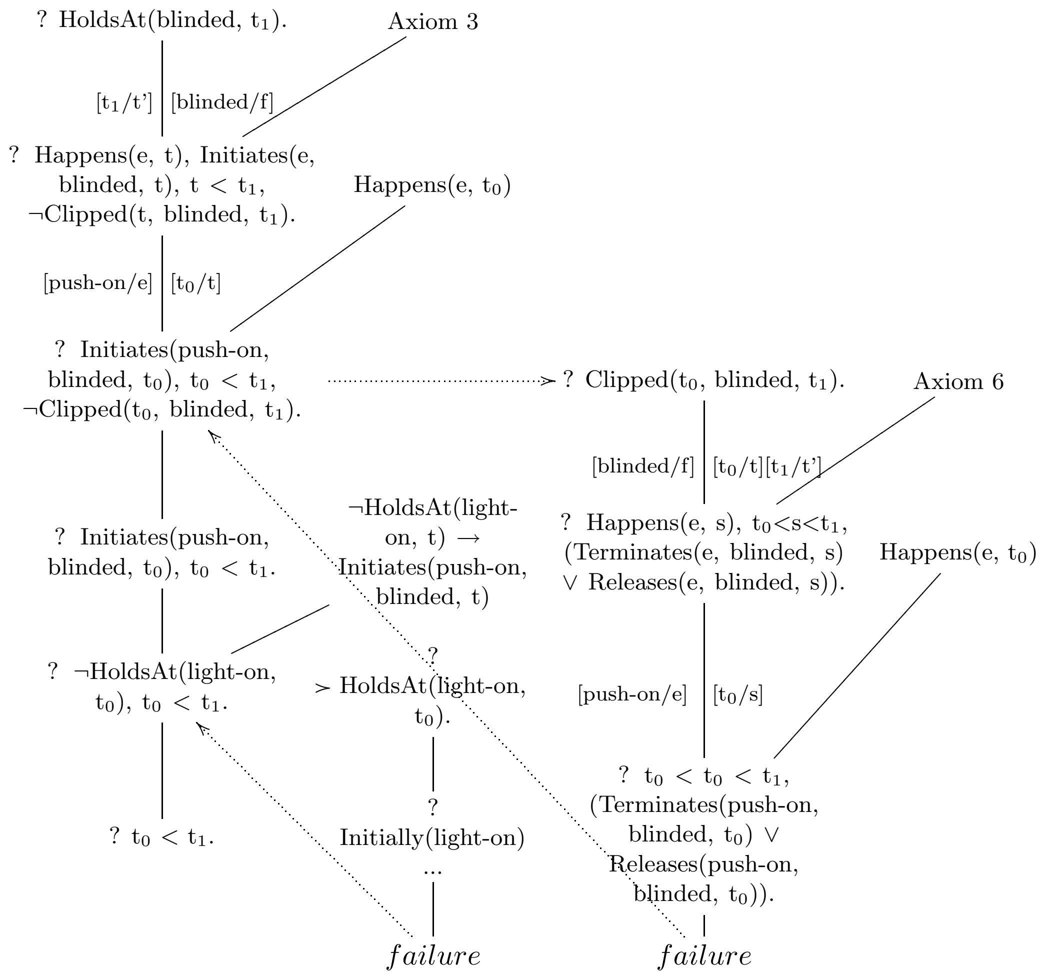


Figure 5.3: Computation tree of example (4).

