8

Temporal Underspecification in Discourse

Uwe Reyle and Antje Rossdeutscher

8.1 Introduction

It has been realized for many years that text coherence requires that each next sentence can be seen to stand in a certain rhetorical relation to some (typically just preceding) part of the antecedent text. Moreover, which rhetorical relation the interpreter assigns to a new sentence often also influences other aspects of interpretation, such as the temporal relations between events and states described by the new sentence and its rhetorical relatum. The first theory to deal with these interactions within a formal dynamic setting is the S(egmented) D(iscourse) R(epresentation) T(heory) of Asher (Asher 1993). SDRT exploits non-monotonic logic to determine the possible interactions between discourse and temporal structure. Updates trigger inferences from an axiomatic system combining discourse relations, temporal relations and world knowledge. Cases where different sources supply conflicting conclusions about interpretation are dealt with by the underlying non-monotonic logic. Default mechanism and defeasible reasoning apply, however, only with respect to a fixed and fully disambiguated context, i.e. to the case of attaching a new sentence to some node representing a fully disambiguated sentence meaning in the discourse tree.[1]

[1]This assumption is also implicit in (Asher 1996). First thoughts towards giving up such a restriction are only given in (Asher and Fernando 1997). They involve the

Linguistic Form and its Computation.
Edited by
Christian Rohrer, Antje Roßdeutscher and
Hans Kamp.

Although it is well known that this assumption is unrealistic and cognitively inadequate, it is a common assumption in formal theories of discourse structure. On the other hand approaches to underdetermination of meaning have made it clear that spelling out all the information which can be given at some level of representation goes beyond what is needed to arrive at a full interpretation of an utterance. Therefore, context representations must accommodate the fact that discourses usually do not induce a unique rhetorical relation between discourse segments; nor do descriptions of eventualities allow the recipient to fix a unique temporal order among them.

The approach presented here is based on an underspecified treatment of individual sentence representations as well as temporal and discourse structural relations between sentences. Furthermore we differ from the Asher and Lascarides approach [2] in that we do not consider discourse relations as vehicle for deriving interpretation. Our approach is a cascade of interpretation principles that starts from underspecified representations of the context and the sentence to be added. It then checks for possible persistence of states (present in the context) over the time period denoted by the new sentence and eventually puts an end to them. This is accompanied by a presupposition resolution procedure. Both processes add information, contribute to a partial disambiguation of the context and result in an updated structure that represents the temporal relations between the newly described eventuality and the context in an underspecified way. The next step concerns the compatibility of the resulting interpretation with the set of discourse relations.

Our starting point for the underspecified representations of sentences S is UDRT. In (Reyle et al. 2000) we have extended UDRSs and UDRS-construction to cope with temporal ambiguity at sentence level. The UDRS construction algorithm is based on underspecified representations of the semantics of tense forms and adverbials which may mutually contribute to their disambiguation. The sources of temporal ambiguity are threefold: The first concerns anteriority and posteriority. Tense forms as well as frame adverbials do not always constrain the location of reported eventualities as anterior or posterior w.r.t. the *now*. Eventualities reported in the German present tense may denote past as well as future occurrences of the eventuality; and adverbials like *am Montag*, or *at the 5th of May* may refer to past as well as future instances of mondays, or 5th days in May. The second source of ambiguity is provided by the possibility to interpret German Present Perfect as describing events, or

use of higher order variables over discourse relations.

[2] s.(Lascarides and Asher 1993)

as the states resulting from them. Event readings imply anteriority and only combine with adverbials that have anterior interpretations. State readings are either interpreted as holding at the *now*, or have a posterior meaning. And the third source of ambiguity is the German Präteritum. It may be used to describe completed eventualities, or it may be used with internal viewpoint to describe their progressive aspect.[3]

The calculation of the update proceeds in essentially two steps. First, every new sentence (or clause) S of a discourse is translated into a temporally underspecified UDRS, UDRS(S), by the extended UDRS-construction algorithm. I.e., no intersentential anaphoric connections are established, no presuppositions are verified or accommodated. The task of the second step is to integrate this UDRS(S) into the context, US-DRS(K), (representing the preceding text (or dialogue)). The result of this step usually is underdetermined. The integration consists of

(i) partially resolving temporal and nominal relationships between the eventuality/ies described by S and pronouns contained in S and their temporal and nominal antecedents in USDRS(K),
(ii) verifying and/or accommodating the presuppositions of S.

Both steps go hand in hand with coherence principles. The main such principle is monotonicity. It requires that any property assigned to an individual in a sentence will continue to be true of that individual unless evidence to the contrary can be derived from eventualities explicitly mentioned in the text. For the disambiguation of the ambiguity introduced by the Präteritum, e.g., this means that the progressive state is assumed to hold as long as there is no information implying its completion. A pivotal role in this process of termination of property attribution to individuals (such as inferring completions of events) is played by presupposition justification. This process works directly on temporally underspecified UDRSs and can be seen as attributing further constraints to the overall representation, possibly yielding a partial disambiguation.

8.2 Interpretation Principles

To give an idea of how intricate the interactions between various interpretational principles can be even in comparatively simple cases, let us look at the following example.[4]

(1) a. *Maria ging zur Bushaltestelle. Der Bus kam.*

[3]For a complete description of temporally underspecified UDRSs see (Reyle et al. 2000). In this paper we must restrict ourselves to the treatment of the ambiguity provided by the German Präteritum.

[4]The detailed discussion of this example is given in Section 8.5.

b. *Maria ging zur Bushaltestelle. Der Bus kam. Sie stieg ein und fuhr bis Hauptbahnhof.*

c. *Maria ging zur Bushaltestelle. Der Bus kam. Sie rannte und sie erreichte ihn.*

The two continuations of (1a), (1b) and (1c), present quite different stories. (1b) reports a sequence of completed events describing how Maria got to the main station. (1c) tells us how Maria almost missed the bus: she ran in order to catch it.[5] Thus one main difference between the stories is viewpoint aspect of the eventualities: The first sentence in (1) is understood as accomplished action in the continuation (1b), whereas it carries an internal temporal perspective in (1c). Note that the ambiguity of the German Präteritum can only be resolved when the third sentence is being processed.

Let us assume that the interpreter of (1) is cautious and wants to base his interpretation only on the facts that the sequence of event descriptions provides. With respect to the ambiguity provided by the Präteritum this means the representation of the first sentence distinguishes between the amount of secure information, i.e. information that holds in both readings, and information that is specific to a particular reading. Secure information implies the existence of a state of Maria being in motion, s_1:move(m), and the fact that the manner of this motion is *gehen*. Similarly we conclude from the second sentence that the bus is in motion, s_2:move(b). The goal of the first motion event is the bus stop, and the goal of the latter could be either the bus stop, or Maria. But it is not certain that any of these goals will be reached. The only thing we can do at this stage of processing is, therefore, to temporally relate the two motion events. As the German Präteritum does not allow to reverse the ordering relations of the described eventualities[6] the possibility that the event of the bus coming has been accomplished before Maria started to walk to the bus stop is ruled out. The following possibilities remain and seem to imply a case analysis: $e_1 \bigcirc s_2$, $s_1 \bigcirc s_2$, $s_1 \bigcirc e_2$, $e_1 \prec e_2$, where e_1 and e_2 refer to the accomplished events described by the first and second sentences, respectively, and s_1 and s_2 to their respective progressive states. Our first goal in this paper is to develop an interpretation algorithm that is based on an underspecified representation of the Praeteritum and thus avoids a case analysis of this type.

[5] These are the most prominent interpretations of (1b) and (1c). We will discuss the other interpretations shortly.

[6] In English this is possible if the causal relations indicate the reversed order, as in *Max fell. John pushed him.*.

Our second goal concerns the reconstruction of conceptual dependencies between the reported eventualities. We consider a text to be a realization (or an attempt at realization) of the conceptual structure the story teller has in mind. The conceptualization of the story has to be distinguished from the actual episode which the story describes, and in relation to which the story will be either true or false. It has often been noted that the "brute" facts of an actual episode can be described from different angles, which project different connections between them. A sample scenario of brute facts with respect to which (1b) would be true is the following. Maria gets out of the front door of her house and walks towards the bus stop at the corner. At that moment a bus pulls off the curb further down the street. The woman gets to the bus stop a few seconds before the bus. The bus stops and she gets on. If these are the "brute facts" together with the temporal order in which they occurred, how do they hang together conceptually? Did the woman leave the house and walk to the bus stop because she was familiar with the schedule and thus knew when the bus would come, and did the bus get out of its bay simply in order to get to the stop at the appointed time? Or did the woman walk to the bus stop because she had seen the bus coming? Or did the bus driver, much taken with this regular passenger, wait for her in his bay and pull out when he saw her so as to make sure she would get on his bus and not on the next one? These are some of the possible ways in which the observer might 'conceptualize' what he saw, or in which the observer might establish "non-accidental connections" between the observed eventualities. Theories of discourse interpretation use discourse relations to represent the conceptual glue between the eventualities reported.[7] Discourse relations, however, systematically introduce ambiguities. Our second goal, therefore, is to develop an interpretation strategy that constrains the realm of possible discourse relations. This will be achieved by a binary connective, $\rightsquigarrow$, that establishes a non-accidental connection between the eventualities it combines.[8] We start with a few definitions.

