Flat underspecified representation and its meaning for a fragment of German

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Contents

Preface

The idea of formalizing human thinking in order to obtain the ability to distinguish valid arguments from others impartially and systematically is a very old one. At least since the Middle Ages this idea is paralleled by the desire for automata which might mime this ability, i.e. for machines which can compute the consequences of propositions automatically. A medieval precursor of Konrad Zuse and his followers in this respect is Raimundus Lullus (1235-1316); a later one, representative of the French siècle d'or, is Blaise Pascal (1623-1662). With the milestone of Frege's Begriffsschrift, the field opens, such that beyond the bounds of the computation of arithmetic expressions, which is the subject of the machine of the Pascal type, the computability of more complex propositions is looming on the horizon. Sacrificing the smooth *fuzziness* (*ambiguity* and *vagueness*) of natural language in favour of the concept of a formal language with precise, unambiguous (model-theoretic) interpretation of its expressions, Frege's work marks the starting point of the very productive age of modern mathematical logic, which provides exact (correct) deduction algorithms for expressive formal languages. From the prespective of language philosophy however, the formal approach that Frege and his successors Hilbert, Gentzen, Gödel and others followed remained unsatisfactory, despite of its uncontested merits. This is because the general assumption was that the approach be viable for formal languages only and that natural languages, because of their notorious ambiguity, in principle, couldn't be reconstructed as formal languages. As a consequence they were considered to be inaccessible to model-theoretic interpretation and to disallow for corresponding sound (and complete) deduction systems. Epistemologically,therefore, the work of Montague marks a further milestone, no less eminent than the work of Frege, because it presented a setting which exactly allowed for this, namely to understand natural languages as formal languages (viz. the programmatic *English as a Formal Language*) . Using Montague's logical apparatus it was possible to analyse sentences into (unambiguous) expressions of intensional type theory representing the readings of the sentence. Mainly because of this possibility to exactly represent the different readings of natural language expressions, formal linguistics in the line of Montague has been very productive and generated many relevant findings about the mechanics of natural language. However, the ambitious goal of understanding texts and reasoning about texts automatically, which, at least for many people at the early times of model-theoretic semantics seemed within reach, hasn't been achieved yet, at least not to any substantial degree. To a large extent this is due to the fact that sentences normally have too many readings, so that, with respect to performance, the classical *generate and test* is inapplicable because too many readings are generated and not enough readings are filtered out by contextual constraints on the basis of world knowledge date bases of a realistic (modest) size. (1) exemplifies how lexical and structural ambiguities are multiplied out by compositional semantics into a multitude of readings:

(1) *Die lustigen verkleideten Männer und Frauen und Kinder aus Disneyland warteten beim Einlass.*
The funny/cheerful disguised men and women and children from Disneyland waited at the entrance/when entering.

(1) shows several ambiguities: *lustig* might mean *funny* or *cheerful*. *Einlass* might be understood as an event of *entering* or as *entrance* in the sense of a location. Depending on this, *beim* might be understood as temporal or spatial relation, *aus* might be understood as *originating from* or solely as *coming from*. Next to these lexical ambiguities there are structural ambiguities: The prepositional phrase headed by *aus* might attach to *Kinder*, or to *Frauen und Kinder* or to *Männer und Frauen und Kinder*. Similarly, the adjectives *lustig* and *verkleideten* might relate to the different parts of the noun coordination as accessible from the left (*Männer* or to *Männer und Frauen* or *Männer und Frauen und Kinder*) and correspondingly for the determiner *die*. Also, the subject of the sentence might be read collectively and distributively in several ways (a group, a set of groups, a set of people). This is relevant with respect to the event reading of the *bei*-PP (there is a waiting of the (one) group before its collective entering or sequences of waitings and enterings). Admitting that some of the combinatorial possibilities are ruled out for structural and sortal reasons (the scope of the determiner must include the scope of the adjective, the temporal *bei*-reading presupposes the event reading of its argument etc.), we nevertheless obtain some 20 - 30 readings. (1) might look a bit like the notorious sophisticated hand-made example the linguist figures out to motivate some bizarre new theory, but one quickly realizes that coordinations, lexically ambiguous terms, quantifiers with different readings and scopal possibilities etc. are nearly always present and multiply the readings of phrases, sentences and texts, such that reasoning on the basis of texts, which through Montague's insights came to be within reach in theory, practically is intractable, because of the combinatori al explosion. This *combinatorial explosion puzzle* [1] is one of the central questions of modern computational linguistics and also of language philosophy. Its solution is a prerequesite of intelligent text processing and knowledge management. Two often made observations are extremely important with regard both to processing and to philosophical explication. Firstly, context often seems to rule out readings on the fly, before they are fully processed. Psychologically, this means the recipient of a text even doesn't notice them. Secondly, also often, the recipient draws conclusions from utterances without

[1] Poesio's term, see [Poesio(1996)].

considering in detail the alternative readings as resulting from the (still unresolved) sentential ambiguities. Sometimes he isn't even aware of these ambiguities. These observations support the view that ambiguity, vagueness, indefiniteness etc. are not deficiencies of natural language, but essential and elegant means which make it possible to keep communication and its signs efficient, avoiding sumptuous vocabularies and inappropriate overspecification of information. If this is true, representations of ambiguous structures and terms are psychologically real, i.e. when trying to understand a text we build up information structures which are possibly ambiguous and we can manage such structures very well. This means that, next to the considered reasons of technical tractability, there are independent epistomological reasons for assuming an attitudinal layer of so called *underspecified representations*and for developing and investigating calculi which can model the corresponding deductive competence.

The task of designing a language for underspecified representations will be the subject of this study. The task is twofold. Firstly, we must provide vocabulary and composition rules of the language which make it possible to represent the same text by different representations which develop from each other by partial disambiguation, as may be triggered by (additional) contextual information. Secondly, we must define a semantics for the language and, in particular, we must say what (partial) disambiguation means with respect to the formal setting developed. We call the theory, which results from working this out, *flat underspecified discourse representation theory* (FUDRT). It is not new. It has been presented for the first time in 1996 as a working paper of the SFB 340. It developed from the experiences we made when we tried to implement the semantic component of an analysis system for a large fragment of German, starting from Reyle's *underspecified discourse representation theory* (UDRT). The study presented here completes and updates this older presentation in certain respects, revises it in some others. However, the main motivation for the present text is to turn this technical report, which addresses the computer scientist who is deeply involved in implementation aspects, into a more generally intelligible version, which we hope to be of interest to the philosophically interested reader also.

The experience that we made was the following. Literature provided a number of proposals for treating different types of ambiguities. However, none of these proposals presented a unified account of ambiguity. In particular, at that time, UDRT treated scopal ambiguity, but no other type of ambiguity, like lexical or presuppositional ambiguity. Other theories dealt with lexical ambiguity, distinguishing relevant categories from each other for instance, without incorporating their findings in a overall system for natural language processing, etc. Besides the topic of ambiguity, there could be found a wide range of contributions to other relevant topics like verb semantics and aspect, adverbial modification, negation, quantifiers, presupposition and referential terms, etc., often with classical (i.e. more or less uncontested) suggestions for a formal treatment. However, also here, the number of contributions which dealt with incorporating the specific formal representations in one formal setting were relatively rare. Therefore, the task was to partition the relevant word classes into subclasses whose members conform to the same representation schema and to provide a compositional semantics for the structures which can be built by combining elements of these classes. Conforming to the same representation schema meant that the respective representations use or combine the same types of conditions, as defined on the basis of a common kernel of usual DRT vocabulary, including discourse referents for events, representation conditions for attitudinal states of agents etc. The guideline being broad coverage, the task was certainly not to work out the meaning of single representatives of the different classes. This means, it was relevant to distinguish between frequency adverbs and manner adverbs say, because frequency adverbs take their argument in the scope of a quantifier whereas manner adverbs do not, but it was not relevant to work out the semantics of single adverbs, as, for instance, the semantics of *often*, as opposed to *sometimes* or *always*. Nevertheless, the formalism should support assigning more detailed representations to the original coarse-grained partial representations in a cascaded manner and in a way that the respective interaction with other partial representations be preserved with respect to logical type, but, possibly specified as regards content such that it can (automatically) trigger (partial) disambiguation of the respective representation.

Meanwhile a number of alternative approaches to underspecified representation have appeared. However, we think that with respect to coverage, the approach has advantages when compared to its competitors, where many still tend to deal with selected phenomena of ambiguity only. Also, underlying the semantics component of a commercial Machine Translation system (cf. [Eberle(2002)]), it must prove itself to the customer on a daily basis. This is the second reason for presenting FUDRT again and in a form which might be accessible to a larger audience. [2]

The book is structured as follows. First, the paradigm of ambiguity will be sighted, as can be compiled form the literature. This should motivate the fundamental structural definitions of the representation schemata presented in the second section. In the third part, which is the most extended, the representation classes of a relevant part of the linguistic inventory will be enumerated. In the fourth part, fundamental conditions of the model-theoretic interpretation of flat underspecified representation structures will be presented. Section 5 summarizes the main features of the theory. The appendix exemplifies that the theory and its constructs respectively easily can be adapted as semantic component of a symbolic, compositional, feature structure based system for analysing NL-texts. It does this by incorporating the suggested semantics into an HPSG grammar of German.

[2] As when spelling out the theory for the first time, I would like to thank Hans Kamp, Uwe Reyle, Peter Krause, Michael Schiehlen, Carl Vogel and the other members of the former IMS semantics group for helpfull discussion. Also, I would like to thank Hans, Peter and Carl for trying to take my personal English closer to standard English.

Chapter 1

Introduction

The notion of ambiguity is highly ambiguous and is worth taking a closer look at. (1), which we repeat here as (2), illustrates a number of lexical and structural ambiguities.

(2)

Die lustigen verkleideten Männer und Frauen und Kinder aus Disneyland warteten beim Einlass.
The funny/cheerful disguised men and women and children from Disneyland waited at the entrance/when entering.

Einlass exemplifies a clear *lexical ambiguity*. It can mean an event of *entering* (*der Einlass begann um 19 Uhr / the entrance was at 7 o'clock p.m*) and an object or location (*der Einlass war auf der Vorderseite / the entrance was at the front side*). However there are more subtle lexical ambiguities which do not encompass such sortal distinctions. *Lustig* either means some habitual property or disposition in the sense of *cheerful* or it means that (for the considered time slice) its semantic argument shows some behavior which can be designated *by funny*. Similarly, *aus* stands for the more fundamental relation of *originating from* or the more contingent *coming from*. *Männer*, *Frauen*, which can be understood also as *Ehemänner / husbands* and *Ehefrauen / wives* are more of this second type of subtle ambiguity, *bei* (spatial versus temporal relation) more like the first one, where the reading of *bei* directly depends on the the reading of *Einlass* however.

The different possibilities of determining the semantic argument of the determiner *die*, of the adjectives *lustig* and *verkleidet* and of the prepositional phrase headed by *aus* describe a specific kind of structural or scopal ambiguity, called *attachment* ambiguity: It is not clear whether these modifiers attach to the entire noun coordination (*Männer und Frauen und Kinder*) or to substructures of it (to *Männer und Frauen* or *Männer* and to *Frauen und Kinder* or *Kinder* respectively).

Provided it is clear what structure attaches to what other, it still may be unclear of what type the attachment is.

(3)

Il passe des clients au restaurant.
He provides customers to the restaurant.
Customers go to the restaurant.
Customers pass by the restaurant.
He goes from the customers to the restaurant.