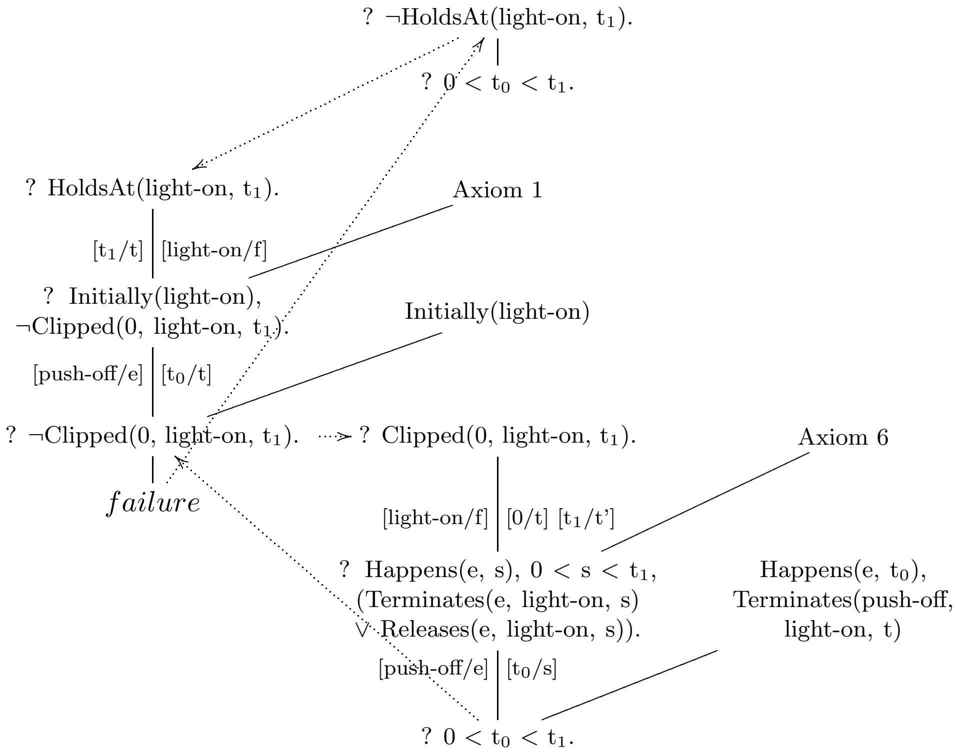


Figure 5.4: Computation tree of example (5) with $t_0 < t_1$.

Figure 5.5: Computation tree of example (5) with $t_0 < t_1$.