Definition 1:
AmbInf (Ambiguous Information)

> Ambiguites are represented by conditions of the form $K_1 \overset{!}{\vee} K_2$, where K_1 and K_2 are UDRSs and $\overset{!}{\vee}$ is the ambiguity operator (see (Reyle 1996)).

[7] See e.g. (Moens and Steedman 1988), (Steedman 1998), (Caenepeel 1989), (Caenepeel and Sandström 1993), (Sandström 1993), (Glasbey 1995),(Hobbs 1990), (Lascarides and Asher 1993), (de Swart 1994), (Asher 1996), e.t.c.

[8] The relation has been introduced in (Rossdeutscher 2000).

SecInf (Secure Information)

Everything that is not in the scope of $\overset{!}{\vee}$ is *secure information* in $\mathcal{K}$.

INC ($\mathcal{K}$-Incompatibility)

Suppose two states s_1:P_1 and s_2:P_2 belong to the secure information of a UDRS $\mathcal{K}$. Then s_1 and s_2 are *incompatible* w.r.t. the secure information of $\mathcal{K}$, if

- $\mathcal{K}$ is consistent.
- $\mathcal{K} \not\vdash \mathrm{s}_1 \prec \mathrm{s}_2$, and $\mathcal{K} \not\vdash \mathrm{s}_2 \prec \mathrm{s}_1$
- $\mathcal{K} \cup \{s_1 \bigcirc s_2\}$ is inconsistent.

s_1 and s_2 are *potentially* $\mathcal{K}$*-incompatible* if for some disambiguation $\mathcal{K}'$ of $\mathcal{K}$ s_1 and s_2 are incompatible w.r.t. the secure information of $\mathcal{K}'$.

s_1 and s_2 are $\mathcal{K}$*-incompatible* if they are potentially $\mathcal{K}$-incompatible for all disambiguations $\mathcal{K}'$ of $\mathcal{K}$.[9]

DbINC (Disambiguation by INC)

Suppose two states s_1 and s_2 are $\mathcal{K}$-compatible but $\mathcal{K}'$-incompatible for some disambiguation $\mathcal{K}'$ of $\mathcal{K}$. Then the possibility to disambiguate $\mathcal{K}$ to $\mathcal{K}'$ is excluded by eliminating the relevant condition $\mathrm{K}_1\overset{!}{\vee}\mathrm{K}_2$ from $\mathcal{K}$ and merging that argument of $\overset{!}{\vee}$ with the UDRS-component in which $\mathrm{K}_1\overset{!}{\vee}\mathrm{K}_2$ occurred that is not responsible for the $\mathcal{K}'$-incompatibility of s_1 and s_2.[10]

DbINC gives states a disambiguating potential. It applies to states that are introduced during the interpretation process either by direct projection from the lexicon (as in (2)), or to states that are introduced by presupposition accommodation (as in (3) and (4)). The state of immortality is incompatible with the interpretation of *croak* as *die*. The situation in (3) is similar. The German verb *ausleihen* is ambiguous. It can either mean *borrow* or *lend*. The difference to the *croak*-case is that the incompatibility manifests itself in the presuppositions of the *borrow*- or *lend*-reading. Only the presuppositions of the *lend*-reading are compatible with the result state of the buying event, namely 'having x'. In (4) the first sentence is ambiguous w.r.t. a collective or distributive reading. Again the presuppositions of *treffen* versus *trennen* identify the intended meaning.

(2) *Everything that is immortal croaks.*

[9]For non-ambiguous UDRSs $\mathcal{K}$ the notions of $\mathcal{K}$-incompatibility and $\mathcal{K}$-incompatibility w.r.t. the secure information of $\mathcal{K}$ are equivalent.

[10]By the definition of (potential) incompatibility the resulting UDRS is consistent.

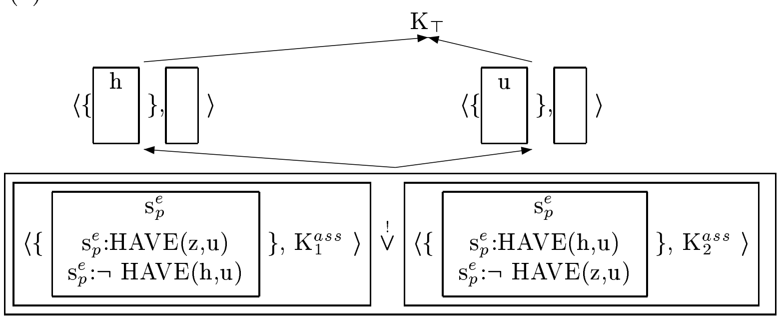
(3) *Hans hat sich gestern ein Auto gekauft. Aber er hat es gleich ausgeliehen.*

(4) *Fritz und Sabine fuhren nach Paris.* $\left\{ \begin{array}{l} \text{i. } \textit{Dort trafen sie sich.} \\ \text{ii. } \textit{Dort trennten sie sich.} \end{array} \right.$

The structure of the UDRSs representing the second sentence in (3) is given in (5),[11] where the lexical ambiguity of the verb *ausleihen* occurs in the bottom UDRS-component. Each reading of *ausleihen* is represented by a pair $\langle$ K^{pres}, K^{ass}, where K^{ass} is the assertional part K^{pres} is a set of presuppositional UDRSs. The pronouns *er* and *es* are treated as presupposition triggers. K_1^{ass} abbreviates

$$\boxed{\begin{array}{c} e \\ s_p^e \supset\!\subset e \supset\!\subset s_r^e \\ e{:}BEC(HAVE(h,u)) \end{array}} \text{ and } K_2^{ass} \boxed{\begin{array}{c} e \\ s_p^e \supset\!\subset e \supset\!\subset s_r^e \\ e{:}BEC(HAVE(z,u)) \end{array}}.$$

(5)



(5) shows that we have to extend the definition of UDRSs in order to accommodate presuppositions at subordinate levels. We do this by allowing in the definition of UDRS-conditions (as given in (Reyle 1993), or (Reyle 1996)) conditions that have the form of *presuppositional UDRS*s. We use the abbreviation UDRS also to denote presuppositional UDRSs. If necessary we write UDRS^{+pr}, or UDRS^{-pr}, to indicate whether the UDRS may carry presuppositions or not.

Definition 2:

A *Presuppositional UDRS* is a UDRS containing presuppositional UDRS-conditions. A *presuppositional UDRS-condition* is a pair of the form
$\langle \mathcal{K}, \text{K} \rangle$, where $\mathcal{K}$ is a set of non-presuppositional or presuppositional UDRSs, K a non-presuppositional UDRS.

[11] We ignore information derived from the tense form.

Assuming that the presuppositions of the pronouns are bound by the referents for *Hans* and *ein Auto* introduced in the first sentence we get an incompatibility between the result state of the event of buying the car s^{res}:HAVE(h,u) and the presuppositional state s_p^e:¬HAVE(h,u) that is part of the *borrow*-meaning of *ausleihen*. By DbINC the UDRS at the right hand side of $\overset{!}{\vee}$ will take over the place of the bottom element in (5) and its presupposition will be justified by s^{res}, i.e. the state s_p^e and the condition s_p^e:HAVE(h,u) will be bound and the condition s_p^e:¬HAVE(z,u) will be accommodated.

Having discussed the case of disambiguation by incompatible states, DbINC, we now turn to the case of incompatibility w.r.t. the secure information a UDRS provides. Consider the sequence in (6).

(6) *# Hans bought a car. He borrowed it.*

(6) is not acceptable simply because there is an incompatibility of states belonging to the secure information. Note that (6) cannot be understood as a true report of the following sequence of brute facts: Hans buys a car, he sells it and then he borrows it. The following principle says that for any incompatibility there must be an eventuality mentioned in the text that justifies this incompatibility, as in (7).

(7) *Hans bought a car and gambled it away the same day. Then he borrowed it to take his girl-friend out for dinner.*

JoINC (Justification of $\mathcal{K}$-Incompatibility)
Incompatibility of two states s_1 and s_2 such that $\neg\, s_2 \prec s_1$ holds in $\mathcal{K}$ is *justified in* the context UDRS $\mathcal{K}$, if $\mathcal{K}$ contains an eventuality ev such that

- $\mathcal{K} \not\vdash beg(\mathrm{s}_2) \prec ev$, and
- $\mathcal{K} \not\vdash ev \prec beg(\mathrm{s}_1)$.

A side effect of JoINC is that it constrains presupposition accommodation. Despite their disambiguating potential presuppositions cannot directly provide evidence for a change of state. This means that if the change of state is not provided elsewhere in the text, then their accommodation contradicts JoINC. Consider the following examples.