In (3), on the basis of the assumption that *il*, *des clients* and *au restaurant*, all three modify the verb, it is still unclear whether they fill a subcategorized role or not and if yes, which one. We call this type of ambiguity *functional ambiguity*. Of course, disambiguation here is interleaved with lexical disambiguation (compare the possible translations).

Next to these attachment ambiguities, there is another structural ambiguity which is generally called *scopal ambiguity* and which is presented by the (unconstraint) order of relative scope of quantifiers, as in (4).

(4)

Wenigstens 200 Vögel wurden von 3 Naturschützern registriert.
At least 200 birds were registered by 3 nature-lovers.

In (4) the quantifier from the (surface) subject can have scope over the von-PP (the deep subject) or vice versa. In the first case, the sentence describes a situation where at least 200 birds have been registerd by 3 nature-lovers each (that is, there might be up to 600 observers). This reading is not unlikely in the context of reporting statistics about the efficiency of the work of some agency for nature conservation say. In the second case, there is a set of just three nature-lovers who did the registration of the birds, where it is still unclear whether they acted separately or conjointly. In the first case, which is the *distributive reading* of the quantified pharse, there are at least 200 birds for each of the persons, which provides us with a total of at least 600 birds. In contrast, in the second case, which is the *collective* reading, there is a total of at least 200 birds, wher the corresponding acts of registrations which are conjointly effectuated by the three nature-lovers. Note that also these readings are very well acceptable in a context as described above. We see that with respect to quantifiers which are ambiguous between collective and distributive reading, scope ambiguities become relevant only if at least one of the quantifiers obtains distributive reading. We will treat the collective-distributive antonymy that (some of) the quantifiers show as a lexical ambiguity of these quantifiers.

A further type of ambiguity is presented by the pragmatic/semantic assumptions about the situation the utterance or text is about, or in other words, by the different possibilities of incorporating the utterance or text representation into the attitudinal state of the recipient and into the representation of the preceding text respectively, in accordance with the presuppositional clues of the utterance or text. This means that, often, these clues aren't unambiguous.

Among other things, such clues are referential terms like pronouns and definite descriptions which refer to individuals or objects introduced in the preceding text or which, by other reasons, are familiar to both hearer and speaker (sender and addressee of the information). Often there is more than one individual or object in the discourse universe which the referential term can relate to or there is none, so that a so-called *antecedent* must be *accommodated*, which means that such an individual or object, without being mentioned, must be assumed to exist with regard to the *common ground*, i.e. the information state which sender and addressee share. Things get even more complicated if the description of the referential term, as such, is ambiguous, which is the case with respect to both of the definite descriptions of (2). When *Einlass* obtains the object reading the antecedent must be an object also, otherwise (when *Einlass* means *when entering*) it must be an event. Conversely, if the discourse universe provides possible antecedents which conform to only one of the readings of the description, this information can disambiguate the referential term: Provided the preceding text has introduced a set of men (for instance by *she noticed three or four horribly disguised men*), not a set of men and women or a set of men, women and children, it is likely that the subject of (2) obtains a structural analysis accodring to [*the ... men*] *and* [*women and children ...*] , such that the definite description can refer to the set which the recipient is already familiar with. This means, with respect to this context, that it is more likely that the determiner attaches to *Männer*, not to *M"anner und Frauen* etc. The same is true with respect to the other structural analyses of the NP if there are corresponding antecedents.

We can take from this that resolution of presuppositional links is interleaved with lexical and structural disambiguation of referential terms.

Other presuppositional clues are presented by tenses: Past tense normally refers to some reference time in the past (as provided by the story as is told so far) and correspondingly with respect to anticipated events etc. Of course, making reference to the event structure of the preceding text is a source of ambiguity also. Another one, connected to presupposition, is the structuring of the sentence in focused (new) information and background (old) information,as effectuated by accent and/or focus adverbs. (The conclusions that can be drawn with respect to the information states of sender and addressee can depend on this).

Often this type of ambiguity interacts with the resolution of elliptical expressions, which can be seen as an instance of the resolution of referential terms (in the sense of resolving zero-VP-anaphora). *Ambiguity of elliptical expressions* is due to the fact that there may be several phrases which can serve as 'antecedent' to the ellipsis and that these phrases may be ambiguous themselves. A specific problem is posed by the fact that acceptable disambiguation of the ellipsis is dependent on the disambiguation of the antecedent. Consider (5):

(5)

Ahmed ist erstaunt: Ben Kalisch liebt seine Frauen und Kinder und nicht die Pfeifen und Chalil auch.

> Ahmed is suprised. Ben Kalisch loves his wifes and children and not the pipes and Chalil too.

The first question to answer is whether the quality of not loving pipes is part of the antecedent of the ellipsis or not. Next to this, we must decide about how we want to understand *seine Frauen und Kinder*), because this will put constraints on the interpretation of the ellipsis. The possessive determiner can apply to*Frauen und Kinder* , (a), or to *Frauen* alone, (b), and it can relate to Ahmed, (i), or to Ben Kalish, (ii). If Ben Kalish loves *the wives of Ahmed* and *the children of Ahmed*, (a.i), the same is true for Chalil. If Ben Kalish loves *his own wives and children*, (a.ii), Chalil may also love his own wives and children, i.e. *Ben Kalish's wives and children*, or he may love *those of Ben Kalish*, where the first alternative uses the so-called *sloppy identity* of the interpretation of the pronoun, which means that the pronoun-antecedent-relation of the ellipsis is structurally identical to the one of the ellipsis antecedent, and the second the so-called *strict identity*, which means that the corresponding denotations must be the same. In the first case, identity relates to the referential behavior of pronouns therefore and in the second to the reference as such. Note that with respect to relating the pronoun to Ahmed (i) there is no such difference because the alternatives coincide by making reference to a discourse referent which is introduced outside the scope of the ellipsis antecedent (whose identity cannot alter therefore by shifting the description to another situation). Similarly, we obtain three readings for (b), where the possessive pronoun applies to *Frauen* and where *cildren* obtains (generic) bare plural reading.

In the next paragraphs, we will throw a (brief) look on what literature tells us about dealing with lexical and structural ambiguity and about underspecified representation of presuppositional and elliptical terms (viz. the representation of the corresponding resolution constraints). The examples should have made clear that this must include the phenomenon called *parallelism*) that similar terms (when more or less neighbored) must be disambiguated in the same way.

1.1 Lexical items

As a starting point, attempts to explain and classify lexical ambiguity usually distinguish between *homonymy* and *polysemy*. These notions refer to the two diachronic processes which create ambiguity: On the one hand, two different terms, different in form and content (at some time), undergo some conventional diachronic law of formal transformation, which makes them formally identical, they become *homonymous*. On the other, a single term may get used in a larger variety of contexts, so that from the 'original' meaning there might have developed a number of specialized uses, that is, meanings.

The first process may involve the base form or the entire set of inflected forms. English *bank* and German *Bank* are often mentioned as examples . English *bank* denotes a monetary institution (from Italian *banca* > French *banque*) or a location as in *the banks of the Ohio* or a form of a location *bank of clouds*. Similarly, the contrast in German is between the interpretation as monetary institution (with the same root) and as piece of furniture *das Bänklein unter der Linde*), from Germanic *banki*. Here, however, the contrast relates to the base form only *die Banken* versus *die B"anke*. Other examples are German *Ball*/English *ball* with respect to the contrast between social event (*give a ball* from Latin *ballare* and round object *kick a ball*, from Lombardic *ballo* or French *sable* (*sand*) which takes over the general meaning from *sablon* which stems from Latin *sabulum*. The alternative heraldic meaning *sable* stems from Polish *sabol*.

Typical examples of the second process are French *bois* (for 'little forest', from Latin *boscus*, with the derived meaning of 'wood' as material) or German *Mann* (for 'adult male human being' and for the more specific 'husband') etc.

The distinction is not without problems for two reasons.

First, when it is used in order to explain the uncontested 'feeling' of the native speaker that there are basically two types of ambiguity, because, then, one must assume that the language user is aware of diachronic processes and knows corresponding laws of change, which, normally, is not the case. It is true, however, that, nevertheless, he or she seems to associate ambiguous terms like *bank*or *ball* with different words, whereas with respect to terms like *bird* (*a queer bird*) or *wood*, he or she doesn't, even if, in the first case, the *homography* or *homonymy* relates to all forms (as with respect to *bank* in contrast to *Bank*) and if, in the second case, the different meanings are relatively distinct (like astrological and medical *cancer*).

Second, as dichotomy, the notion is philologically questionable, because, it is difficult to give precise criteria for what a root is, given the fact that words may take different developments with respect to different registers, dialects, languages so that, with respect to a particular time slice and register or dialect or language, such developments may be seen as developments of different roots, whereas, against a larger background, they may not. Also, there is no complete knowledge about word and use of words in earlier times. [1]

On the basis of this, it seems more promising to abstract away from the dynamic relation between *signifiant* and *signifié* and to explain the homonymy/polysemy-feeling of the language user from a synchronic perspective alone, concentrat-

[1]Note, for instance, that there are reasons to assume that for *bois*, besides Latin *boscus*, there is another similar root which contributed to deriving the second meaning of material. This may have been supported also by the fact that there is another descendant of *boscus*, *bocage*, which, by its clear meaning of 'little forest', might have taken over the function of expressing 'little forest' from *bois* in a number of contexts. Definitely, the processes are interleaved: With respect to *bank*, it is clear that Italian *banka* traces back to *banki* also and that the sense of institution developed from the fact that banking transactions happened at tables or 'benches' respectively. As it seems all present meanings of *Bank* or *bank* have to do with the function or the form of what *banki* stood for (note that in English there is also the 'furniture'-like bank-of-oars-reading). But this uncertainety is not an argument against the distinction as such and the awareness of the distinction. To the development of the notions and to fundamental investigations in this respect, compare [Bréal(1897)], [Heger(1963)].

ing on the semantic differences. A convincing classification of this type can be found in [Pinkal(1995a)]. It has influenced approaches to underspecification like [Poesio(1994)]. It distinguishes so-called *P-type ambiguous* terms from *H-type ambiguous* terms, where, as the names make clear, relevant differences associated with the older dichotomy of homonymy and polysemy are taken up, without making any reference to diachronic behavior however: The meanings of P-type terms relate to each other, they have something in common, whereas those of H-type terms do not, where existence of a common semantic concept can be tested by the so-called *precisification imperative* (which provides the intersubjectively defined distinctive criterion therefore): If the term *requires precisification*, it is *H-type ambiguous* , else it is *P-type ambiguous*. The term requires precisification if its *base level* is *inadmissible*. That is, if there is no meaning (other than the unsatisfactory disjunction of the alternative senses) which unites the readings. Thus, German *Bank* and French *sable* are H-type ambiguous, because there is no unitary concept which (exactly) is equivalent to the disjunction *monetary institution* $\vee$ *bench* and *sand* $\vee$ *heraldic sable* respectively. Similarly, *Engländer* is H-type ambiguous because there is no concept which catches the meaning of *Englishman* $\vee$ *monkey wrenk* in a sufficiently precise and satisfactory way. In contrast, German *Mann* is P-type ambiguous, because the reading *husband* is a precisification of the relatively unspecific base level meaning *male and adult human being* which is not necessary in each and every context (i.e. *Mann* $\equiv$ *man* $\wedge$ *husband*).