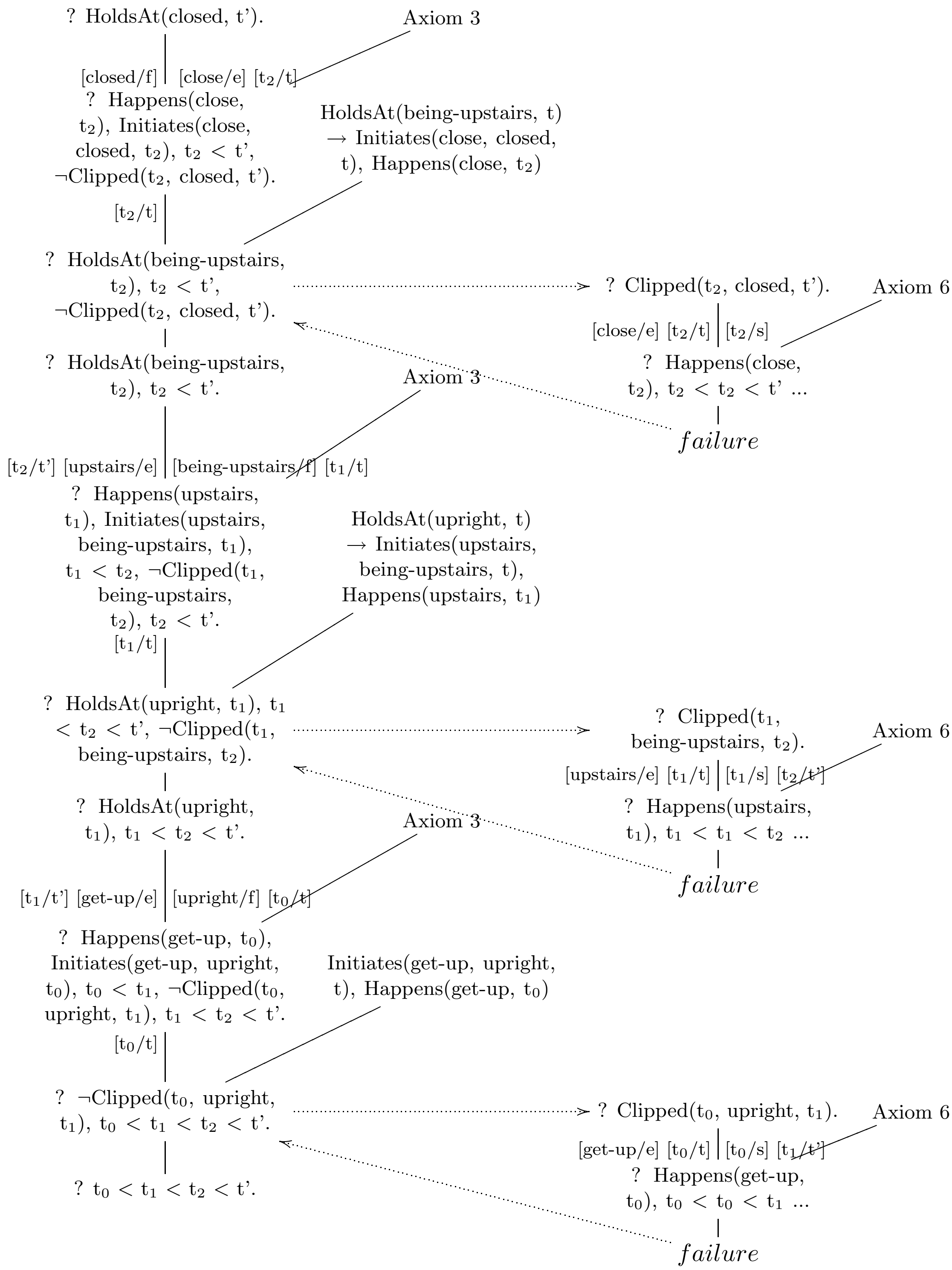
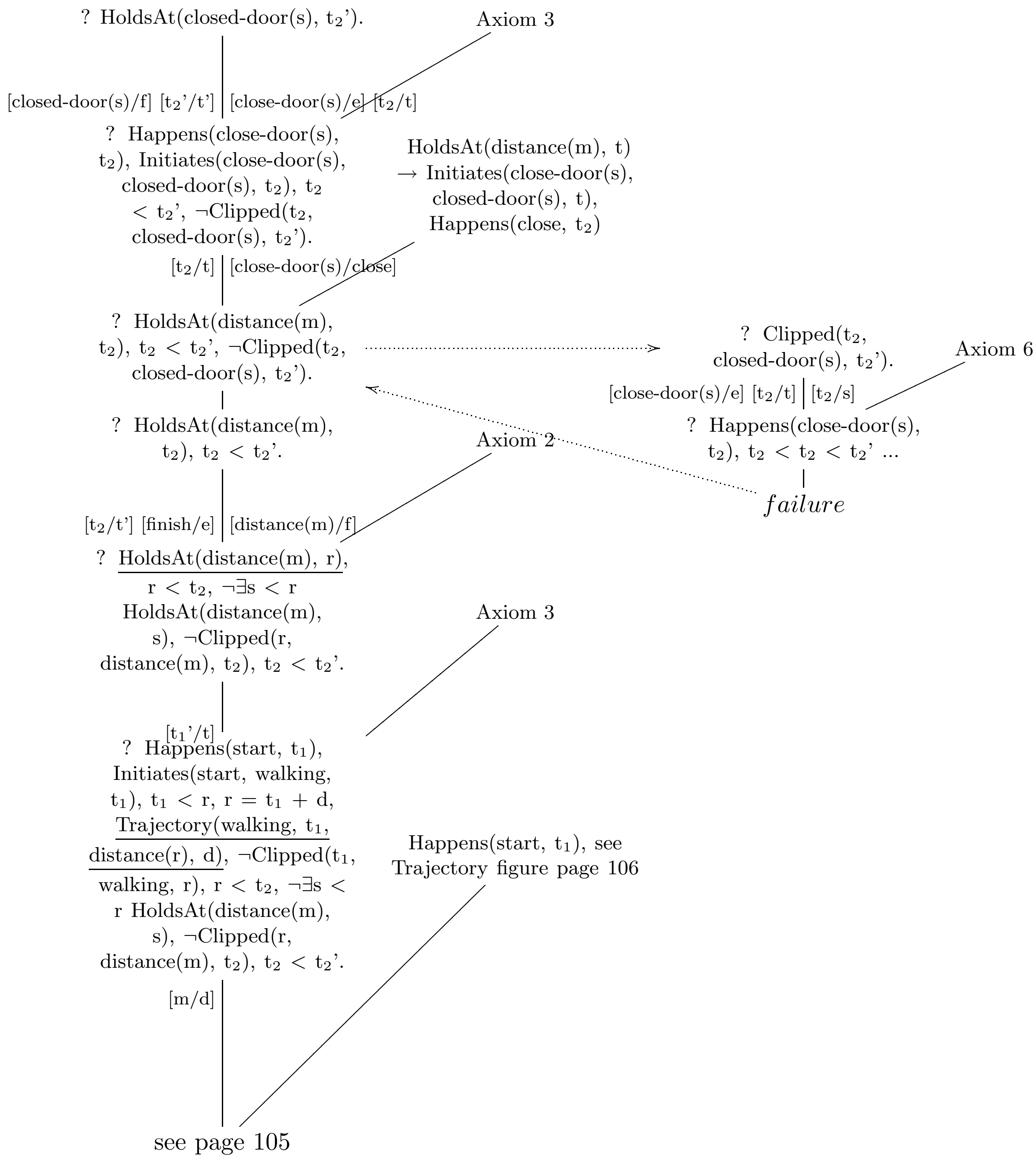