(8) *Maria rannte zur Bushaltestelle. Der Bus kam. # Sie rannte schnell zurück und stieg ein.*

(9) *Maria rannte zur Bushaltesstelle. Der Bus kam. # Sie stand auf und stieg ein.*

(10) *Maria rannte zur Bushaltesstelle. Der Bus kam. Sie holte ihre Monatskarte aus der Tasche und stieg ein.*

If we assume that the goal of the event of running back, i.e. of the third sentence in (8) is the bus stop, the unaccepatbility of (8) is explained as follows. Because going back to the bus stop presupposes a state of having been there, which cannot be inferred from the first sentence – neither for its progressive interpretation nor from the completed event. Either Maria has not yet reached the bus stop, or she has reached it and is still there. In both cases she is in the state of not having left the stop. Suppose we accommodated the presupposition of the third sentence. Then an incompatibility arises from this presupposition and the state of not having left the bus stop. This incompatibility, however, cannot be justified, which explains the unacceptability of (8). Therefore we must assume that the goal of the event of running back is somewhere on her way to the bus stop. But the meaning of (8) can neither be that Maria went back <u>from</u> the bus stop to catch the bus at some distance from the bus stop[12] (and the fact that one is inclined to consider this interpretation at all supports the analysis). (9) is odd because 'running' implies 'not sitting' and achieving the goal of walking to the bus stop does not imply any change with respect to the property of 'not sitting'. The last sentence of (9) presupposes, however, that Maria was sitting. Like in (8) this incompatibility cannot be justified. This is different in (10). From the presupposition that Maria has a monthly season ticket in her bag no incompatibility to a state triggered by the first two sentences can be derived. Therefore we are allowed to accommodate the presupposition.

To sum up the discussion so far we formulate the following (preliminary) update rules.

Update Rules

(a) States s_1 and s_2, that are described by consecutive sentences in the Praeteritum yield the condition $\neg(s_2 \prec s_1)$.

(b) (preliminary) Let s_1 and s_2 be two incompatible states such that $\neg(s_2 \prec s_1)$. Whenever an eventuality ev justifies JoINC then we update the representation with the condition $s_1 \prec s_2$.

(c) Let s_1 and s_2 be two states that (i), are not potentially incompatible, and (ii), are such that their temporal order is not determined by a frame adverbial. Then the condition $s_1 \bigcirc s_2$ is added to the representation.

[12]It follows from the semantics of *kommen* that the goal of the bus must be either Maria or the bus stop. But if we assume that Maria is at the bus stop before she runs back, then the goal of the bus must be (some location at) the bus stop. A contradiction.

Update Rule (c) is motivated by examples like (11).[13] It correctly predicts that the whisky is filled into dirty glasses. (11) supports this inference non-defeasibly. We cannot understand it as saying that the rinsing event occurred between the event of taking the dirty glasses and the event of filling them.

(11) *He took two dirty glasses and filled them with whisky. (#) When he had rinsed them he had noticed that one of them was cracked.*

Update Rule (c) is restricted such that s_1 and s_2 result from sentences that belong to some part of a text that does not contain any adverbials.[14] This is motivated by the pair in (12).

(12) *John made a short trip to London. # He visited the Louvre.*
John made a short trip London. Then he visited the Louvre.

We will not be able to give a precise formulation for sentences including adverbials here. This will be done at another occasion. We consider Update Rule (b) more closely in the next section.

8.3 Non-accidental Dependencies

We said that our second goal was to constrain the realm of possible discourse relations by establishing 'non-accidental connections' between eventualities reported in the text. Whether the text succeeds in providing these connections is on the one hand a matter of its linguistic form, and especially of the means that are used for connecting the sentences which introduce or resume the different events of which the story is made up. On the other hand it is a matter of detailed lexical knowledge, presupposition justification and specific interpretation principles.

In this paper we only consider sequences of sentences that are not connected by subordinating or coordinating conjunctions, adverbials, or words as *so*, *however*, and the like. Such sequences thus lack overt linguistic triggers for establishing non-accidental dependencies between the 'brute facts' they report. Brute facts are described by individual clauses; their temporal location is only partially determined by the tense forms of the individual clauses and by the linear order in which the describing clauses follow each other in the text. Further constraints on temporal reference may be derived from the non-accidental dependencies the interpreter establishes between them. If a causal-like relation is assumed to hold between two eventualities their temporal relation is fixed at the same time. The question is, when should such causal-like relations

[13]The example is discussed in (Caenepeel and Sandström 1993)

[14]Further restrictions are necessary. E.g., if s_1 is a state of being drunk, then we cannot assume that this state persists through time.

be introduced. In this section we will state one principle that forces the introduction of a non-accidental dependency, and others that do so only by default. Both principles do, however, not necessarily trigger non-accidental dependencies between adjacent sentences in a sequence. Consider (13).

(13) *A train full of clingfilm arrived at Rome main station. The area of the Vatican was closed to the public.*

Here non-accidental dependencies are hard, if not impossible to get without accommodating special scenarios. One reason for the feeling that (13) is understood as a report of two brute facts only is that there are no links between the two sentences that are triggered by presupposition justification or filling in of implicit arguments. The only things that the two sentences share are temporal and spatial vicinity of the events they report, the former resulting from interpretation strategies for sequences of tensed sentences and the latter from world knowledge. Therefore the interpreter has to – if ever he or she wants to make sense out the two sentences – accommodate, or invent particular background assumptions from which the conceptual glue that makes the reported events stick together may be derived. The availability of such relations without the need for making further assumptions distinguishes internally coherent stories from random, or else topic-related *enumerations* of happenings. Sometimes the background assumptions (or the topic) are given later in the text. A continuation of (13) with (14) establishes a *topic based* external coherence, which would lead to a representation like $e_3 \rightsquigarrow \{e_1, e_2\}$.

(14) *Christo had finally received the permission to wrap it.*

If we consider the first two sentences of (1) the situation becomes much more complicated. As in (13) there are no linguistic clues that would force the interpreter to derive any particular non-accidental dependency relation between the eventualities described. That the two eventualities are perceived as coherent nevertheless depends on the fact that one way to conceptualize the text is based on standard world knowledge: Maria went to the bus stop because the bus came, or was about to come. This is supported by the use of the definite NP *der Bus*.[15] The conceptualization according to which the bus came because Maria went to the bus stop requires non-standard background assumptions and is thus less preferred. In any case, if we were forced to derive a discourse relation or a relation of non-accidental dependency between the first two sentences of (1), we would have to introduce an ambiguity representing

[15] We will come back to this shortly.

the two different possibilities of conceptualization. In addition to this ambiguity there would remain the possibility to interpret the sentences as enumeration of independent, brute facts.

As we will see our algorithm is not committed to deciding whether to establish one of the two possible conceptual links or not to establish a conceptual link at all. It thus avoids this ambiguity. But what are the cases, where a conceptual link must be introduced? We need to identify them because otherwise we would remain at the level of constructing representations of sequences of brute facts only. Consider the following examples.

(15) a. *Kevin fell ill. His mother cured him.*
b. *An apple fell off the tree. Hannah picked it up.*
c. *John found the door closed. He opened it.*

According to our intuitions none of these sequences has a mere enumeration reading. The reason is that first sentences describe eventualities that result in states which are presupposed by the second sentences. To convince ourselves that this is true we must discuss the following variant of the examples in (15).

(16) *Mary's contact lense fell on the carpet. She vacuumed it up.*

Although the presupposition of the second sentence in (16) is bound by result state of the first sentence, (16) permits two conceptualizations. The first interpretation fits the pattern of (15b). Vacuuming the contact lense up is Mary's reaction to it falling on the carpet. The second interpretation is an enumeration interpretation. The contact lense falls on the carpet and Mary hoovers it up. But this latter interpretation is only available under the assumption that either Mary is not aware of the fact that the contact lense has fallen down and that she is about to hoover it up, or the interpreter doesn't want to commit himself to this assumption. This shows that the non-accidental dependency interpretation can be avoided if the verb in the second sentence of sequences like the ones in (15) allows for a non-intentional interpretation. This is the case for (16). *To cure* and *to open* might also be used to describe non-intentional actions. To get these interpretations one must, however, assume that the result states of curing Kevin and opening the door are brought about by some additional event in an unintended causal chain, which in turn is brought about by an action performed by the agent. E.g., opening a door could be caused by unintentionally pushing a button, or intentionally pushing a button without knowing that this would cause the opening of the door. Both cases require the accommodation of a further event that is different from the one described in the second sentence and causes the result state to come about. As the accommodation of such actions is not supported by the descriptions in (15) we will not allow their accommodation under the assumption that the sequences in (15) are completed episodes or stories. In the case of (16) no such accommodation is neccessary, because one can unintentionally hoover something up simply by hoovering it up.