However, for both types of ambiguity it is constitutive that they **allow for precisification**, in the sense that, there are contexts where the sentence which uses them cannot be assigned a definite truth value. (Otherwise the terms couldn't be truly called ambiguous).[2] This characterizes the *semantically indefinite* sentence. The possibilities of precisification determine the type of indefiniteness. The precisification spectrum may be perceived as discrete, or as continuous and the alternatives may be perceived as mutually exclusive or ordered according to an appropriate scale of intensification. However, it is not always easy to distinguish between the continous case and the relatively fine-grained discrete case: Is the color adjective *blue* ambiguous in the sense that it stands for a number of conventionalized degrees of blueness like *navy blue, royal blue* etc. or does 'blueness' continuously dicrease or increase? Typically, a predicate of the continuum type is called *vague*, the others are *ambiguous* in the proper sense. Because there is no clear-cut distinction between *vagueness* and *ambiguity proper*, it is reasonable to subsume them under the one notion of *indefiniteness*).

Psychologically, it is very plausible that an indefinite term which lacks a base level concept and whose readings are mutually exclusive – which marks the case of ambiguity in the narrowest sense so to speak – requires precisification, independent of the thematic focus of the text or utterance. Thus, representations of ambiguous terms like German *Bank*, French *pile* (for *batterie* or *side of a coin*), English *scale*

[2] Remark that we cannot say *in all contexts*, because in some of these there may be contextual clues which disambiguate the term.

(measuring versus zoological sense), if created at all by the recipient of a corresponding text or utterance, obviously aren't stable. There is the clear desire to resolve the ambiguity rapidly, by asking for clarification or by inference.

If the alternatives aren't mutually exclusive, the recipient can 'live' without disambiguation as it seems, even if there is no basic, most general concept (as is always in the case of continua and scales), provided there are no (immediate) contradictions deducible. Thus, *green pear* either characterizes a pear by its degree of ripeness or by its colour ([Pinkal(1995a)]) (but, of course, there are pears which are green-coloured and unripe) and the recipient may let it stand as it is, as far as the ambiguity does not obscure the understanding of the text in a relevant sense. Of course, if it does, because it is central to understanding the story to know exactly what the ambiguous notion stands for, clarifying routines will be triggered in this case also, even if there exists a base level concept of the ambiguous notion. For example, the sentence *the Santa Maria is a fast ship* is ambiguous, because the scalar adjective *fast* expresses a qualification of *high speed*, which is vague however, because it is not clear whether this means *fast for a modern ship* or *fast for a ship of the 15th century* or *fast for a ship of the cog type* etc. This does no harm if the exact degree of speed isn't central to the story, it does however if its is, in the context of a meticulous description of the construction type etc.

Remains the case of terms with mutually exclusive alternatives which, however, have something like a common base level description, in the sense that they show a common semantic feature which is relatively characteristically for them. Think of functional descriptions like *printer* or *writer* which denote the agents associated with corresponding functions and which, rather regularly, can be partitioned into human beings and machines or tools. It seems to us that, also in this case, independent of the interest of the text, ambiguity is felt and must be resolved or tend to be resolved at least. Note, by the way, that the recipient may disambiguate a term without being aware of this, for instance because one of the alternatives, generally or with respect to the text type, might be thus preferred that the others aren't even noticed. (Thus, *Engländer*, normally, isn't perceived as being ambiguous).

It has been emphasized that the decribed thematic/contextual need for (lexical) clarification is not specific to truly vague or ambiguous predicates. Zwicki and Sadock assume so-called *indeterminate* or *unspecified*terms which might be specified further also (cf. the classification in [Zwicki/Sadock(1975)]). As an example, Zwicki and Sadock present the sentence *my sister is the Ruritanian secretary of state*, which clearly is true or false, provided the identity of the contextual anchors for the referential terms (*me*, *my sister*, the *Ruritanian state*, the utterance time). Nevertheless, so Zwicki and Sadock, even knowing who is meant by *my sister*, the recipient may wonder whether the sister is older or younger than the author of the text or, knowing that the author has more than one sister, he may wonder whether this sister is older than the other(s). Also, the recipient may wonder whether the state of being *Ruritanian secretary* holds since long or not. That is, he would like to have the predication specified to *being the Ruritanian secretary since X*. This means that, guided by discourse interest, additional questions may arise which ask for related information. With respect to the example, the information asked for is information which according to typed feature representations of semantic hierarchies or nets, like *WordNet*, could be found as value of some attribute of an instance of a semantic type (compare [Miller et al.(19)]). *WordNet*, for example, subclassifies its semantic types, which are disambiguated word senses, by specifying features like *size*, *age*, *lifetime*, so that, from corresponding values of a corresponding complete representation of the discourse referents of Zwicki and Sadock's example, the information asked for could be concluded.

A short supplementary reflexion makes clear that, with respect to asking for more information about a mentioned term in a particular discourse situation, indetermination or unspecifity of the term in the sense of Zwicki and Sadock is not the end of the story. For instance, if in a detective story we learn that *the inspector noticed that there was a cigarette in the ashtray* the main interest normally is not to ask for the brand of the cigarette or for the type of tobacco it is made of, that is, for information which typically is associated with *cigarette* by its feature description, rather the interest is to know who did smoke the cigarette. This means, in this context, *cigarette* is unspecific because it doesn't tell something about the associated smoking event and, in particular, about the agent of this event. Infomation of this type, which is information about associated event (types) and their roles, probably could be found in the (specified) *qualia*-structure of the term.

According to the architecture suggested in [Pustejovsky/Anick(1988)], [Pustejovsky(1995)], the items in the lexicon are assigned *qualia*-structures which provide ontologically rather complex descriptions of the object or eventuality presented by the lexical entry. Often this is information about the thematic roles and their possible properties including in particular, with respect to objects, the processes typically associated with the item. Mainly, this is done for the purpose of filling the gaps of textual information, for instance, by keeping track of the relations between discourse referents in the presence of so called *bridging phenomena*. [3]

Approaches like [Pustejovsky(1995), Mineur/Buitelaar(1996)] however suggest and use qualia-structures for explaining and modeling the ambiguity of terms also which show different prototypical specifications (and which, otherwise, with respect to common semantic types, would be hardly classified as ambiguous).

Approaches to representation and resolution of ambiguity like[Buvač(1996)] and [Nakashima/Harada(1996)] also emphasize the impact of context on the meaning of the lexical material. They illustrate that this contribution and the specificity of it varies with the purposes of the text or the utterance: The more the communication

[3] *Bridging* is necessary if a referential term like *the smoker* is introduced which cannot be related to a discourse referent of the preceding text or the shared attitudinal states of author and recipient as described so far because there isn't introduced a referent which could satisfy to the conditions. However, if a particular cigarette (end) has been mentioned before, as in our detective example, we can infer , via a bridging supposed smokng event, that there must have been a smoker (who is probably the antecedent of our referential term).

is situated in a marked scenario, the more the particular background knowledge covers the intrinsic linguistic basic meaning of the word. Take the specific meaning of words in technical languages. Partly this is exploited for modelling the natural language question-answering front-end of expert systems, so that the meaning of the words vary according to the particular domain the expert system models.

There is also the radical position saying that, with regard to the open word classes, the basic semantic contribution of the lexical items (which is present at all occurrences of the corresponding word) is nearly null, that is, that the lexical items are maximally ambiguous, and that nearly the entire information load is carried by pragmatic inferences over the contextual situation, see [Green(1996)] for this and for corresponding examples.

We learn from such studies that, depending on the communicational aims, nearly every term (predicate) might be subject to clarification and refinement in some context. What are the consequences of this finding?

Epistemologically, to our opinion, treating all of the considered phenomena as instances of ambiguity isn't helpful. It is even inadequate because expressions like *sister*, *working as secretary*, *cigarette* clearly are not ambiguous, not in the sense of *ball* or *printer* etc., and taking them into account dilutes the notion of ambiguity so that the essence of ambiguity cannot be caught, which, we think, is closely related to the precisification imperative against the background of structuring the world into concepts. From a practical point of view however, indeed, we must be aware of the fact that each term, more generally each condition in a representation or a part of a representation can be subject to the desire of further specification in the sense that we want to know additional properties of an object, individual or situation or why such an object, individual or situation has this or that property.

The abduction approach seems to be most consequent in this latter respect. According to this, the (specific) meaning of a word in a specific context is determined by the basic lexical meaning (if any) together with all that can be inferred for it abductively (i.e. non-monotonically) from context on the bases of some appropriate background knowledge containing the axiomatic knowledge about the items used (see [Hobbs et al.(1993), Hobbs(1996)] and Hobbs' earlier papers [Hobbs(1985a), Hobbs(1985b)]). As a consequence, the meaning of a word in context or of a condition in a representation can change dynamically, depending on whether supplementary context (the ongoing on the story say) adds new information to it. Note that this dynamics might mean revision of the assumptions about the term also!

What will be the position of the theory to be developed here with respect to modelling specification, be it disambiguation of truly ambiguous terms or other? We agree that, in context, nearly every notion can be used very creatively and that it can be understood according to the contextually suggested meaning. In contrast to Green's and corresponding positions, we think, that ambiguous terms like *Mann* or *Bank* aren't a priori semantically empty, that is: on the level of language competence. We think that the nature of this ambiguity, in nuce, is very clear to the native speaker, i.e.the different basic meanings of the words and we think that these assumptions are intersubjective knowledge that can be obtained by introspection. These assumptions do not contradict the observation that on the level of performance there is an additional range of variation, through contextual precisification, through pragmatic rules which effectuate figurative interpretation of the terms or (other) type coercion (triggered, for instance, by Gricean cooperation against the background of conflicting constraints). It is also correct, it seems, that it is usually difficult to draw a sharp line between the lexical semantics of an item and its semantic contribution in a particular context (making use of world knowledge on the basis of pragmatic rules). According to this picture, we favor a design where the semantic description of an item may be refined or replaced by a completely different one by the knowledge engineer at any time, depending on the (changing) purpose of the analysis system. In addition, we want that such refinements can be stored together with the item and get 'popped up' automatically by some particular triggering contextual situation. That is, it must be a feature of the representation of a lexical item that, depending on the context, the semantc contribution it makes is gradually refined. This includes (cascaded) disambiguation caused by particular contextual givings. In short, inspired by approaches like [Hobbs(1985a)] and the concepts underlying *object oriented programming*, we will define the semantic contribution of lexical items as multivalued functions from triggering information states (representations) into information states (representations), where the values, being representations, may make use of such functions also. For example, *printer* will introduce a functional DRT-condition *printer(x)*, which, depending on the context, might be disambiguated as the predicate *printer1(x)* or the predicate *printer2(x)*, with *printer1* a predicate for human beings and *printer2* for machines. However, it might be disambiguated also to a complex condition

e
person(x)
e: print(x)
agent(e)=x

which says that x is the agent of a (single) printing (and presumably not a professional printer), where *printing* as such is a multivalued function also which may give rise to different specifications. We call the functions *multivalued* because we assume disambiguations which cannot be based on contextual information, so that, in this case, for the same arguments, we may obtain different representation values. Because of the fact that these functional terms tie together the different representations of the ambiguous word and flatten them to one atomic representation (which interacts with other representations with respect to semantic type and information about the arguments, which is beyond the properties in question, just like the disambiguations), we call them *flat* representations.

It has been often noticed that ambiguous terms cannot be treated as disjunctions (see [Pinkal(1985), Hirst(ed.)(1987), Poesio(1994), Buvač(1996), Deemter(1996)] and others). This is true even for the H-type ambiguous terms with clear-cut alternative meanings, as the negation test makes clear:

(6) *Peter folgte genau Hansens Anweisungen und kam tatsächlich zu einem idyllischen Platz. Dort war aber keine Bank.*
Peter carefully followed Hans' instructions and came to an idyllic place. There was no bench/bank however.