Figure 5.6: Computation for example (8) with the second verb phrase as an achievement.



? HoldsAt(closed-door(s), t₂').
Axiom 3
[closed-door(s)/f] [t₂'/t'] [close-door(s)/e] [t₂/t]
? Happens(close-door(s), t₂), Initiates(close-door(s), closed-door(s), t₂), t₂ < t₂', ¬Clipped(t₂, closed-door(s), t₂').
HoldsAt(distance(m), t) → Initiates(close-door(s), closed-door(s), t), Happens(close, t₂)
[t₂/t] [close-door(s)/close]
? HoldsAt(distance(m), t₂), t₂ < t₂', ¬Clipped(t₂, closed-door(s), t₂').
? Clipped(t₂, closed-door(s), t₂').
Axiom 6
[close-door(s)/e] [t₂/t] [t₂/s]
? Happens(close-door(s), t₂), t₂ < t₂ < t₂' ...
failure
? HoldsAt(distance(m), t₂), t₂ < t₂'.
Axiom 2
[t₂/t'] [finish/e] [distance(m)/f]
? HoldsAt(distance(m), r), r < t₂, ¬∃s < r HoldsAt(distance(m), s), ¬Clipped(r, distance(m), t₂), t₂ < t₂'.
Axiom 3
[t₁'/t]
? Happens(start, t₁), Initiates(start, walking, t₁), t₁ < r, r = t₁ + d, Trajectory(walking, t₁, distance(r), d), ¬Clipped(t₁, walking, r), r < t₂, ¬∃s < r HoldsAt(distance(m), s), ¬Clipped(r, distance(m), t₂), t₂ < t₂'.
Happens(start, t₁), see Trajectory figure page 106
[m/d]
see page 105

? Initiates(start, walking, t_1), $\underline{\neg\text{Clipped}(t_1, \text{walking}, t_1{+}m)}$, $\neg\exists s < t_1{+}m$ HoldsAt(distance(m), s), $\underline{\neg\text{Clipped}(t_1{+}m, \text{distance}(m), t_2)}$, $t_1 < t_1{+}m < t_2 < t_2$'.

$\dashrightarrow$ see Clipped figure page 106

failure

? Initiates(start, walking, t_1), $\neg\exists s < t_1{+}m$ HoldsAt(distance(m), s), t_2), $t_1 < t_1{+}m < t_2 < t_2$'.

$\dashrightarrow$? HoldsAt(distance(m), s), $s < t_1{+}m$

failure

? Initiates(start, walking, t_1), $t_1 < t_1{+}m < t_2 < t_2$'.

HoldsAt(upright, t) $\rightarrow$ Initiates(start, walking, t)

[t_1/t]

? HoldsAt(upright, t_1), $t_1 < t_1{+}m < t_2 < t_2$'.

see end of figure page 103

[t_1/t]

? $t_0 < t_1 < t_1{+}m < t_2 < t_2$'.

Figure 5.7: Computation for example (8) with the second verb phrase as an accomplishment.