To sum up: when we have a succession of two events e_1 and e_2, described in that order and e_2 is (naturally interpreted as) an action of a person x that presupposes (the result state of) e_1, then e_2 is understood as *reaction* to e_1; and to contravene this impression the author has to make special provisos, such as adding the words 'accidentally', 'by mistake', or the like to the second sentence, or following up with a disclaimer like (17).

(17) *She hadn't noticed it.*

To state the interpretation principle for cases like this it is convenient to generalize the notion of presupposition binding. We call an eventuality ev *responsible for* a state s, if s can be derived from e by means of the lexical theory (i.e., axioms specifying the meaning of lexical predicates like AT, NEAR, BEC, RES, PROG, etc.). In particular this means that ev is responsible for s, if s is the result state of ev. If $E = \{ev_1, ..., ev_n\}$ is a set of eventualities, then E is said to *bind* a (presuppositional) state s, if E is the smallest set such that s can be derived from E by means of the lexical theory.

RbP (Reaction by Perception)

Suppose $\{ev_1, ..., ev_n, ev_{n+1}\}$ are eventualities described by a sequence of sentences $S_1, ..., S_n, S_{n+1}$ such that (a) and (b) hold,

(a) ev_n is an agentive eventuality described by S_n with agent x that presupposes a state s,

(b) s is bound in the context UDRS by the set of eventualities $\{ev_1, ..., ev_{n-1}\}$, such that no event in that set is an action of agent x, and

(c) neither is S_{n+1} a disclaimer as in (17), nor does S_n express non-intentionality by phrases like *accidentally*, *by mistake*, or the like,

then we may accommodate the condition $(ev_1 \wedge ... \wedge ev_{n-1}) \rightsquigarrow ev_n$.

We should underline the fact that RbP excludes two action descriptions, e_1 and e_2, that are performed by the same agent. The reason is that an action description of some agent cannot be conceptualized as his or her reaction on (the result state of) an action he or she performed.

[16] Nevertheless two actions of one agent x may be interpreted as non-accidentally depending on each other. This is so, if we assume e_1 and e_2 to be (part of) the execution of a plan of x's.

(18) *Mary left school. She went home.*

Assuming an underlying plan that determines Mary's actions as described in (18) amounts to assume – among other things – that Mary intends to go home already before she starts to do so. This state of her intending to go home will then overlap the event of leaving school by update rule (c), since there is no (potential) incompatibility between intending to leave school and intending to go home. This is different in (19).

(19) *Mary went to school. She went home (again).*

Here we get a conflict in Mary's intentions. Hence update rule (b) applies and we may infer that the intention to go home is formed when or after she arrived at school. Nevertheless (18) and (19) are similar in that the eventuality in the first sentence may be understood as being responsible for the execution of the intention associated with the second.[17] But the assumption that Mary's actions actually follow the execution of a plan is an assumption by default only. Each sequence of descriptions of actions with the same agent could also be reported by the author without the assumption of plan execution.

The situation is different, when other eventualities come into play. Consider (20). The presupposition of the last sentence, namely that Mary is near the bus, is justified by the information provided by the first two sentences. They imply that both, Mary and the bus are at the bus station, and hence Mary is in the vicinity of the bus.

(20) *Mary went to the bus station. The bus came. She got on.*

(20) has two different interpretations. One interpretation takes both events, the one descibed in the first and the one in the second sentence, to be necessary for Maria to get on the bus. This means that Mary wouldn't have been able to get on the bus, if she hadn't gone to the bus station, nor would she have been able to get on the bus if the bus hadn't come. In terms of non-accidental dependencies this can be expressed by the following condition: $\{e_1, e_2\} \rightsquigarrow e_3$, where e_i denotes the event described in the i-th sentence of (20). The other interpretation makes only the coming of the bus responsible for Mary's entering it. It is much more prominent if we replace the second sentence with *A taxi*

[16] See (Rossdeutscher 2000), Ch. 3, for evidences.

[17] In the case of (19) this may seem odd. But compare it to *Kevin got out of the pool. He jumped in again.*

came.[18] For this reading we thus only get $e_2 \rightsquigarrow e_3$, and there is no non-accidental connection between the first and one of the other two events. The following rule maximizes the conceptual links by default.

PE (Plan Execution)

Suppose $\{ev_1, ..., ev_n\}$ are eventualities described by a sequence of sentences $S_1, ..., S_n$ such that (a) and (b) hold,

(a) ev_1 and ev_n are agentive eventualities with agent x,

(b) ev_n presupposes a state s,

(c) $\{ev_1, ev_2, ..., ev_{n-1}\}$ are eventualities that bind s

(d) ev_1 is an event, i.e. the action is completed,

then we may by default accommodate the condition

$(ev_1 \wedge ... \wedge ev_{n-1}) \rightsquigarrow ev_n$.

8.4 The Interpretation of the German Praeteritum

We represent the ambiguity of the Praeteritum by means of the ambiguity operator $\overset{!}{\vee}$ as given in (21). The option on its left hand side does not bring any new information and is thus equivalent to the information contained in the main DRS, s:PROG(λ e e:K). Here, the progressive operator, PROG, takes an event type as argument. During semantics construction this event type is specified by the verbal semantics, K. The option on the right hand side of $\overset{!}{\vee}$ guarantees the existence of the completed event (also specified by K) which has s as its progressive state.

$$(21)\quad \boxed{\begin{array}{c} \mathrm{s} \\ \mathrm{s{:}PROG}(\lambda\ \mathrm{e}\ \mathrm{e{:}K}) \\ \boxed{} \;\overset{!}{\vee}\; \boxed{\begin{array}{c} \mathrm{e} \\ \mathrm{e{:}K} \\ \mathrm{s} = \mathit{prog(e)} \end{array}} \end{array}}$$

Any state that is incompatible with the progressive state s:PROG(λ e e:K) provided by a description in the Praeteritum will on the basis of

[18]Why this is so has to do with the definite NP *the bus*. Suppose the bus station is marked by a sign at which we also find a letter box. In such a case the two sentences *Mary went to the bus stop/letter box.* denote the same movement performed by Mary, but are very different if we take Mary's intentions into account. If we say that Mary went to the letter box, then the use of the definite NP *the bus* must be justified on other grounds than the information provided by the first sentence, e.g., that there is only one bus a day, or something the like. And in this case a reading that makes the first two eventualities jointly responsible for the action described in the third sentence is not possible. On the other hand the description in the first sentence of (20) triggers the accommodation of an antecedent for the NP *the bus* in the believe state of Mary.

JoINC trigger the event reading if only there are no other eventualities that may justify the change to a state, where $\neg$ s: PROG(λe e:K) holds. This is so in (22), where the conflict between moving and standing triggers the completion of the moving event. A similar situation is given in (23). Here the conflicting states are s_1^{pr}:$\neg$AT(m,bh) and s_2:AT(m,bh), where s_1^{pr}:$\neg$AT(m,bh) is presuppositional information associated with *gehen zu*, and s_2:AT(m,bh) is triggered by *dort.* s_1^{pr} holds as long as the goal is not reached, and is therefore co-final with the progressive state. So again the completion justifies the change from not being at the bus stop to being there. In (24) we have incompatible states in the first and third sentence. But this time the incompatibility is given by the difference in manner of motion and does not necessarily affect s_1^{pr}:$\neg$AT(m,bh). In this case there are two possibilites to satisfy JoINC, either by the completion of the moving event, or by the eventuality described in the second sentence.

(22) *Maria ging zur Bushaltestelle. Sie stand 5 Minuten im Regen bis der Bus kam.*

(23) *Maria ging zur Bushaltestelle. Dort stieg sie in die Linie 81 ein.*

(24) *Maria ging zur Bushaltestelle. Ein Hund kläffte sie an. Sie rannte (davon).*

In case the completion of the moving event is used to justify the change we get the following temporal conditions $e_1 \prec ev_3$, $\neg$ ($ev_2 \prec e_1$) and $\neg$ ($ev_3 \prec ev_2$). There remains thus an ambiguity w.r.t. the temporal location of ev_2 and w.r.t. the completions of ev_2 and ev_3. As the condition $e_1 \prec ev_3$ represents a sequence of actions of the same agent, $e_1 \rightsquigarrow ev_3$ is impossible to assume. The two events are thus independent and we may represent (24) as enumeration $\{e_1, ev_2, ev_3\}$, together with the just mentioned temporal constraints. This is compatible with an interpretation where the barking is background information and with an interpretation that establishes an isomorphism between the brute facts and the eventualities reported. The other case to consider is the one, where the barking is taken to justify the running. Then the running away is naturally understood as a reaction of Maria to the barking of the dog, which we will represent by $ev_2 \rightsquigarrow ev_3$. This still allows for interpreting the first sentence as describing either a completed or uncompleted event.