The second sentence of (6) clearly does not mean that at the place that Peter reached there was neither a bench nor a bank. It does mean either 'there was no bench' or 'there was no bank', depending on what Peter and Hans have spoken about or what the previously had in mind before. The modelling of lexical ambiguity via multivalued functions takes up this restriction (the context deciding about the admissible value being the same for the different occurrences of the functional term in a coherent passage of the text). In connection with H-type ambiguity, it is also important to realize that interpretations must provide intensional models. Otherwise the definitory incompatibility of the H-type alternatives could not be distinguished from the casual extensional difference of alternatives in other cases. We will come back to the model theoretic consequences of the investigations of this section in greater detail, when spelling out the basics of our representation language in section 2.9 and the interpretation framework in chapter 5.

1.2 Structures

Traditionally, when considering structural ambiguities a main topic, or even the main topic, has been the relative scope of quantifiers, where sufficiently complex sentences allow for different distributions normally, as in (4), which we repeat here as (7).

(7)

Wenigstens 200 Vögel wurden von 3 Naturschützern registriert.
At least 200 birds were registered by 3 nature-lovers.

We have said that in this sentence the quantifier from the subject may have scope over the one from the agentive von-PP (confronting us with a set of 600 nature-lovers), or conversely (where, in both cases, it is an open question whether the three persons act jointly or not, wich, in the second case would provide as with at least 600 registered birds). Depending on the language considered, syntactic structure may put some constraints on the permutational possibilities. For German, [Frey(1993)] argues convincingly that syntactic scrambling is necessitated in order to allow for other scope orders than the one predicted by the obliqueness-hierarchy. Next to such hard constraints, which may or may not be present, there are others which suggest preferences on the basis of inherent properties of the quantifiers, of pragmatic and conventional rules and the influence of information structuring (to examples of German, see [Pafel(1988)]).

An early attempt to represent this type of ambiguity is Schubert and Pelletier's *logical form*, which leaves the quantifiers in place and assumes a postprocessing routine which arranges the quantifiers according to contextual constraints, see [Schubert/Pelletier(1982)]. The basic idea which can be found there has been spelled out exactly in [Cooper(1983)] and has been known since then as so called *Cooper storage*. According to this, the pairing of syntactic and semantic analysis is liberalized in that the quantifier from an NP is not directly applied to the argument from the VP when the NP is applied to the VP syntactically, but is stored in a 'quantifier memory' say and can be 'discharged' later. This idea became very influential in the following years. Modulo technical details, it underlies a number of suggestions of analysis systems such as the *Core Language Engine* of [Alshawi(1992), Alshawi/Crouch(1993)], also [Alshawi(1996), Poesio(1996)] and, amongst other things, it defines the semantics treatment of the HPSG-setting of [Pollard/Sag(1994)].

Basically, as said, the algorithm stores the quantifiers in a list, from which they can be retracted later and applied to the actual intermediate representation, where variety of readings is made possible, because there is no apriori input/output sequencing constraint like *first in/first out*, the only inherent constraints about the possible orders of discharge being constraints exercised by syntactic hierachy which, defining islands, isolate the quantifiers 'living' on a particular island from the others. The problem of the storage mechanism in its basic form therefore is not that it would not allow for the correct scopal disambiguations of an ambiguous sentence, but that it is not selective enough to describe exactly these disambiguations. At least, it cannot do it, if there are contextual constraints which allow some, but not all permuations of the quantifiers of an island, as is the case in (8), according to Frey's theory.

(8)

Wenigstens drei der möglichen Fragen stellten genau fünf Kandidaten wenigstens zwei Frauen in der Sendung, wie zu beobachten war.
In the program, exactly five candidates asked at least three of the possible questions to at least two women, as could be observed.

In (8) the quantifier from the direct object may have wide scope with respect to the subject, but not the quantifier from the indirect object.

Theories like *minimal recursion semantics* (MRS) try to solve such restriction problems by naming the structures and by establishing constraints about the argument of a functor representation through disjunctively enumerating the admissible argument structures, see [Copestake et al.(1995)]. Thus, labelling the results of applying subject, object, indirect object to a VP argument (the verb) in turn by $\boxed{1}$, $\boxed{2}$, $\boxed{3}$, and stipulating that the argument of $\boxed{1}$ is $\boxed{2} \vee \boxed{3}$ and the argument of $\boxed{2}$ is $\boxed{1} \vee \boxed{3}$, we obtain the desired constraints on the set of admissible readings of (8). In section 2 we will show that such approaches, which rely on constraining the **direct** argument of a functor, aren't expressive enough to delimit the admissible scope orders in the right way when there are more than three quantifiers. One might object that verbs seldom allow for more than three quantifiers, if at all (beyond the class of ditransitives, such a verb must subcategorize for more than three roles). However, one has to be aware of the fact that there are other scope bearing elements in the sentence besides the subcategorized roles. There are adjoint prepositional phrases which may interact with the quantifiers of the verbal roles and there are quantifying and 'modalizing' adverbials which, with respect to scope order, interact with these roles also, see (9) for an example.

(9)

In wenigstens fünf europäische Urlaubsgebiete flogen wenigstens drei Reiseveranstalter ihre Kunden mehr als 20 Mal. At least three tour operators took their customers by plane to at least five european vacation spots for more than 20 times.

(9) and its readings illustrate that we need a formalism which allows us to describe each possible partial ordering over a (finite) set of partial representations. (Note that the only constraint is that the customers of the indirect object are in the scope of the tour operators of the subject NP, which cannot be expressed by constraints about the direct argument of the subject NP). In the literature several types of solution can be found. On the one hand there are suggestions like Muskens's (see [Muskens(1995), Krahmer/Muskens(1998), Muskens(1999)]), which put the problem not as a problem of describing the acceptable meanings of the ambiguous sentence, but of describing the (fully specified) structures which represent these meanings (unambiguously).

According to this setting a description is a set of nodes, partially ordered by a dominance relation ∇. The nodes stand for substructures of the syntactico-semantic representations of the sentence and are decorated by (first order) terms for the corresponding semantic descriptions. This allows for interleaved descriptions of syntactic and semantic constraints and for representing syntactic and semantic ambiguities elegantly. It also makes it possible to exploit completeness of the first order predicate calculus for the purpose of (non-monotonically) interpreting NL-texts. Nevertheless, through the ontological reduction, important information is lost with respect to entailment, in particular accessibility information about the discourse referents (see [Eberle(1996a)]).

On the other hand and in contrast to such approaches of ontological reduction, there are suggestions which accept the higher-oder status of the semantic functors of the sentence. An example is Pinkal's *radical underspecification*, where the problem of formulating ordering constraints is tackled by using variables for the functors and by describing the constraints through systems of equations (see [Pinkal(1995b)]). For example, for (8), using the functor variables X, Y, Z, X', Y', Z' and the constants S, D, I for the functors from subject, object, indirect object and V for the contribution of the verb, the following equations would be stipulated to hold (where SE is the representation of the sentence):

X(S(Y(I(Z(V))))) = SE,
X'(D(Y'(I(Z'(V))))) =SE,

The first equation says that I is applied to V, if Z is the identity operator (Type/Type), or to VP, and that S is applied to the result of this, if Y the identity operator, or to a higher node of the V-projection line. This means S has scope over I. The second equation similarly claims that D has scope over I. Now, instantiating the variables as follows
X=D, Y'=S and
Y, Z, X', Z' = the identity

we obtain the solution with the quantifier of the direct object taking wide scope. In contrast, if we instantiate as below, we obtain the solution with S having scope over D:

X'=S, Y=D and
X, Z, Y', Z' = the identity

The disadvantage of this approach is that the resolution of the equation systems requires higher-order unification, which, as such, is undecidable. However recent studies have shown that for the relevant representation problems one can do probably with a weaker version, which is decidable.

Reyle's approach, the *Underspecified Discourse Representation Theory* (UDRT), in a way is a compromise, but an attractive compromise, between suggestions in the vein of Muskens' and Pinkal's. As in Muskens' approach there are first order objects which carry information about the parts of the sentence for which they stand. Whereas in Muskens' description theory approach these objects, the nodes, carry both syntactic and semantic information, in UDRT, these objects, called *labels*, carry semantic information only. In this respect the labels are just like the *handles* of the MRS approach. However, whereas in MRS the handles are used to describe underspecified immediate dominance (they exclusively designate the arguments of functor representations), in UDRT the set of labels is assumed to be ordered by a general dominance relation $\leq$ which satisfies the axioms of a partial order and describes the scope relations of the sentence. The labels point to structures which are classical DRSs with all the properties such DRSs have, in particular that their interpretations are information states. In this sense UDRT is a hybrid approach and one of the advantages of making available the expressiveness of DRSs for the underspecified description is that DRT's accessibility theory can be exploited for the underspecified case: The (partial) order of the labels (partially) rules the accessibility hierarchy of the DRSs of the sentence parts. Because of these advantages, UDRT is at the basis of our approach. Nevertheless, we do not take over its implicit assumption that the (semantic) representation of the syntactically defined parts of the sentence can do without making reference to the other partial representations, except for the information that is available from the syntax-semantics-interface (like linking information between the verb and its complements). Taking into account the impact of (non-intersective) adverbial modification on the nature of the sentence event and considering the ambiguity between the collective and the distributive reading of some quantifiers and some other minor composition phenomena, we will argue in section 2.5 that, at the very least, it makes underspecified sentence representation much easier, when the partial representations of functors can take up the distinguished referent of their argument and determine the distinguished referent of the representation which results from application. In other words: representations of semantic functors should be DRS-functors, not saturated DRSs. Therefore, in our approach, the labels of functors like quantifiers, instead of pointing to DRSs as in UDRT, will point to functions from representations to representations, where both the input and the output representation have their distinguished discourse referents. By combining the representation of lexical ambiguities via multivalued functions, as described in the last section, and scopal ambiguities as sketched in this section, we will obtain some nice representation solutions for the puzzles about collectivity and distributivity discussed in [Does/Verkuyl(1996)] and elsewhere.

With respect to interpretation, we will extend the concept of *multivalued function* to underspecified representations as such. In contrast to classical (U)DRT, the meaning of the (underspecified) representation is not just the set of information states which interpret the DRS (the set of DRSs which can be constructed from it by linearization, where linearization means extending the partial order to a total order and to rule conversion by it). We assume that the flat underspecified discourse representation structure of the sentence (FUDRS) is a functional term whose value is a member of the set of possible linearizations (which is the set of DRSs of the sentence). It is only in a second step, that the DRS-value of the FUDRS (and with it, the FUDRS itself) obtains the canonical interpretation of a DRS. This two-level approach of interpretation makes it possible to account for a number of phenomena of structural parallelism: As with respect to the evaluation of flat lexical terms we assume that linearization of FUDRSs is stable with respect to local context. This means that the choice of a specific linearization for a substructure guides the later evaluation of other substructures in that similar substructures (with respect to quantification constraints) obtain similar linearizations (if possible), see section ?? about linearization and model theory.

Note that this two-level setting in a way relates our approach to Muskens' suggestion of treating ambiguity by underspecified descriptions of fully specified representation structures. The difference however is, firstly, that in the present approach the partial semantic representations assigned to the labels aren't first order terms but expressive FUDRSs and, secondly, that specification is a cascaded process which, next to order constraints, affects gradual lexical disambiguation and other phenomena which we will turn to now and in the remaining sections of this introduction.