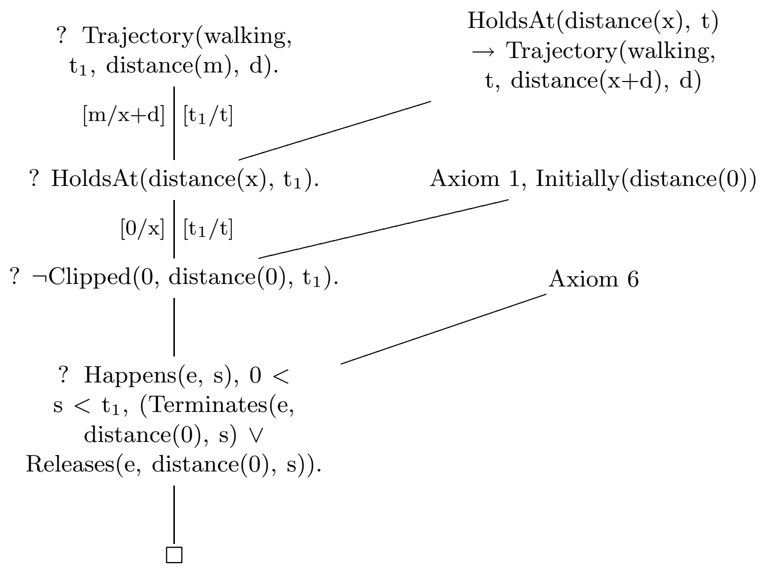


Figure 5.8: Trajectory predicate in example (8) with accomplishment.

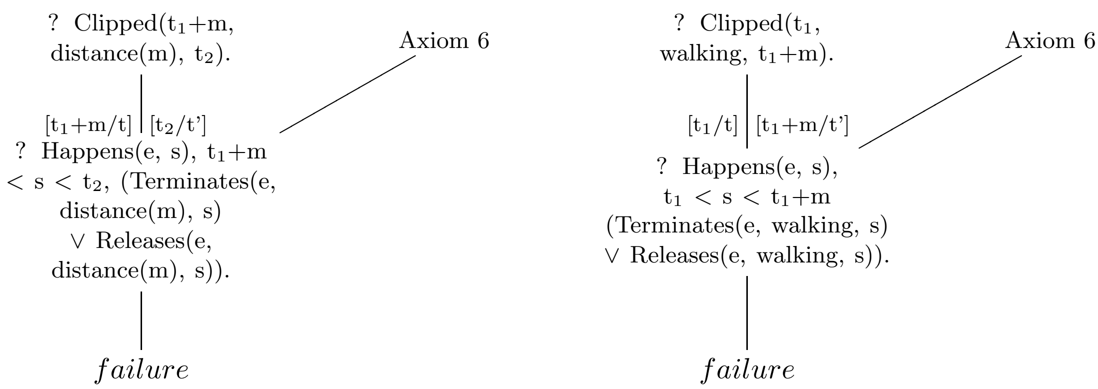


Figure 5.9: Clipped predicate in example (8) with accomplishment.

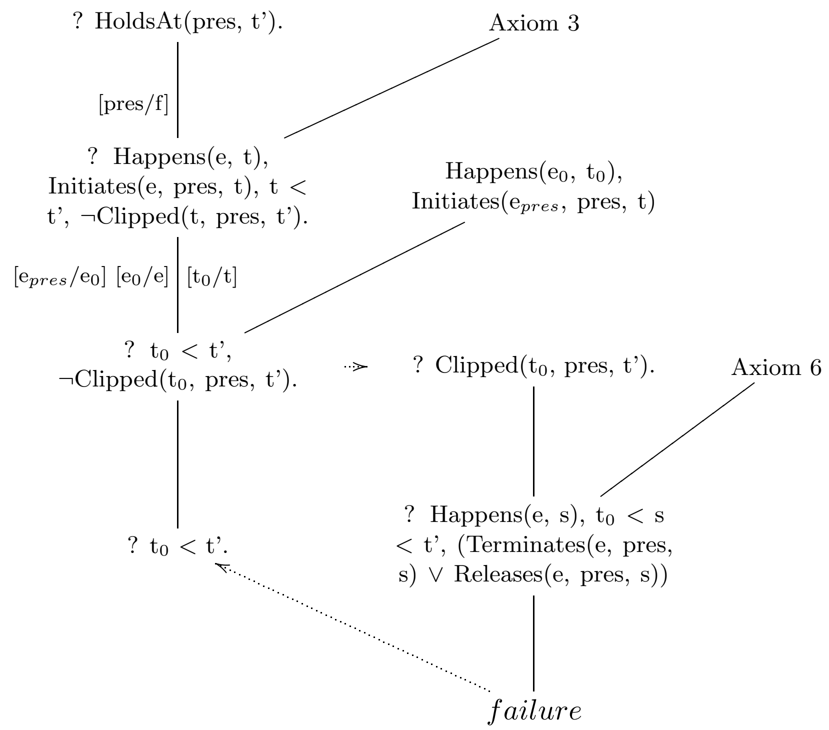


Figure 5.10: Computation tree for the fluent f_{pres} with $t < t_0$.