Without conflicting states no disambiguation takes place. This is the case for the first two sentences in (1). They will provide as secure information that the progressive states, s_1 and s_2, both hold. The temporal relation between the two states is only restricted by the fact that German Praeteritum doesn't allow for inverse order interpretations, i.e. $\neg$

($s_2 \prec s_1$). We state the updated version of Update Rule (b) above.

Update Rule (b) (updated) Let s_1 and s_2 be two incompatible states such that $\neg(s_2 \prec s_1)$. Whenever an eventuality ev justifies JoINC then we may update the representation with the conditions $s_1 \prec s_2$.
If agens(ev) $\neq$ agens(s_2) then add ev $\rightsquigarrow s_2$.

To get intuitions right it is important to compare (24) to (25). Our principles correctly predict that (25a) can only be interpreted as a sequence of completed events. The interpretation according to which Maria started running somewhere on her way to the bus stop is not available because there is no event justifying JoINC. Such an interpretation is only possible in the presence of temporal adverbials. (25b) can be understood as an enumeration of facts (snapshots observed by somebody looking out of the window every five minutes). To get a reading according to which the second sentence in (25a) gives more information about the manner of motion of the first, s_1 must be reinterpreted such that it doesn't specify the manner of motion, which is possible with the German verb *gehen* but not with other verbs of motion as shown in (25c).[19]

(25) a. *Maria ging zur Bushaltestelle. Sie rannte.*
b. *Maria ging zur Bushaltestelle. Fünf Minuten später rannte sie.*
c. *Maria radelte zur Bushaltestelle. *Sie schob ihr Fahrrad.*

We have seen that presuppositions cannot provide direct evidence for a change of state. But they may do so indirectly via their disambiguating potential. Resolution or accommodation of presuppositions may trigger contextual disambiguation, thus turning insecure information into secure information, which then may justify a change of state. Consider the following variant of (1b).

(26) *Maria ging zur Bushaltestelle. Der Bus wartete (dort). Sie stieg ein und fuhr bis Hauptbahnhof.*

einsteigen presupposes a state of Maria and the bus being in a relation of local vicinity, s_3:AT(m,b). Because the bus is at the bus stop, s_2:AT(b,bh), it follows that Maria must be at the bus stop, too, i.e. s_4:AT(m,bh). The incompatibility of s_4 with the state s_1^{pr}:$\neg$AT(m,bh) excludes the progressive reading (by the disambiguating force of presuppositions). The event reading establishes compatibility with s_4. It also satisfies JoINC, because it contains an eventuality that is responsible for the change from s_1^{pr} to s_4. For (1b) the interpretation is more complicated because we cannot simply assume that the bus is at the bus stop,

[19]Compare footnote (20).

when Maria enters it. For some speakers (1b) allows for the possibility that Maria enters the bus on her way to the bus stop. We will come back to this later.

The continuation with the third sentence in (1c) is analogous to (24). The third sentence *Sie rannte* describes a moving event of Maria, just as the first one does. The two events differ w.r.t. their manner of motion.[20] Again there are two possibilities to justify this change of states. The first is to assume the completion of the event described by the first sentence, yielding a narrative interpretation saying that Maria went to the bus stop and then started to run. Here the second sentence serves as background information. The second possibility is to make the coming of the bus responsible for Maria to start running while she is on her way to the bus stop. We will show in detail how the readings of (1) are derived in the next section.

8.5 The case study

8.5.1 Lexical matters

Lexical entries for verbs are given in the form of a pairs of DRSs preceded by a sequence of λ-operators abstracting over the verb's arguments. The first element of the pair of DRSs contains presuppositional, the second assertional information. The assertional part contains information about the main eventuality as well as about eventualities associated with it by aspectual operators (Compare (28)). The temporal relation the main eventuality bears to the evaluation time of the finite tense form is represented by means of two typed metavariables $\upharpoonleft_t$, a placeholder for the temporal evaluation time, and $\upharpoonleft_f$, a placeholder for the frame time. Main lexical states contribute $\upharpoonleft_t \subseteq \upharpoonleft_f \subseteq$ s, main events e $\subseteq \upharpoonleft_t \subseteq \upharpoonleft_f$. The latter relations are inherited by eventualities introduced by aspectual operators. This information will make up the bottom element of the UDRS to represent the sentence in which the verb occurs. Information about tense is provided at Infl (a functional category in the syntactic representation of the sentence to be analyzed). Tense forms introduce two discourse referents t_t, the evaluation time, and t_f, the frame time, into the UDRS's top element together with the condition determined by the tense form. t_t and t_f instantiate $\upharpoonleft_t$ and $\upharpoonleft_f$ during UDRS-construction. $\upharpoonleft_t$ may only be bound by a referent of type t_t and $\upharpoonleft_f$ by one of type t_f. For a detailed description of this algorithm see (Reyle et al. 2000).

[20] That the manner of motion is that of walking depends on the goal of *gehen*. VPs like *zum Graben gehen, zum Haus gehen, zur Bushaltestelle gehen* all support this inference, whereas *zur Schule gehen, nach Hause gehen, zum Uhrmacher gehen* don't.

The basic pattern for motion verbs like *gehen*, or *rennen* is given on the left hand side of (27). Although being activities we treat them as event type verbs, thus contributing e $\subseteq \uparrow_t \subseteq \uparrow_f$ and s $\subseteq \uparrow_t \subseteq \uparrow_f$. Furthermore we assume that the manner of motion is simply given by the verb itself. The right hand side of (27) contains the contribution of directional *zu*.

(27) $$\lambda\, \mathrm{x} \boxed{\begin{array}{c} \mathrm{e\ s} \\ \hline \mathrm{e} \subseteq \uparrow_t \subseteq \uparrow_f \\ \mathrm{s} \subseteq \uparrow_t \subseteq \uparrow_f \\ \mathrm{s} = \mathit{prog}(\mathrm{e}) \\ \mathrm{s{:}move(x)} \\ \mathrm{manner(s)} = \mathit{verb} \end{array}} \qquad \lambda\, \mathrm{z}\ \lambda\, \mathrm{e} \boxed{\begin{array}{c} \\ \mathrm{goal}_{zu}(\mathrm{e,z}) \end{array}}$$

Composition of lexical entries (according to syntactic structure) is governed by simple compositionality and by lexical rules. One such rule states that the combination of a motion verb with directional *zu* (i) replaces the condition goal_{zu}(e,z) by an additional specification of the event type, namely e:BEC(λs s:AT(x,z)), and (ii) brings in the presupposition that up to the completion of the event e, $\neg$AT(x,z) holds. For the phrase *gehen zu* this yields (28).[21]

[21] We ignore the problem that the manner of motion may depend on the type of the PP. See footnote 20.

(28)

$$\lambda x \lambda y \left\langle \begin{array}{|c|}\hline s^{pr} \\ \\ s^{pr}{:}\neg\ AT(x,y) \\ \hline \end{array}, \begin{array}{|c|}\hline e\ s \\ \\ e{:}BEC(\lambda\ s\ s{:}AT(x,y)) \\ e \subseteq \uparrow_t \subseteq \uparrow_f \\ s \subseteq \uparrow_t \subseteq \uparrow_f \\ s^{pr} \supset\!\subset \mathit{end}(e) \\ s = \mathit{prog}(e) \\ s{:}move(x) \\ manner(s) = \mathit{gehen} \\ \mathit{end}(s^{pr}) \not\prec \mathit{end}(s) \\ \mathit{beg}(s^{pr}) \prec \mathit{beg}(s) \\ \hline \end{array} \right\rangle$$

German Praeteritum introduces the two temporal discourse referents t_t and t_f, together with the conditions $t_t \prec n$ and $t_f \prec n$. t_t and t_f instantiate $\uparrow_t$ and $\uparrow_f$, respectively. In addition the Praeteritum transforms the assertional part of the lexical entry such that the information about the completion of the described eventuality becomes part of one of the two possible readings. The information given by the other (i.e. the progressive reading) is subsumed by the non-progressive reading. The result of combining (28) with the temporal information at Infl is the following.

(29)

$$\lambda x \lambda y \left\langle \begin{array}{|c|}\hline s^{pr} \\ \\ s^{pr}{:}\neg\ AT(x,y) \\ \hline \end{array}, \begin{array}{|c|}\hline s\ t_t\ t_f \\ \\ t_t \prec n\ \ ;\ \ t_f \prec n \\ s{:}PROG(\boxed{\lambda e\ e{:}BEC(\lambda\ s\ s{:}AT(x,y))}) \\ s{:}move(x) \\ s \subseteq t_t \subseteq t_f \\ manner(s) = \mathit{gehen} \\ \mathit{end}(s^{pr}) \not\prec \mathit{end}(s) \\ \mathit{beg}(s^{pr}) \prec \mathit{beg}(s) \\ \boxed{}\ \stackrel{!}{\vee} \begin{array}{|c|}\hline e \\ \\ e{:}BEC(\lambda\ s\ s{:}AT(x,y)) \\ e \subseteq t_t \subseteq t_f \\ s^{pr} \supset\!\subset \mathit{end}(e) \\ s = \mathit{prog(e)} \\ \hline \end{array} \\ \hline \end{array} \right\rangle$$

Kommen is a goal oriented movement verb, too. It denotes a transition from a spatial region l_1 to a region l_2. What distinguishes *kommen* from other verbs of movement is the nature of l_2. *Kommen* presupposes the existence of an attitude bearer y relative to whose mental state l_2 is salient, carries the point of perspective, PoP. In the simplest cases l_2 is the actual position of attitude bearer herself. But it could also be her house, her office, the stage of the theater play she is watching, or the busstop she is walking to. We express this mental salience by means of a condition of the form $s^{pr}{:}\mathrm{ATT}(y,\langle \mathrm{BEL}, \boxed{\mathrm{PoP} = l_2}\rangle)$. The following entry represents *kommen* as a relation between the presupposed l_2 and the subject, x, which entails that x is in the neighbourhood of l_2 once the *kommen*-event is completed.