A further type of structural ambiguity, generally understood to be more syntactic in nature than the scope ambiguities considered above, is presented by the problem of applying modifiers, in particular PPs, to structures which show different possibilities for attaching the modifier, as witnessed by the well-known *telescope*-example (10) with its possible structurings (a) and (b).

(10) *Peter saw the man with the telescope.*
a) [[*Peter*] $_{NP_{subj}}$ *saw* [*the man*] $_{NP_{obj}}$ [*with the telescope*] $_{PP}$
b) [[*Peter*] $_{NP_{subj}}$ *saw* [*the man* [*with the telescope*] $_{PP}$] $_{NP_{obj}}$

The alternative bracketings in (a) and (b) illustrate the two possible readings with the PP modifying the *seeing*, (a), or modifying the *man*, (b).

Notice that this type of ambiguity is not a specific variant of scope ambiguity and cannot be reformulated as such: The question is not whether to apply the PP-functor before the direct object quantifier to the verb- or VP-representation or the other way around. In both cases we would obtain the event modifying reading (a) in (10). Assume (underspecified) semantic representations K_v, K_{obj}, K_{pp} for the verb (or the subj+verb-VP), the direct object and the PP in (10). Then we obtain (b) only if K_{pp} is applied to K_{obj} first and then the thus modified K_{obj}-functor to K_v.

In order to represent this type of ambiguity, next to the partial ordering relation $\leq$, we make use of a second relation between labels, called *first*. As in UDRT, $l_1 \leq l_2$ means that the representation which is labelled by l_1 must be in the scope of the representation which is labelled by l_2. More precisely, in our approach this means that possible linearizations of the corresponding FUDRS are constrained in such a way that the l_1-functor must be applied to the contextual argument before the l_2-functor. In contrast *first*(l_1,l_2) means that the l_2-functor might be applied to the l_1-functor (before this one is applied to the current contextual argument). There are two problems connected to this:

Firstly, when linearizing the FUDRS, choosing this option means interpreting the PP as an NP-modfier, omitting it means interpreting it as VP-modfier. Here, we can exploit the circumstance that the representations of the lexical items are flat. The representation of *with* will be such that K_{pp} in (10), which results from applying it to *the telescope*, will be a functional term which (among other things) can turn VPs into VPs and NPs into NPs. Note that disambiguation of the *first*-statement and choice of the semantic type of the PP are dependent in both directions: If for some reason the PP is disambiguated to a VP-modifier-reading say, the *first*-statement disappears.

Secondly, the attachment problem can be more complex. (11), a variant of (10), exemplifies this.

(11) *Peter saw the man and the child with the telescope.*

Next to modifying the VP and the direct object as a whole, the PP of (10) can also apply to a part of the direct object only, viz. to its right conjunct. Since, syntactically, the PP can attach to any NP (or VP) neighbor to its left, we can construct even more complicated versions of this example. In order to correctly deal with the general case, we assume that the labels of the representations come with information from the syntax-semantics information, in particular with information about the position at the surface. As long as the relevant substructures of the representation aren't disambiguated structurally they are FUDRSs with a basic argument representation and a number of functor representations. This means that weakening the meaning of *first*(l_i,l_j) to saying that the l_j-functor might be applied to the l_i-representation or to the right-most functor of the l_i-functor set or to the corresponding right-most functor of this representation and so forth (provided the correct semantic type) or to none of them, allows for encompassing all these readings. In section ext, we will provide this definition for *first*. With it, we can obtain correct representations for cases with multiple attachment ambiguities, and since this formal means is not restricted to representations which stem from PPs, we can obtain correct representations of puzzling examples from the literature, which mix coordination with AP- , PP- and Det-attachment. An example is the following, taken from [Marcus(1987)] and [Marcus et al.(1983)]:

(12) *They sell green apples, pears and bananas from Erie.*

Note that in (12) *green* may apply to *apples* or to the coordination and similarly the PP may attach to the last conjunct or to the coordination and probably to the intermediate coordination level also.

A final remark on this subject: It is a prerequisite of this construction that syntactic analysis doesn't anticipate the decision about the argument the modifier in question is applied to. We assume therefore that semantic construction applies to parse forests (see [Schiehlen(2001)] for this) or that the definition of the syntax-semantics interface uses a specific mechanism according to which, in the construction, such modifiers are percolated to a maximal position.

Attachment ambiguity is closely related to functional uncertainty. With regard to examples like (10), choosing the argument the considered functor must apply to decides about the type of modification also. This is not always the case. (3) illustrates that we cannot always decide without further information whether a PP has to be interpreted as a complement or as an adjunct. We emphasize that this type of ambiguity doesn't necessitate further formal means in order to be represented correctly: As sketched above in relation to the adjoining cases of prepositions, we will treat this as a lexical ambiguity by assigning corresponding evaluations to the lexical item.

1.3 Presuppositions

An insight of [Sandt(1992)] has been to understand presupposition projection as a kind of anaphora resolution, or to put it another way: relating (referentially used) pronouns and definite (and some indefinite) descriptions to their antecedents is a specific case of presupposition projection and the entire phenomenon of presupposition projection behaves according to the mechanics of anaphora resolution. This means that the meaning of presuppositions in utterances or texts is generally to relate to antecedents, with the only difference that, depending on the type of the presupposition, these antecedents are discourse referents for objects or events or parts of information of the common ground that speaker and hearer share at the time of the utterance or which is provided by the preceding text. An essential consequence of this point of view is that DRT's basic finding and representation, which is the accessibility relation (see [Kamp(1981b)]), constrains presupposition projection as a whole, not solely the resolution of referential terms. In order to represent the presuppositional conditions of a sentence representation and to distinguish them from the other conditions, van der Sandt partitions DRSs into presuppositional and assertional segments, as in the representation (13_{rep}) of (13), where the upper DRS describes the presuppositional and the lower DRS the assertional information of the sentence.(Underlining represents accentuation.)

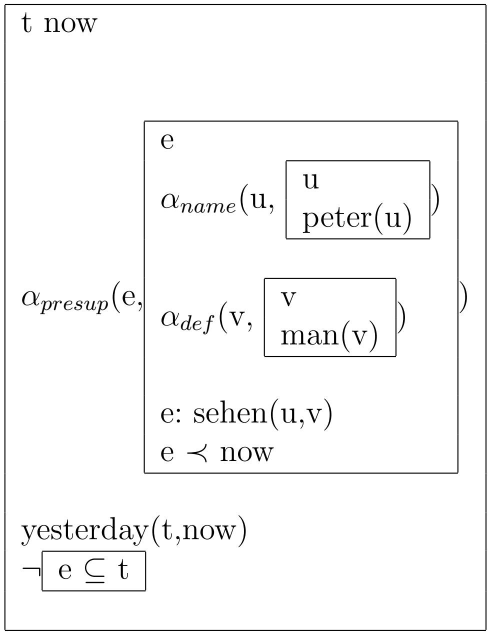
(13) *Peter hat den Mann nicht gestern gesehen.*
Peter didn't see the man yesterday.

(13_{rep})

u v e now peter(u) mann(v) e: sehen(u,v) e $\prec$ now
t yesterday(t,now) $\neg$ [e $\subseteq$ t]

We will deviate from this type of representation via segmentation (which is also used in [Kamp(2000)]) and will pick up a suggestion of Bos and others, according to which the presuppositional part of an assumption is represented as a specific DRS-condition, called α-condition, which introduces the presupposed object together with its presupposed properties, [Bos/McGlashan(1994), Bos et al.(1994), Bos(1995)]. Developing this formal means further, our representation of (13) will be (13_{rep}).

(13_{rep})



The reason for representing presuppositions via conditions instead of using partitioned DRSs is twofold. First, we can see a number of different types of presupposition, whose conditions of resolution or accommodation are not exactly the same. Thus, following the accessibility hierarchy of the DRS, the antecedent of a pronoun may 'live' at some intermediate DRS-level, whereas definite descriptions normally have to be resolved to the main DRS level, and names always. The resolution of tenses follows other regularities than the resolution of descriptions and this is also true for the resolution of entire propositions. Therefore it makes processing easier when the specific type of the presuppositional information is signified. For this purpose, it seems to be more natural to provide different types of condition which classify the nature of the presuppositional anaphor rather than different types of DRSs. Of course. one is free to understand the alpha conditions simply as DRSs of some particular presupposition type, with a distinguished DRF or a distinguished predication. Presuppositions may appear nested inside each other (as in (13)). This also suggests representation via conditions rather than representation through partioning of information. The main reason however why we prefer conditions is that we understand the impact of the presuppositional information not so much as one which consists in conveying static information, which makes its contribution in situ so to speak. Its nature is to trigger a process of searching the contextual knowledge for information which confirms the presuppositional assumption. If this process can be terminated successfully, in other words, if the assertional part of the (new) sentence can be anchored to context by the presuppositional constraints, then the presupposition trigger as such can disappear from the representation of the discourse. Because of this dynamic and 'volatile' behavior of presuppositional information, we prefer the treatment in the form of condition.

When incorporating the new information (the new utterance, the new sentence) into the preceding discourse representation, the presupposition condition is resolved to some accessible part of this representation, its *landing site*. If there are embedded presuppositional conditions, new processes of resolution are triggered after this first one, which, when climbing up the DRS-hierarchy searching for suitable antecedents, start out from the position of this first landing site. Thus, one of the interpretational consequences of nestedness of triggers is that the antecedents must mirror this nestedness. (The antecedent of an embedded presupposition must be accessible from the antecedent of the embedding presupposition). Note that this doesn't necessarily mean that the order of resolving the anaphors must correspond to the nestedness. However, choice of antecedents will constrain resolution of the remaining anaphors.

Of course, resolution of presupposition, as sketched here, is a specific kind of disambiguation. Note that the meaning of the suggested representation of presuppositional information is not a disjunction of the possible antecedents which satisfy the constraints expressed by the corresponding α-statements. Similarly to the interpretation of lexically ambiguous information by multivalued functions, we assume a procedural interpretation, which in this case is a resolution algorithm which, next to syntactic filtering, makes use of semantic constraints, including accessibility and, possibly, of pragmatic weighting of the alternatives. Thus, with respect to model theory, we assume the meaning of a presupposition trigger to be a multivalued function from information states to information states, where for an information state represented by a DRS K, the value is one of the information states which develop from K by resolution of the condition according to the syntactic and semantic filtering of the resolution component (which includes syntactic binding constraints like HPSG's (local) *o-freeness* for pronouns and descriptions and semantic selectional restrictions and accessibility constraints). Phenomena of parallelism, which can be observed also for this type of ambiguity, can be taken into account through corresponding pragmatic weighting of structural pecularities which awards a bonus to possible antecedents whose structural position is similar to the one of the pronoun (both are subjects, both are direct objects, both are in fromt position etc.).

In this book we can say nothing more specific about the resolution component. We can only state the general warning that one should be aware of the fact that the different disambiguation procedures interact and that, therefore, an interleaved architecture which integrates the different components is desirable if not necessitated.[4]

As a semi-formal résumée of this informal considerations about presupposition we can list the most relevant types of α-conditions that will be used in this book, together with a sketchy account of their filtering conditions:

- Pronouns:

[4]Starting out from the suggestions of [Lappin/McCord(1990), Leass(1994)] about syntactic based resolution and pragmatic weighting, in [Eberle(2003a)] we have presented a (pronoun) resolution component which applies to syntactic and FUDRS-analysis of the sentences and which, in particular, takes into account the interdependencies between scope disambiguation and anaphora resolution.

x
α_{pro}(u, [u])
x=u

where
Cand(u)=
{y| accessible(y,x) ∧ locally_o_free(y,x) ∧ same_paragraph(y,x) ∧ semantically_unifiable(y,x) ∧ morphologically_unifiable(y,x) }

- Definite descriptions (with N(x) the corresponding nominal predication):

x
α_{def}(u, [u / N(x)])
x=u

where
Cand(u)=
{y| accessible(y,x) ∧ o_free(y,x) ∧ semantically_unifiable(y,x) (= N(y)) ∧ morphologically_unifiable(y,x) }
[5]

- Propositions
(designated by a DRF P and represented by FUDRS):

P
α_{presup}(Q,Q:FUDRS):
P=Q

where Cand(Q)= {Y| accessible(Y,P) ∧ Y ↔P}
where '↔' claims equivalence. The simplest form to define it,is to say that its description is a notational variant of FUDRS or corresponds to a reading of FUDRS.