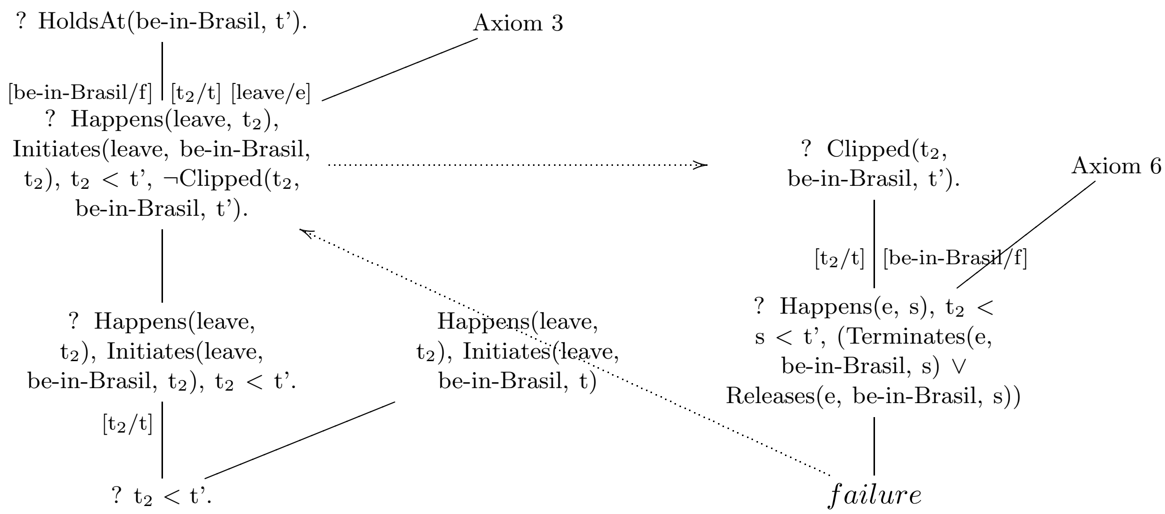


Figure 5.11: Computation tree for the fluent be-in-Brasil of example (11).