(30)

$$\lambda x \left\langle \boxed{\begin{array}{c} y\ l_2\ s_1^{pr}\ s_2^{pr} \\ s_1^{pr}{:}\neg\ \mathrm{AT}(x,l_2) \\ s_2^{pr}{:}\mathrm{ATT}(y,\langle \mathrm{BEL}, \boxed{\mathrm{PoP} = l_2}\rangle) \\ \uparrow_t \subseteq s_2^{pr} \end{array}}\ ,\ \boxed{\begin{array}{c} e\ s \\ e{:}\mathrm{BEC}(\lambda\ s\ s{:}\mathrm{AT}(x,y)) \\ e \subseteq \uparrow_t \subseteq \uparrow_f \\ s \subseteq \uparrow_t \subseteq \uparrow_f \\ s_{21}^{pr} \supset\!\subset \mathit{end}(e) \\ s = \mathit{prog}(e) \\ s{:}\mathrm{move}(x) \\ \mathit{end}(s_1^{pr}) \not\prec \mathit{end}(s) \\ \mathit{beg}(s_1^{pr}) \prec \mathit{beg}(s) \\ s \subseteq s_2^{pr} \end{array}} \right\rangle$$

As already mentioned, l_2 may be the attitude bearer herself. This allows for a moving target, and in the case of (1b) gives leeway for the interpretation according to which the bus moves towards Maria while she is on her way to the bus stop and let her go in – a scenario which is more realistic for the variant in (31).[22]

(31) *Maria ging zur Bushaltestelle. Ein Taxi kam. Sie stieg ein und fuhr bis Hauptbahnhof.*

The entry for *einsteigen* is similar to that of *gehen*. The only two differences concern the manner of motion, i.e. manner(s) = *einsteigen*, the additional presupposition that the object is not allowed to move, i.e. $s_2^{pr} = \neg$ move(y),[23] and the presupposition that the subject is near (or next to) the object, $s_3^{pr} = \mathrm{AT}(x,y)$.

[22]Intuitions differ with respect to the availability of this interpretation. We will not enter discussion of how these diffences come about.

[23]This presupposition distinguishes the verb *einsteigen* from *aufspringen*. One can use the latter verb to get on vehicles that are in motion.
The presupposition of *einsteigen* is more complicated than the simple ¬move(y) expresses, because it makes sentences like *Nicht einsteigen before der Zug hält!* absolutely senseless. A finer grained treatment of the presupposition must, therefore, model the presuppostion as reduction in speed to a degree that allows a person to get on.

(32)

$$\lambda x \lambda y \left\langle \begin{array}{|c|}\hline \mathrm{s}_1^{pr}\ \mathrm{s}_2^{pr} \\ \hline \mathrm{s}_1^{pr}{:}\neg\ \mathrm{IN(x,y)} \\ \mathrm{s}_2^{pr}{:}\neg\ \mathrm{move(y)} \\ \hline \end{array}, \begin{array}{|c|}\hline \mathrm{e\ s} \\ \hline \mathrm{e{:}BEC}(\lambda\ \mathrm{s\ s{:}IN(x,y)}) \\ \mathrm{e} \subseteq \uparrow_t \subseteq \uparrow_f \\ \mathrm{s} \subseteq \uparrow_t \subseteq \uparrow_f \\ \mathrm{s}_1^{pr} \supset\!\subset \mathit{end}(\mathrm{e}) \\ \mathrm{s} = \mathit{prog}(\mathrm{e}) \\ \mathrm{s{:}move(m)} \\ \mathrm{manner(s)} = \mathit{einsteigen} \\ \mathit{end}(\mathrm{s}_1^{pr}) \not\prec \mathit{end}(\mathrm{s}) \\ \mathit{beg}(\mathrm{s}_1^{pr}) \prec \mathit{beg}(\mathrm{s}) \\ \mathrm{s} \subset \mathrm{s}_2^{pr} \\ \hline \end{array} \right\rangle$$

8.5.2 Updating

As we have seen in the preceding section any sentence contributes essentially three types of information. The first type consists of the secure assertorical information, *secinf(S)*, the second type consists of a (possibly empty) set of presuppositions, *pres(S)*, and the third type represents the insecure, or ambiguous information given by S, *ambinf(S)*. Presuppositional information may of course be ambiguous too. The sentence DRSs for the first two sentences are given in (33).

(33)

$$\mathit{secinf}(S_1) = \begin{array}{|c|}\hline \mathrm{m\ bh\ s_1\ t_t^1\ t_f^1} \\ \hline \mathrm{Maria(m)} \\ \mathrm{Bushaltestelle(bh)} \\ \mathrm{t}_t^1 \prec n\ ;\ \mathrm{t}_f^1 \prec n \\ \mathrm{s_1{:}PROG}(\begin{array}{|l|}\hline \lambda \mathrm{e\ e{:}BEC(} \\ \lambda\ \mathrm{s\ s{:}AT(m,bh))} \\ \hline \end{array}) \\ \mathrm{s_1{:}move(m)} \\ \mathrm{s}_1 \subseteq \mathrm{t}_t^1 \subseteq \mathrm{t}_f^1 \\ \mathrm{manner(s_1)} = \mathit{gehen} \\ \mathit{end}(\mathrm{s}_1^{pr}) \not\prec \mathit{end}(\mathrm{s}_1) \\ \mathit{beg}(\mathrm{s}_1^{pr}) \prec \mathit{beg}(\mathrm{s}_1) \\ \hline \end{array} \qquad \mathit{secinf}(S_2) = \begin{array}{|c|}\hline \mathrm{b\ s_2\ t_t^2\ t_f^2} \\ \hline \mathrm{Bus(b)} \\ \mathrm{t}_t^2 \prec n\ ;\ \mathrm{t}_f^2 \prec n \\ \mathrm{s_2{:}PROG}(\begin{array}{|l|}\hline \lambda \mathrm{e\ e{:}BEC(} \\ \lambda\ \mathrm{s\ s{:}AT(b,l))} \\ \hline \end{array}) \\ \mathrm{s_2{:}move(b)} \\ \mathrm{s}_2 \subseteq \mathrm{t}_t^2 \subseteq \mathrm{t}_f^2 \\ \mathit{end}(\mathrm{s}_{21}^{pr}) \not\prec \mathit{end}(\mathrm{s}_2) \\ \mathit{beg}(\mathrm{s}_{21}^{pr}) \prec \mathit{beg}(\mathrm{s}_2) \\ \hline \end{array}$$

pres(S_1) =

$$\begin{array}{|c|}\hline s_1^{pr} \\ \hline s_1^{pr}:\neg\ \mathrm{AT}(m,bh) \\ \hline \end{array}$$

ambinf(S_1) =

$$\begin{array}{|c|}\hline \begin{array}{|c|}\hline \quad \\ \hline \quad \\ \hline \end{array} \overset{!}{\vee} \begin{array}{|c|}\hline e_1 \\ \hline e_1:\mathrm{BEC}(\lambda\ s \\ s:\mathrm{AT}(m,bh)) \\ e_1 \subseteq t_t^1 \subseteq t_f^1 \\ s_1^{pr} \supset\!\subset \mathit{end}(e_1) \\ s_1 = \mathit{prog}(e_1) \\ \hline \end{array} \\ \hline \end{array}$$

pres(S_2) =

$$\begin{array}{|c|}\hline y\ l\ s_{21}^{pr}\ s_{22}^{pr} \\ \hline s_{21}^{pr}:\neg\ \mathrm{AT}(b,l) \\ s_{22}^{pr}:\mathrm{ATT}(y,\langle \mathrm{BEL}, \boxed{\mathrm{PoP}=l}\rangle) \\ t_t^2 \subseteq s_{22}^{pr} \\ \hline \end{array}$$

ambinf(S_2) =

$$\begin{array}{|c|}\hline \begin{array}{|c|}\hline \quad \\ \hline \quad \\ \hline \end{array} \overset{!}{\vee} \begin{array}{|c|}\hline e_2 \\ \hline e_2:\mathrm{BEC}(\\ \lambda\ s\ s:\mathrm{AT}(b,l)) \\ e \subseteq t_t^2 \subseteq t_f^2 \\ s_{21}^{pr} \supset\!\subset \mathit{end}(e_2) \\ s_2 = \mathit{prog}(e_2) \\ \hline \end{array} \\ \hline \end{array}$$

The update of the two sentence DRSs consists of the following tasks.