- Reference times t
(temporally related to some temporal parameter, like t *R now*

t
α_{rt}(t', [t' / t' R now])
t=t'

where Cand(t')= {t"| t ∈ reference_times ∧ t R now }

[5]Note that the representations of pronouns and definite descriptions look as if the constraints on the resolution of definite descriptions are stricter than those of pronoun resolution, instead of them being more liberal. The decisive differences which correct this impression are part of the resolution component proper, viz. the different definition of the Cand-set.

There will be other types of α-conditions, in particular conditions for other temporal anchors and also a condition for indefinite descriptions, with corresponding filter conditions.

Often, we will abstain from using explicit equality statements (as suggested by the classical DRT approach, cf. [Kamp/Reyle(1993)]) and use abbreviated representations with one DRF instead, as illustrated by the following variant of the pronoun representation:

x
α_{pro}(x, $\Box$)

As a last remark, note that similarly to certain lexical ambiguities (the 'weak' P-type ambiguities), depending on the focus of the communication, some presuppositional descriptions may remain unresolved without this being noticed by the recipient.[6]

1.4 Ellipsis

Ellipsis is a feature of economy, similar to the (other) types of ambiguity considered so far. Parts of the information are omitted which can be reconstructed by syntactic parallelism constraints from the contextual knowledge. Typically the 'elided part' is a verb or a verbal phrase. Generally, its semantic contribution is reconstructed in close analogy to the interpretation of (other) anaphoric expressions. The ellipsis acts as a kind of zero anaphor, which picks up an antecedent proposition, conserves the part of the meaning of it which relates to the omitted structure and replaces the remaining elements by what is contributed explicitly by the elliptical expression (see [Vennemann(1975), Krifka(1992)], to German, in particular [Klein(1981)]).

Compare the simple standard example (14), where the verb *kommt* is erased and where the subject *Peter* is replaced by *Mary*.

(14) *Peter kommt und Mary ∅ auch.*
Peter comes and Mary ∅ too.

According to the sketched interpretation of ellipsis, with *auch/too* referring to the first conjunct minus its subject, (14_{rep}) seems to be a correct outline of the representation of the meaning of (14).

(14_{rep})

[6] See [Poesio/Reyle(19)] for some interesting investigations in this respect.

u v
peter(u) e1: kommen(u) mary(v) e2: kommen(v)

Sometimes, more than one constituent needs replacement, as illustrated by (15) and its (sketchy) representation (15_{rep}):

(15) *Peter gives the letter to Mary and Holger the book to Christiane.*

(15_{rep}))

u v w e1 x y z e2
peter(u) the_letter(v), mary(w) e1: give(u,v,w) holger(x) the_book(y) christiane(z) e2: give(x,y,z)

Without evaluation of contextual constraints, FUDR-structures are representations which consist of a set of functors, an argument representation and a set of ordering conditions. With respect to VP-representations, this means that the contribution of the verb and the complements and adjuncts can easily be distinguished.

We will exploit this in our representation of elliptical terms: We represent the elliptical term (i.e *too* or the empty string) as a VP-representation, which, as such, takes a number of complement-representations as arguments, $\text{Fu}_{1,T1},\ldots, \text{Fu}_{n,Tn}$, and which results in a representation, call it R. R presupposes a VP-representation L (via an α_{ell}-statement) whose set of functors FSET_L subsumes a subset S whose elements correspond to $\text{Fu}_{1,T1},\ldots, \text{Fu}_{n,Tn}$ with respect to syntactic-semantic type and R, additionally, asserts a copy of the presupposed representation with the functors of S replaced by $\text{Fu}_{1,T1},\ldots, \text{Fu}_{n,Tn}$. This yields:

$$\lambda < \text{Fu}_{1,T1},\ldots, \text{Fu}_{n,Tn} > \boxed{\alpha_{ell}(\text{L}, \{\text{Fu}_{1,T1}',\ldots,\text{Fu}_{n,Tn}'\} \subseteq \text{FSET}_L)} \cup$$

$$\text{copy(L) } [\text{Fu}_1',\ldots, \text{Fu}_n'] \;/\; [\text{Fu}_1,\ldots, \text{Fu}_n]$$

Note that this is indeed the representation of an anaphoric term whose antecedent is a FUDRS. According to this schema, the empty string anaphor of (15) obtains the following representation:

(15_{zero_rep}) Elliptical zero anaphor:

$$\lambda < \mathrm{Fu}_{1,subj},\ \mathrm{Fu}_{2,obj},\ \mathrm{Fu}_{3,iobj} >$$

$$\boxed{\alpha_{ell}(\mathrm{L},\ \{\mathrm{Fu}_{1,subj}\text{'},\ \mathrm{Fu}_{2,obj}\text{'},\mathrm{Fu}_{3,iobj}\text{'}\} \subseteq \mathrm{FSET}_L)} \cup$$

$$\mathrm{copy(L)}\ [\mathrm{Fu}_{1,subj}\text{'},\ \mathrm{Fu}_{2,obj}\text{'},\mathrm{Fu}_{3,iobj}\text{'}]\ /\ [\mathrm{Fu}_{1,subj},\mathrm{Fu}_{2,obj},\mathrm{Fu}_{3,iobj}]$$

This means, it is a 3-place functor which can apply to the three functors of the elliptical term *Holger the book to Christiane* ∅. After conversion, we obtain the following representation for the elliptical term:

($15_{ellipsis}$) Elliptical term:

$$\boxed{\alpha_{ell}(\mathrm{L},\ \{\mathrm{Fu}_{1,subj}\text{'},\ \mathrm{Fu}_{2,obj}\text{'},\ \mathrm{Fu}_{3,iobj}\text{'}\} \subseteq \mathrm{FSET}_L)} \cup$$

$$\mathrm{copy(L)}\ [\mathrm{Fu}_{1,subj}\text{'},\ \mathrm{Fu}_{2,obj}\text{'},\mathrm{Fu}_{3,iobj}\text{'}]\ /\ [\mathrm{l}_{1,subj}:\underline{\mathrm{holger}},\ \mathrm{l}_{2,obj}:\underline{\mathrm{the}}(\underline{\mathrm{book}})\ ,\mathrm{l}_{3,iobj}:\ \underline{\mathrm{christiane}}]$$

Ellipsis resolution of α_{ell}-condition must identify L with the representation of *Peter gives the letter to Mary*:

(15_{ell_ante}) Ellipsis antecedent:

$$\mathrm{L} = \ < \mathrm{e}_1, \begin{array}{|l|}\hline \mathrm{e}_1 \\ \\ \mathrm{e}_1\text{: give(u,v,w)} \\ \hline \end{array} > \left\{\begin{array}{l} \mathrm{l}_{1,subj}:\underline{\mathrm{peter}}_u \\ \mathrm{l}_{2,obj}:\underline{\mathrm{the}}(\underline{\mathrm{letter}})_v \\ \mathrm{l}_{3,iobj}:\underline{\mathrm{mary}}_w \end{array}\right\} \&\mathrm{OC}$$

Replacing the ellipsis trigger by its antecedent in ($15_{ellipsis}$) yields the follwing FUDRS:

(15_{FUDRS}) Resolved elliptical term:

$$\mathrm{L} = \ < \mathrm{e}_2, \begin{array}{|l|}\hline \mathrm{e}_2 \\ \\ \mathrm{e}_2\text{: give(x,y,z)} \\ \hline \end{array} \left\{\begin{array}{l} \mathrm{l}_{1,subj}\text{'}:\underline{\mathrm{peter}}_x \\ \mathrm{l}_{2,obj}\text{'}:\underline{\mathrm{the}}(\underline{\mathrm{letter}})_y \\ \mathrm{l}_{3,iobj}\text{'}:\qquad \underline{\mathrm{mary}}_z \end{array}\right\} \&\mathrm{OC}\ \ [\mathrm{l}_{1,subj}\text{'},\ \mathrm{l}_{2,obj}\text{'},\ \mathrm{l}_{3,iobj}\text{'}]\ /\ [\mathrm{l}_{1,subj}:\ \underline{\mathrm{holger}}_x,\ \mathrm{l}_{2,obj}:\ \underline{\mathrm{the}}(\underline{\mathrm{book}})_y,\ \mathrm{l}_{3,iobj}:\ \underline{\mathrm{christiane}}_z\ ]$$

=

(after replacing the l'-representations by the l-representations)

$$L = \;<e_2, \begin{array}{|l|}\hline e_2 \\ \\ e_2\text{: give(x,y,z)} \\ \hline \end{array}> \left\{\begin{array}{l} l_{1,subj}\text{:}\underline{\text{holger}}_x \\ l_{2,obj}\text{:}\underline{\text{the}}(\underline{\text{book}})_y \\ l_{3,iobj}\text{':}\underline{\text{christiane}}_z \end{array}\right\} \&OC$$

which, after partial evaluation, corresponds to the following DRS:

(15_{DRS}):

$$\begin{array}{|l|}\hline e_2 \\ \\ \alpha_{pn}(x, \begin{array}{|l|}\hline x \\ \text{peter(x)} \\ \hline \end{array}) \\ \\ \alpha_{def}(y, \begin{array}{|l|}\hline y \\ \text{book(y)} \\ \hline \end{array}) \\ \\ \alpha_{pn}(z, \begin{array}{|l|}\hline x \\ \text{christiane(z)} \\ \hline \end{array}) \\ \\ e_2\text{: give(x,y,z)} \\ \hline \end{array}$$

We have anticipated the FUDRS-format for sketching how we will treat ellipsis. We omit saying more specific to it here, hoping that the representations used so far are self-explantory enough with respect to the central features of the ellipsis treatment that we aim at. Otherwise the reader is recommended to refer to chapter 2.

As before with the other types of anaphoric expressions, we are faced with the fact that there is uncertainty about the identity of the antecedent. As a consequence the expression is ambiguous. This is the reason why ellipsis figures in this catalogue of types of ambiguity..[7]

In our representation of the ellipsis we use *copy* instead of *equality*, as in all the other α-statements, with the effect that the presupposed information is extended by new information. This is necessary, because some of the constituents of the elliptical construction – its eventualitiy and probably other individuals – are different from those of the antecedent: It is **not** the same situation which is described by the ellip-

[7]Our modelling presupposes the antecedent to be structured into functor- and argument-representations. If for some reason the antecedent has been disambiguated before, so that, all applications having been carried out, it just shows the structuring of a DRS, we can use information from the syntax-semantics interface and separate the information about the verbal roles into different representations in order to reconstruct the structured FUDRS that we need, with fully specified ordering constraints in this case, from the presupposition antecedent.

tical clause but only one which is *isomorphic* to the one described in the antecedent. In the literature it has often been observed that this isomorphim constraint does not rule out ambiguities with regard to the interpretation of the elliptical term, even if it is precisely known what the functors and their argument are. On the one hand this is due to embedded anaphoric expressions and the fact that for (some of) these it is not sufficient to know the concrete antecedent but to know how the link is meant (as to provide *strict* or *sloppy* identity). On the other hand, in the case of ellipsis antecedents which aren't further evaluated, that is in the case of underspecified representations, there are further sources of ambiguity. Thus, scope ambiguities of the antecedent transfer to the elliptical term. Consider the simple example (16).