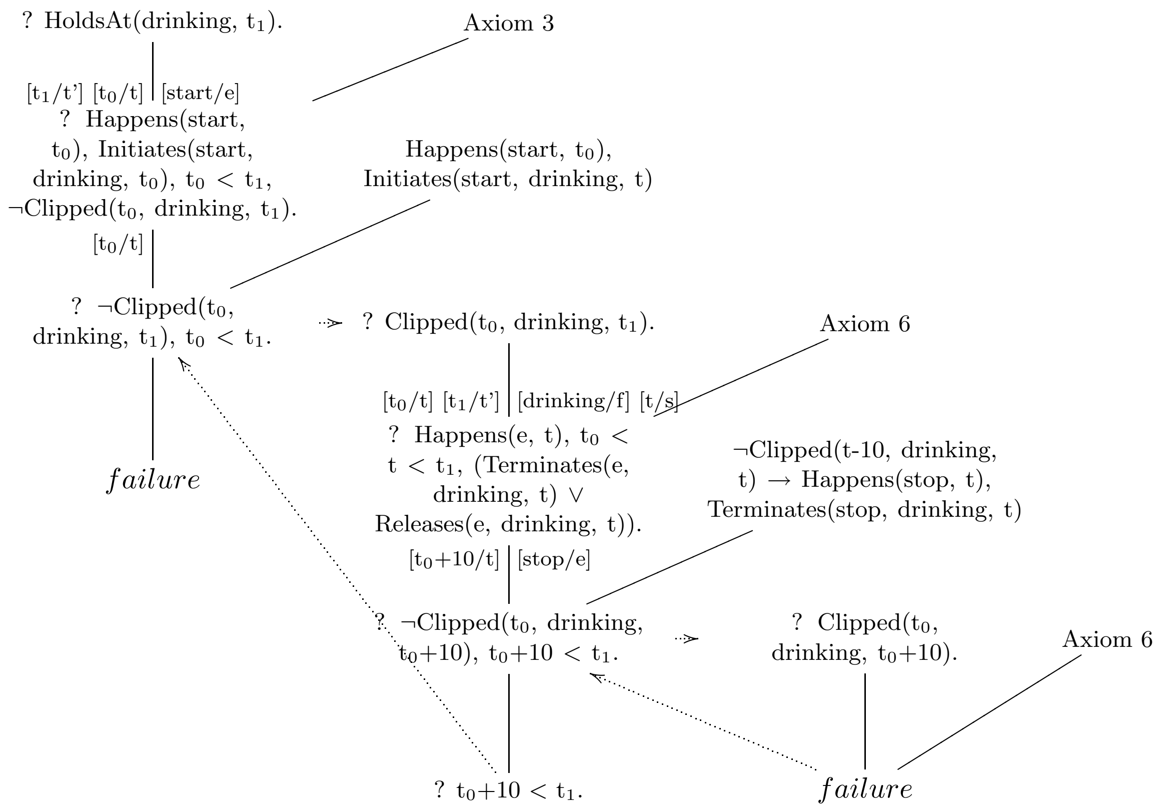


Figure 5.12: Computation tree of example (12) with $t_1 > t_0+10$.

? HoldsAt(drinking, t_1), $t_0 < t_1$.

Axiom 4

$[t_1/t']$ [stop/e]

? Happens(stop, t), Terminates(stop, drinking, t), $t < t_1$, ¬Declipped(t, drinking, t_1), $t_0 < t_1$.

HoldsAt(quantity(c), t) ∧ HoldsAt(drinking, t) ∧ HoldsAt(f(10), t) → Happens(stop, t), Terminates(start, drinking, t)

? Declipped(t, drinking, t_1).

Axiom 7

? Happens(e, s), $t < s < t_1$, (Initiates(e, drinking, s) ∨ Releases(e, drinking, s)).

failure

$[t_0/t]$

? HoldsAt(quantity(c), t), HoldsAt(drinking, t), HoldsAt(f(10), t), $t < t_1$, $t_0 < t_1$.

Axiom 5

$[t_0/t]$ [start/e]

? Happens(start, t_0), Initiates(start, ticking, t_0), $t_0 < t_0+d < t_1$, $t=t_0+d$, Trajectory(ticking, t_0, f(10), d), ¬Clipped(t_0, ticking, t), HoldsAt(quantity(c), t), HoldsAt(drinking, t).

Happens(start, t_0), Initiates(start, ticking, t), HoldsAt(f(x), t) → Trajectory(ticking, t, f(x+d), d)

? HoldsAt(f(10−d, t_0), $t_0 < t_0+d < t_1$, $t=t_0+d$, ¬Clipped(t_0, ticking, t), HoldsAt(quantity(c), t), HoldsAt(drinking, t).

Axiom 1, Initially(f(0))

[10/d]