- Merging of secure information:
  secinf(S_1) and *secinf*(S_2) are merged. The fact that the two sentences are both in the Präteritum contributes $\neg\ s_2 \prec s_1$ to *secinf($S_{1;2}$)* (by Update Rule (a)).
- Deriving constraints on *secinf*(S_2):
  As there is no contradiction between the two states s_1 and s_2 we cannot strengthen $s_2 \not\prec s_1$ to temporal succession in this case. On the other hand Update rule (c) cannot be applied because s_1 and s_2 are potentially incompatible.
- Presupposition justification:
  The presuppositions of S_1 are accommodated.
  The justification of the presuppositions of S_2 consists of finding antecedents for l and y such that the antecedent of y is an attitude bearer and the antecedent of l a location.[24] The only potential attitude bearer is Maria, hence $y = m$ is added to *secinf*($S_{1;2}$). The antecedent of l is not uniquly determined. It may be resolved to either the location of Maria, *loc*(m), or bh. We keep track of this ambiguity by adding the condition $l = \mathit{loc}(m) \overset{!}{\vee} l = bh$ to *ambinf($S_{1;2}$)*. The rest of *pres(S_2)* will be accommodated.

We get (34) as result of the update with the second sentence.

[24]These are selectional restrictions of the conditions for s_{21}^{pr} and s_{22}^{pr}, which we did not make explicit here.

(34)

$$\mathit{secinf}(S_{1;2}) =$$

$$\mathit{secinf}(S_1) \cup \mathit{secinf}(S_2) \cup \boxed{\begin{array}{c} \mathrm{s}_1^{pr}\ \mathrm{y}\ \mathrm{l}\ \mathrm{s}_{21}^{pr}\ \mathrm{s}_{22}^{pr} \\ \hline \neg\ \mathrm{s}_2 \prec \mathrm{s}_1 \\ \mathrm{s}_1^{pr}{:}\neg\ \mathrm{AT(m,bh)} \\ \mathrm{s}_{21}^{pr}{:}\neg\ \mathrm{AT(b,l)} \\ \mathrm{y} = \mathrm{m} \\ \mathrm{s}_{22}^{pr}{:}\mathrm{ATT(y,}\langle\mathrm{BEL,}\boxed{\mathrm{PoP} = \mathrm{l}}\rangle) \\ \mathrm{t}_t^2 \subseteq \mathrm{s}_{22}^{pr} \end{array}}$$

$$\mathit{ambinf}(S_{1;2}) = \mathit{ambinf}(S_1) \cup \mathit{ambinf}(S_2) \cup \boxed{\mathrm{l} = \mathit{loc}(\mathrm{m}) \overset{!}{\vee} \mathrm{l} = \mathrm{bh}}$$

Continuing with Sie rannte The representation of the first conjunct of the third sentence of (1c) is (35). Note that there is underspecification w.r.t. a potential goal of the running event (compare the entry on page 273).

(35)

$$\mathit{secinf}(S_3) = \boxed{\begin{array}{c} \mathrm{s}_3\ \mathrm{t}_t^3\ \mathrm{t}_f^3 \\ \hline \mathrm{t}_t^3 \prec n\ \ ;\ \ \mathrm{t}_f^3 \prec n \\ \mathrm{s}_3{:}\mathrm{move(w)} \\ \mathrm{s}_3 \subseteq \mathrm{t}_t^3 \subseteq \mathrm{t}_f^3 \\ \mathrm{manner(s_3)} = \mathit{rennen} \end{array}}$$

$$\mathit{pres}(S_3) = \boxed{\begin{array}{c} \mathrm{w} \\ \hline \\ \end{array}}$$

$$\mathit{ambinf}(S_3) = \boxed{\boxed{} \overset{!}{\vee} \boxed{\begin{array}{c} \mathrm{e}_3 \\ \hline \mathrm{e}_3 \subseteq \mathrm{t}_t^3 \subseteq \mathrm{t}_f^3 \\ \mathrm{s}_3 = \mathit{prog}(\mathrm{e}_3) \end{array}}}$$

If we assume that w is resolved to m, the merge of *secinf*($S_{1;2}$) and *secinf*(S_3) contains a pair of states, s_1 and s_3, with incompatible manner of motion. According to JoINC we have to look for an eventuality provided by the text that may be responsible for this change. The only candidates are (i) the completion e_1 of s_1 and (ii) s_2. Taking e_1 amounts to adding the right disjunct in *ambinf*(S_1) to *secinf*($S_{1;2;3}$). With the existence of e_1 we infer the existence of its result state, s_1^{res}, which according to the semantics of BEC satisfies the condition s_1^{res}:AT(m,bh).

Applying update rule (b) leads to the introduction of $e_1 \rightsquigarrow s_3$. By update rule (c) s_1^{res} holds at s_3 and hence the two options y = *loc*(m) and y = bh result in equivalent interpretations. (We chose the representative *loc*(m) and eliminate the disjunction from the ambiguous information in (34).)

(36)

$$
\begin{array}{ll}
\mathit{secinf}(S_{1;2;3}) = & \\
\mathit{secinf}(S_{1;2}) \uplus \mathit{secinf}(S_3) \uplus & \boxed{\begin{array}{c} e_1\ s_1^{res} \\ \\ e_1 \rightsquigarrow s_3 \\ s_1^{res}{:}\mathrm{AT(m,bh)} \\ e_1 \supset\!\subset s_1^{res} \\ s_1 \prec s_3 \\ s_1^{res} \bigcirc s_3 \\ s_1^{res} \bigcirc s_2 \\ e_1{:}\mathrm{BEC}(\lambda\ s\ s{:}\mathrm{AT(m,bh)}) \\ e_1 \subseteq t_t^1 \subseteq t_f^1 \\ s_1^{pr} \supset\!\subset \mathit{end}(e_1) \\ s_1 = \mathit{prog}(e_1) \end{array}} \\
\mathit{ambinf}(S_{1;2;3}) = \mathit{ambinf}(S_2) &
\end{array}
$$

(36) represents an interpretation saying that (i) Maria went to the bus stop and then started to run, and (ii) the bus was approaching the bus stop when, or after she got there. In terms of discourse relations the first and third sentence form a narrative sequence for which the second sentence serves as background.[25]

In the second case s_2 is made responsible for the change, yielding $s_2 \rightsquigarrow s_3$.[26] In addition we get $s_1 \prec s_3$. While all this can be added to *secinf*($S_{1;2;3}$) it does not contribute any information that allows a disambiguation according to DbINC. (37) is the underspecified representation for the set of possible interpretations, namely that either Maria went to the bus stop and then started running when/because the bus came, or Maria was on her way to the bus stop when the coming of the bus made her run.

[25]Note that only two of the reported eventualities are connected by $\rightsquigarrow$. The state described in the second sentence is not connected to them.

[26]This might be refined to $e_2' \rightsquigarrow s_3$, where e_2':*perc*(m,s_2) is the event of Maria perceiving the bus.

(37)

$$\textit{secinf}(S_{1;2;3}) = \textit{secinf}(S_{1;2}) \uplus \textit{secinf}(S_3) \uplus \boxed{\begin{array}{c} \mathrm{s}_2 \rightsquigarrow \mathrm{s}_3 \\ \mathrm{s}_1 \prec \mathrm{s}_3 \end{array}}$$

$$\textit{ambinf}(S_{1;2;3}) = \textit{ambinf}(S_{1;2}) \setminus \boxed{\mathrm{l} = \textit{loc}(\mathrm{m}) \overset{!}{\vee} \mathrm{l} = \mathrm{bh}}$$

In the case where Maria starts running, when she is on her way to the bus stop, PE cannot be applied because the eventuality $\mathrm{ev}_1 = \mathrm{s}_1$ is not completed. Two possibilites have to be distinguished. Either, (i), she runs to the bus stop, thus continuing the execution of her plan with a modified manner of motion. Or, (ii), she gives up her plan and runs towards some other goal. To distinguish between the two cases we must take Maria's intentions into account and model (i) as a case of (mild) plan revision and (ii) as a case were she gives up her plan. In the case of the goal of Maria's original plan will persist and we can infer that the running is still a movement to the bus stop. As there is no space to discuss the construction principles and the representation of propositional attitudes here we have to leave this case as is and will state the relevant construction principles at another occasion. What remains to discuss in this paper is the continuation (1b).

Contination: Sie stieg ein The sentence *Sie stieg ein.* contributes (38).