(16) *Peter gave some advice to every woman and Inge did too.*

In (16) the advice giving of Peter is ambiguous in that the functor from the direct object may have scope over the functor of the prepositional object or the other way around, and similarly the advice giving of Inge described by the elliptical term.

However, what appears at first glance as an additional ambiguity here, isn't really one. The phenomenon of parallel disambiguation of similar ambiguous terms within the same local context, that we have noticed with respect to explicit repetition of lexical items and structures, is obviously confirmed with respect to the copying of ellipsis. Therefore, the problem is not to cope with a new type of ambiguity, but to formulate a constraint which binds the disambiguations of the internal structure and items of the elliptical term to those of the antecedent. CLLS, the *constraint language for lambda structures* defined in [Egg et al.(2000)], focusses on this parallelism between elliptical term and its antecedent in particular and uses a relation $X/X1 \sim Y/Y1$ for describing it.

CLLS is in the tradition of approaches like Muskens', where the formulae are interpreted over domains of structures and give underspecified descriptions of specified structures (which in turn represent the readings of the sentence). $X/X1 \sim Y/Y1$ requires that in an interpreting structure (which is a tree) the substructure which interprets the antecedent X is isomorphic to the substructure which interprets the elliptical term Y, except for the interpretation of the exchanged role (Y1 for X1).

We have said in which respect such approaches are similar to ours: like a CLLS-formula a FUDRS can be seen as a description of structures, of the set of DRSs in this case, which can be obtained from it via linearization. However, whereas in the case of CLLS and similiar approaches the connection of a (closed) formula and its extension in a model is just a relation defined by a conventional interpretation function, in the approach here the multivalued function of linearization, which mediates disambiguation, provides in addition an operational definition of this relation. The advantage of this is that parallelism is a built-in feature of the computation of this relation. When choosing a value for a particular FUDRS (which means determining a specific scope order), one is thereby forced to assume a similar order for any FUDRS of the local context which is represented as isomorphic to the first one with respect to the type of its functor argument structure. This means that, for the local context, we assume the following equation to hold generally:

linearization(copy(L))=copy(linearization(L))

(Since copy(L) is isomorphic to L with respect to number and type of its functors, with respect to the type of its argument and with respect to the constraints about scope order, any linearization of L automatically transfers, to its copy.) In short, the relation $\sim$ (in the sense of CLLS) can be inferred from the assumption that the elliptical term Y is a copy of the antecedent X with some functors [X1,...,Xn] replaced by [Y1,...,Yn] (we write Y=copy(X) [X_1,..., X_n] / [Y_1,..., Y_n]), provided the functors [Y_1,..., Y_n] are of the same type than [X_1,..., X_n] . Thus, in our approach there is no need for the introduction of an additional isomorphism relation $\sim$: If linearization chooses a wide scope reading for subject with respect to object say, it must do exactly the same with respect to the functors of the (resolved) elliptical term (and vice versa), because antecedent and ellipisis are assumed to be parts of the same local context.

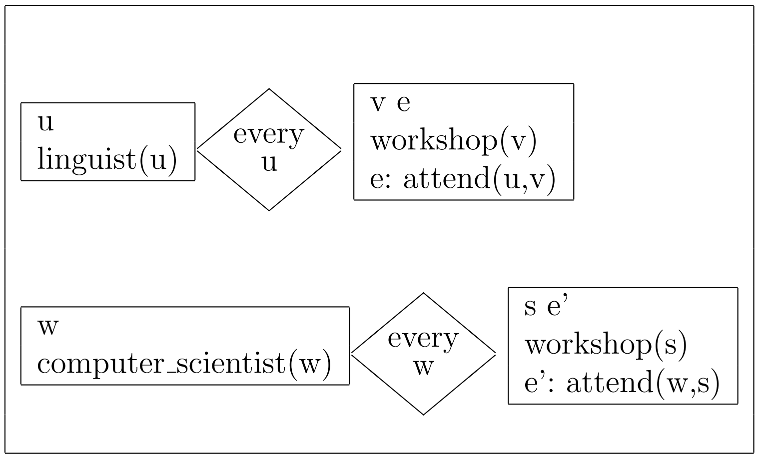
Needless to saying that for this to work, evaluation, just as in the case of lexical ambiguity, must be defined using a kind of blackboard-architecture with bookkeeping of the disambiguations chosen for the (different) evaluation function(s) with respect to the different local contexts. Of course, this requires the definition of monitoring functions which dynamically define and spotlight momentary local context. This, however, is something about which we can say only a little bit in chapter 5.

We conclude this introduction with an example of ellipsis which is more complex than (16). It illustrates the degree of expressivity we reach by the suggested intertwined interpretation of different types of ambiguity. The example is a variant of a similar example due to Hirschbühler (cf. [Hirschbühler(1982)]). In contrast to (16), (17) shows a substantial scope ambiguity. This is due to the fact that, instead of proper names and a singular definite description, its subject NP and object NP are now distributive quantifiers and an indefinite description respectively. In addition, the indefinite may be given a *specific reading*, so that such that we seem to obtain a total of three readings, which we characterize by ($17_{rep.n}$), ($17_{rep.w}$), ($17_{rep.s}$):

(17) *Every linguist attends a workshop and every computer scientist does too.*

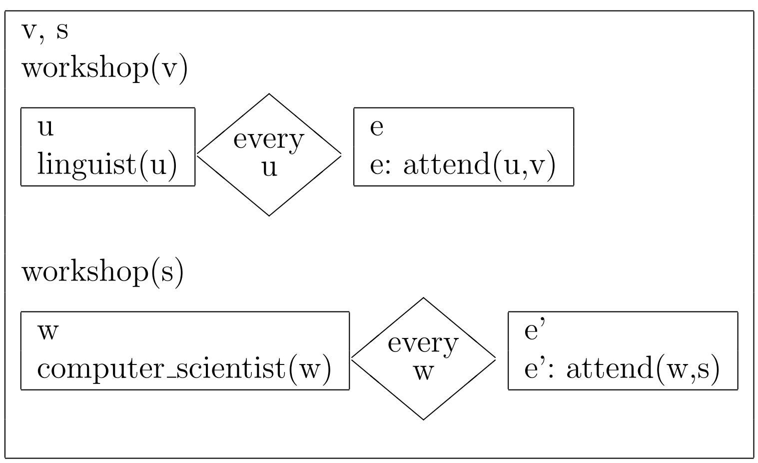
The indefinite may have narrow scope. This yields the reading ($17_{rep.n}$), that for every linguist there is a workshop which he attends (and correspondingly for the computer scientists).

($17_{rep.n}$) Narrow scope of the indefinite:



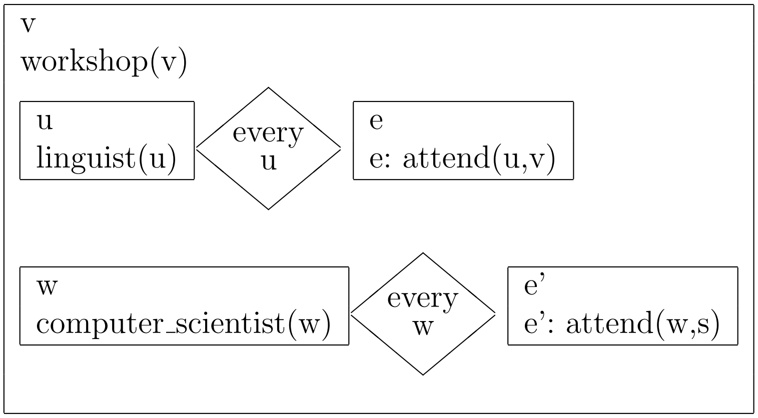
The wide scope reading of the indefinite means that there is a single workshop which all linguists attend (and correspondingly for the computer scientists).

$(17_{rep.w})$ Wide scope of the indefinite:



The third reading assumes specificity of the indefinite. I.e. it is interpreted analogously to a referential definite description: There is a specific workshop which the linguists attend (and also the computer scientists). We present the representation after accommodation of the indefinite description:

$(17_{rep.s})$ Specificity of the indefinite:



Again anticipating the FUDRS-representation format, (17) can be sketched as follows:

($17_{rep.fudrs}$) Underspecified representation:

L: < e, [e | e:attend(u,v)] > $\left\{ \begin{array}{l} l_{1,u}\text{:}\underline{\text{every}}(\underline{\text{linguist}}) \\ l_{2,v}\text{:}\underline{\text{a}}(\underline{\text{workshop}}) \end{array} \right\}$

$\cup$ copy(L)/ [Fu_1/$l_{1,s}$':$\underline{\text{every}}$($\underline{\text{lcomp\_scient}}$)]

Disambiguation of ($17_{rep.fudrs}$) to a specific reading via disambiguation of the indefinite and linearization does not stipulate specific requirements about the order in which the different evaluation processes have to be applied. Evaluating the indefinite description first, we obtain two readings: the specific reading, where a introduces an α-condition which triggers resolution and in this case accommodation of the referent and its description in the empty context of the sentence, or the existential reading according to which the referent and its description are introduced in situ, depending on the scope order chosen. In the latter case, there are two possible orderings. By copying, we obtain the same structure for the elliptical term. Thus, as desired, after conversion, we obtain exactly the three readings represented above. In contrast, if linearization is applied first, we obtain the same ordering constraints for antecedent and copy. Because of the local context constraint the a-conditions must be evaluated in the same way, i.e. both existentially or both specifically. In the latter case, both descriptions refer to a discourse referent of the context which satisfies the description and which is presupposed to be unique with respect to this context. In short, they refer to the same referent (which in our example must be accommodated since no context have been given). Therefore, we obtain in each case the same three readings for first and second conjunct of (17). This means, the FUDR-formalism is expressive enough to subsume the considerd readings in one FUDRS and its evaluation doesn't overgenerate, such that it describes exactly the desired readings.

Chapter 2

Data structures

2.1 Desiderata

We want to work out the lexical and compositional semantics for a relatively broad fragment of German such that it can be used in a general analysis system for German texts. Broad coverage (of a semantic component) immediately follows as a desideratum if one plans to implement a robust system that analyzes (reasonably restricted) every-day language such as what can be found in newspapers (instead of concentrating on a very limited domain consisting of a small number of linguistically interesting sample sentences). If one aims for broad coverage, it is a good policy to structure the system so that it constructs representations appropriate for all readings of input sentences, yet postponing the elaboration of detail appropriate to each reading individually until a post-recognition process. This refers to all kinds of ambiguities considered in the last chapter. We have motivated how FUDRSs should conform to this requirement and we have sketched how they relate to Reyle's UDRSs and in particular how they deviate from them: For the representation of lexical items we (can) use (possibly multivalued) functional expressions instead of basic DRT-conditions, for the representation of modifiers we use DRS-functors instead of DRSs and for the representation of application constraints, we use the relation *first* besides the partial ordering relation $\leq$. In the following sections 2.2-2.9, we will give exact definitions of these features of the FUDRS format. We will proceed in several steps, starting out from the UDRT-representation setting.