see page 111

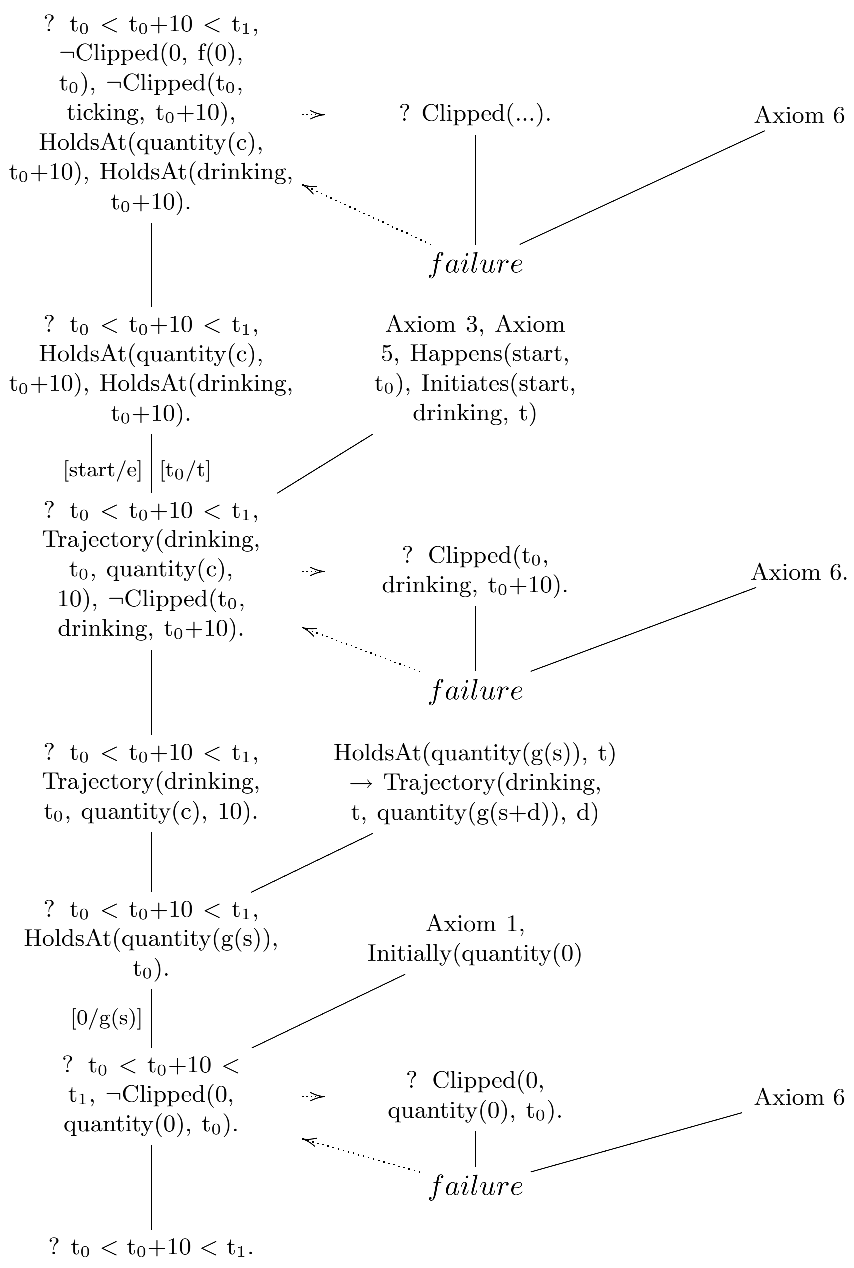


Figure 5.13: Computation tree of example (13).

Conclusion

We would like to conclude this thesis by some remarks on the method we used. First, as the reader will have noticed, our treatment of the French tenses (and other semantics problems) is at a beginning phase of development. After all those pages we only have a fixed treatment of the Passé Simple and the Imparfait, i.e. we have the statements that need to be introduced in the scenario when we encounter a PS or Imp. Concerning our approach to *pendant* and *en* with explicit durations, we think that it could probably be improved. However we think we have also achieved some interesting results.

One of the main advantage of the event calculus formalism as applied in this thesis is actually the methodology used. To remain cognitively plausible, the statement introduced by the PS and the Imp (or *pendant*, and other constructions) should be fixed and kind of minimal. What we mean by minimal is that we shouldn't be allowed to add statements (to what the PS could introduce) because one example resists to our theory. This takes us to our second remark. We noticed during the last chapter, for instance with example (6) page 91, that for some sentences the statements one would expect to be in the scenario on the basis of the lexical and episodic information don't allow us to get a correct representation of the situation at hand. This could be a drawback but we actually think that it is a nice property of our method.

To be more precise, in (6) repeated here as

(14) Jean attrapa une contravention. Il roulait trop vite. (PS, Imp)

we should get an inverse temporal reading with the Imp. That is the Imp sentence is an explanation of the PS sentence. De Swart, for instance, introduces discourse relations based on "clues" given by the text that allow us to say that these two sentences are in a relation of explanation. We think that this should go the other way around. We extend the scenario with world knowledge about the situation at hand (this should be de Swart's clues) that allow us to put the two sentences in relation. Hence we would claim that there is no need for discourse relations. We think that it is cognitively plausible to assume that a subject, being given two tensed sentences, will try to extend the scenario in a reasonable way in order to relate the two sentences (if possible).

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