(38)

$$\textit{secinf}(S_3) = \boxed{\begin{array}{c} \mathrm{s}_1\ \mathrm{t}^3_t\ \mathrm{t}^3_f \\ \mathrm{t}^3_t \prec n \ ; \ \mathrm{t}^3_f \prec n \\ \mathrm{s}_3\mathrm{:PROG}(\boxed{\lambda \mathrm{e}\ \mathrm{e:BEC}(\lambda\ \mathrm{s}\ \mathrm{s:IN(u,v)})}) \\ \mathrm{s}_3\mathrm{:move(u)} \\ \mathrm{s}_3 \subseteq \mathrm{t}^3_t \subseteq \mathrm{t}^3_f \\ \mathrm{manner}(\mathrm{s}_3) = \textit{einsteigen} \\ \textit{end}(\mathrm{s}^{pr}_{31}) \not\prec \textit{end}(\mathrm{s}_3) \\ \textit{beg}(\mathrm{s}^{pr}_{31}) \prec \textit{beg}(\mathrm{s}_3) \\ \mathrm{s}_3 \subseteq \mathrm{s}^{pr}_{32} \ ; \ \mathrm{s}^{pr}_{32} \supset\!\subset \mathrm{s}^{pr}_{33} \end{array}}$$

$$
\textit{pres}(S_3) = \begin{array}{|c|}\hline \mathrm{u\ v\ s}^{pr}_{31}\ \mathrm{s}^{pr}_{32}\ \mathrm{s}^{pr}_{33} \\ \hline \mathrm{s}^{pr}_{31}{:}\neg\ \mathrm{IN(u,v)} \\ \mathrm{s}^{pr}_{32}{:}\neg\ \mathrm{move(v)} \\ \mathrm{s}^{pr}_{33}{:}\mathrm{AT(u,v)} \\ \hline \end{array}
$$

$$
\textit{ambinf}(S_3) = \boxed{\begin{array}{|c|}\hline \quad \\ \quad \\ \hline \end{array} \ \overset{!}{\vee}\ \begin{array}{|c|}\hline \mathrm{e}_3 \\ \hline \mathrm{e}_3{:}\mathrm{BEC}(\lambda\ \mathrm{s\ s{:}AT(m,bh)}) \\ \mathrm{e}_3 \subseteq \mathrm{t}^3_t \subseteq \mathrm{t}^3_f \\ \mathrm{s}^{pr}_{31} \supset\!\subset \textit{end}(\mathrm{e}_3) \\ \mathrm{s}_{31} = \textit{prog}(\mathrm{e}_3) \\ \hline \end{array}}
$$

The pronoun u is resolved to m, Maria, and the implicit reference object v of *einsteigen* is resolved to b, the bus.

Again s_1 and s_3 are incompatible states yielding $\mathrm{s}_1 \prec \mathrm{s}_3$. This time incompatibility manifests itself by the different motion goals, and not necessarily by the difference in manner of motion. One may enter something simply by walking into it. The next step is to look for an eventuality that supports the change from s_1 to s_3. In contrast to the case discussed above, *pres(S_3)* is not empty this time, and it will disambiguate *ambinf($S_{1;2}$)*. Because s^{pr}_{32} requires (by Update Rule (b)) that the bus has arrived at its goal, S_2 gets the completed reading and this triggers the condition $\mathrm{e}_2 \rightsquigarrow \mathrm{s}^{pr}_{32}$. Furthermore the completion of s_2 gives us the result state s^{res}_2:AT(b,l), where the reference of l is still underspecified, i.e. *ambinf($S_{1;2}$)* still contains $\boxed{\mathrm{l} = \textit{loc}(\mathrm{m}) \overset{!}{\vee} \mathrm{l} = \mathrm{bh}}$. The option l = bh implies that Maria must be at the bus stop, too. This gives us the standard narrative interpretation according to which the three sentences describe a succession of three completed events.[27] For l = *loc*(m), then there are two possibilities to disambiguate *ambinf($S_{1;2}$)*. The first is again to assume completion of s_1, yielding the same narrative interpretation. The second is to assume completion of the second event, s_2, but not the first, s_1. In this case the text is understood as saying that the bus drove to Maria while she was walking to the bus stop, and Maria got in.

8.6 Conclusion

We have shown that text interpretation depends to a large extend on presupposition justification and accomodation. Presupposition justification is governed by inferences that exploit knowledge about the underlying lexical theory and by a monotonicity principle, which states that states persist as long as there is no counterevidence provided by the text. The

[27]Strictly speaking we cannot infer the completion of S_3.

dual to this is the requirement that incompatibility of states must be brought about by an event of change that is mentioned in the context.

The theory of interpretation, that we have represented, is based on underspecified representations of temporal as well as conceptual relations between the eventualities reported in a text. In particular we treat the German Praeteritum as underspecified w.r.t. a completed and a progressive reading. We have demonstrated how update rules manipulate information that is split into secure and ambiguous parts without the need for multiplying out ambiguities to perform a case to case analysis. Counterintuitive full disjunctive specification is thus avoided. Disambiguations are carried out only when lexical information such as presupposition binding supports them.

Conceptual dependencies between eventualities reported are included in the representations only if they are non-defeasible. Defaults may apply, but only if the text is assumed to be complete, or if it contains a phrase that implies the completion of the part that precedes it. The underspecified representations correctly constrain the set of different conceptualizations an interpreter may cook up.

Lack of space forced us to restrict our attention to pure paratactic constructions without adverbials, discourse particles and the like. Neither could we work out construction principles that deal with the representation and manipulation of propositional attitudes ascribed to the agent of action descriptions. A further desideratum for future research is to provide a semantics for the relation of non-accidental dependency.

Acknowledgments

We owe Hans Kamp valuable comments on earlier versions of the paper. We thank Kai-Uwe Carstensen, Jasmin Saric, Michael Schiehlen and Judith Tonhauser for intensive discussions on computational aspects on the theory. We also thank Nicholas Asher and the participants of the workshop on Presupposition in Stuttgart, October 2000

References

Asher, Nicholas. 1993. *Reference to Abstract Objects in Discourse.* Kluwer Academic Publisher.

Asher, Nicholas. 1996. Mathematical treatments of discourse contexts. In *Proceedings of the Tenth Amsterdam Colloquium on Formal Sematics*, ed. Paul Dekker and Martin Stokhof. ILLC pubications. University of Amsterdam.

Asher, Nicholas, and Tim Fernando. 1997. Leballing representations of effective disambiguation. In *IWCS II.*

Caenepeel, Mimo. 1989. *Aspect, Temporal Ordering and Perspective in Narrative Fiction*. Doctoral dissertation, University of Edinburgh.

Caenepeel, Mimo, and Görel Sandström. 1993. A discourse-level approach to the past perfect. In *Semantics of Time, Space and Movement*, ed. Michel Aurnague, Andree Borillo, and Myriam Bras.

de Swart, Henriette. 1994. Time adverbials in sentence and discourse. In *Focus and Natural Language Processing*, ed. Peter Bosch and Rob van der Sandt. IBM Deutschland Informationssysteme.

Glasbey, Sheila R. 1995. 'When', Discourse Relations and the Thematic Structure of Events. In *Time, Space and Movement*, ed. Pascal Amsili, Mario Borillo, and Laure Vieu. Workshop Notes od the 5th International Workshop TSM'95.

Hobbs, Jerry R. 1990. The coherence and structure of discourse. In *Literature and cognition*. CSLI. CSLI Lecture notes, 21.

Lascarides, Alex, and Nicholas Asher. 1993. Temporal interpretation, discourse relations, and Common Sense Entailment. *Linguistics and Philosophy* 16:437–49.

Moens, Mark, and Mark Steedman. 1988. Temporal ontology and temporal reference. *Computational Linguistics* 15 – 28.

Reyle, Uwe. 1993. Dealing with Ambiguities by Underspecification: Construction, Representation and Deduction. *Journal of Semantics* 123 –179.

Reyle, Uwe. 1996. Co-indexing Labelled DRSs to Represent and Reason with Ambiguities. In *Semantic Ambiguity and Underspecification*, ed. Kees van Deemter Stanley Peters. Stanford: CSLI Publications.

Reyle, Uwe, Antje Roßdeutscher, and Hans Kamp. 2000. Ups and Downs in the Theory of Temporal Reference. In *Presuppositions and Underspecification in the Computation of Temporal and other Relations in Discourse*, ed. Uwe Reyle. Arbeitsberichte des Sonderfoschungsbereichs 340, Stuttgart/Tübingen, Nr.164.

Roßdeutscher, Antje. 2000. *Lexikalisch gestützte formale Textinterpretation*. Arbeitsberichte des Sonderfoschungsbereichs 340, Stuttgart/Tübingen, Nr.157.

Sandström, Gorel. 1993. *When-Clauses and the Temporal Interpretation of Narrative Discourse*. Doctoral dissertation, University of Umea.

Steedman, Mark. 1998. The Production of time. Department of Computer and Information Science, University of Pennsylvania, June. Draft.