A further desideratum is that the expressions of the theory, its construction algorithm and the respective compositional semantics should be as independent as possible from specific assumptions concerning the syntactic analysis of sentences, so that the algorithm should be compatible with a large number of different syntactic theories and parsers. A consequence of this is that we will assume the expressions to be decorated by (coarse-grained) (morpho)syntactic information that is useful for deciding about correct semantic specification (like case information for deciding about the meaning of (German) prepositions, etc.). The syntax-semantics interface of the specific analysis system must translate the specific syntactic analysis results and provide values of the corresponding attributes (and types) which conform to the FUDR-decoration assumptions. Because of this setting, this means that, with respect to part of speech and phrasal categories, the partitioning into classes should be as neutral as possible with regard to the suggestions of competing grammar theories. In case of conflicting perspectives, we rely on semantic arguments. Thus, in some grammar theories, the noun subcategorizes for the determiner, in others the determiner is an adjoint modifier and, according to the different analyses, the determined noun phrase is called DP or NP, where both decisions leave open whether a categorial distinction is made between the noun and the modified noun. In X-bar theory, the noun is N, the modified noun N', the noun which is saturated with regard to its complements is NP and the noun phrase with determiner is DP, HPSG calls the noun N and all noun projections NP (at least some versions of HPSG), etc. Semantically, the case seems relatively clear: the noun is a predicate (of type t/e) and the determiner turns it in a function from properties into truth values (t/(t/e))). Though in the appendix we will apply the suggested semantic representation formalism to HPSG in the form proposed in [Pollard/Sag(1994)], which assumes subcategorization of the determiner, we assume the determiner to be of type (t/(t/e))/(t/e)) semantically, with the consequence that the semantics of the saturated nominal phrase is not of the same type as that of the other nodes of the nominal projection line. For this reason, we call the saturated noun projection a *determined noun phrase*, DP. In contrast to the terminology of [Pollard/Sag(1994)] we reserve the term NP for the other noun projections (the unsaturated ones – which are of type (t/e)). Because against the background of underspecified representations the representation of single nouns will structurally be much simpler than the representations of nouns that are modified by adjectives, relative clauses etc., we will differentiate N-representations as a specific subclass of the NP-representations (type theoretically there is no difference however). In close parallel, and for similar reasons, we introduce the class of V-representations as a subclass of the VP-representations and we call any verbal projection a VP (*verbal phrase*) – not just the projection that subcategorizes for the subject only. With this, we also want to remain neutral on how the verbal arguments are attached to the verb, i.e. if there is a binary tree analysis (of some predefined order), or if several verbal complements are consumed simultaneously by the verbal head (i.e. if they are daughters of the same VP-node), as assumed in the HPSG-analyses of ditransitives, etc. (cf. [Pollard/Sag(1994)]). The semantically distinctive feature of what we call VP is that an event is introduced with (unresolved) tense information and that type-theoretically, the meaning of the representation is a function from (tuples of) individuals (or instances of other types in case of non-relational verbs) into functions from times (contexts, information states) into propositions. By resolution of the presupposition from the tense information, i.e. by incorporating the sentence-VP in the context, we obtain a structure of type S (for *sentence*, or type-theoretically: t). (In a way, the transition from VP to S corresponds to that of NP to DP: in both cases this transition binds the referent, existentially or by presupposition resolution). The sketched typing will be taken up in sections 2.8 and 3.1, when we come to define the expressions of the theory.

2.2 Partially ordered partial representations

Cooper storage liberalizes scope assignment. This is a prerequisite of underspecification. However, it is not expressive enough in order to express constraints on relative scope order. It generally allows all kinds of permutation. This is not satisfactory. In 1.2, we said that approaches for underspecification which try to describe the desired constraints by disjunctive specification of the immediate argument of semantic functors like minimal recursion semantics (MRS) aren't completely satisfactory either. In MRS pointers to partial semantics are introduced, so called HANDELs, such that semantic functors can be assigned a set of HANDELS which point to the argument candidates. For instance, in the presence of three quantifiers (or, more generally, scope bearing elements) Q_1, Q_2 and Q_3 the constraint that Q_3 *has scope over* Q_1 can be expressed: We can sketch this for example by stipulating $Q_3 : \langle Q_1, Q_2 \rangle$, $Q_1 : \langle Q_2, V \rangle$, $Q_2 : \langle Q_1, Q_3, V \rangle$(where '_: $\langle \ldots \rangle$' relates a representation to its possible immediate arguments with 'V' for *verb*).

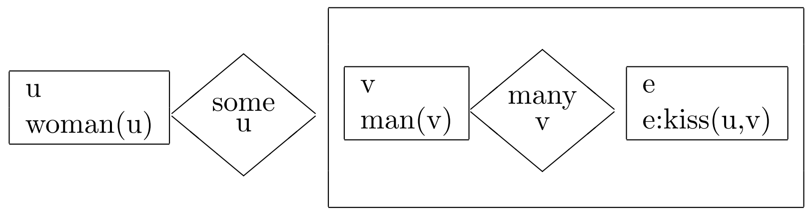
In contrast, if there are more than three quantifiers, this formal means cannot express all of the possibly relevant constraints: The set of stipulations $S = \{Q_3 : \langle Q_1, Q_2, Q_4 \rangle, Q_1 : \langle Q_2, Q_4, V \rangle, Q_2 : \langle Q_1, Q_3, Q_4, V \rangle, Q_4 : \langle Q_1, Q_2, Q_3, V \rangle\}$is the best we can do in order to approximate the constraint in question ($Q_3 \geq Q_1$). Further restricting the sets of alternative immediate arguments that are connected to the quantifiers would rule out orderings that conform to the constraint. However, S is not expressive enough to entail the constraint.

This formal restriction is relevant. It is indeed an insufficiency, because there are other scope bearing elements than (subcategorized) quantifiers (adverbs for instance, see section 3.6), such that cases like the described one aren't far-fetched. The lack of expressivity depends on the strong semantics of the HANDEL argument: the set of HANDELs point to structures which are candidates for being chosen as **immediate argument** of the functor. 'Long distance' scope dependencies (which allow intervening elements) cannot be expressed. This insufficiency is avoided, if the notion of immediate argument is replaced by the more liberal *has scope over*. This leads to a scenario with partially ordered scope bearing elements. This is the suggestion of the *underspecified discourse representation theory* which Reyle has introduced and developed further in a number of articles ([Reyle(1993b), Reyle(1993a), Reyle(1994), Reyle(1995), Reyle(1996)]). This theory is particularly interesting because, next to the compact representation format that it provides for representing scopal ambiguities and constraints, it spells out a logic that allows for directly reasoning with underspecified structures (as far as the case is restricted to first order quantifiers, see [Reyle(1993a), Reyle(1994)]). Example (18) illustrates UDRT-style representations:

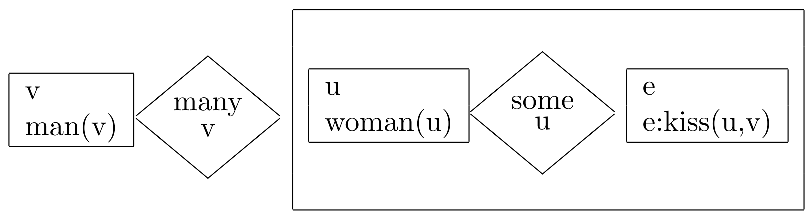
(18) Many men were kissed by some women.

(18_{rep})

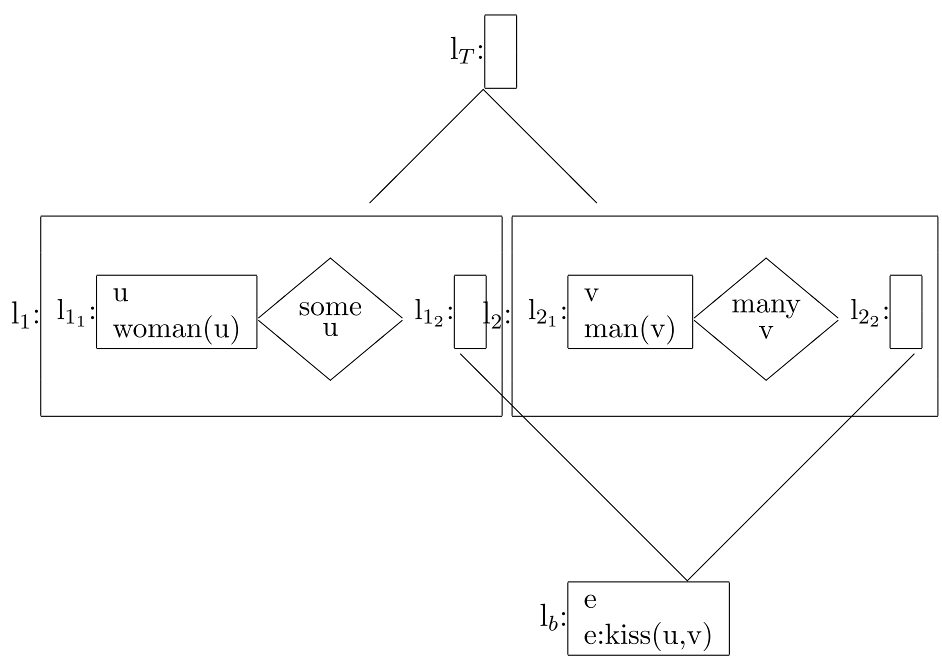
(a)



(b)



(a,b)



Here, (18_{rep}(a,b)) subsumes the alternative readings (a) and (b) of (18). This is realized by labelling the partial semantics and by stipulating the relevant ordering constraints in terms of literals that relate labels by a partial ordering symbol. In the graphic representation, these ordering statements are depicted by the edges. Using the original representation style of [Reyle(1993b)], where the partial DRSs are broken up into labelled single DRFs and conditions that are marked as parts of the same structure by the identical labelling, we can represent (18_{rep}(a,b)) also by the following set of conditions:

$\{l_b{:}e,\ l_b{:}\ e{:}kiss(u,v),\ l_{1_1}{:}u,\ l_{1_1}{:}woman(u),\ l_{2_1}{:}v,\ l_{2_1}{:}man(v),\ l_1{:}\ \langle{\text{some} \atop u}\rangle(l_{1_1},l_{1_2}),\ l_2{:}\ \langle{\text{many} \atop v}\rangle(l_{2_1},l_{2_2}),\ l_b \leq l_{1_2},\ l_b \leq l_{2_2},\ l_1 \leq l_T,\ l_2 \leq l_T\}$

Here, enumerating ordering constraints that can be inferred from the specific structural constellations has been omitted: from a labelled duplex condition l_1: $\langle{\text{QU} \atop x}\rangle(l_{1_1},l_{1_2})$, for instance, we infer $\{l_{1_1} <_s l_1,\ l_{1_2} <_s l_1\}$and $\neg\exists\, l\ (\ l \leq l_{1_1} \wedge l \leq l_{1_2}$, where '$<_s$' means *immediate successor* ($\forall\, l_1, l_2\ (l_1 <_s l_2 \Leftrightarrow l_1 \neq l_2 \wedge \forall\, l\ (l_1 \leq l \leq l_2 \rightarrow (l{=}l_1 \vee l{=}l_2))))$.

Because of the described advantages, UDRT provides the basis of our approach. However, we modify and extend this basis in certain respects. To begin with, in order to enhance readability, we stick to the format of the partial representations in (18_{rep}(a,b)); i.e., we write

$$l{:}\begin{array}{|l|}\hline x_1 \ldots x_n \\ \\ C_1 \\ \vdots \\ C_m \\ \hline\end{array} \quad \text{instead of} \quad \{l{:}x_1,\ \ldots,\ l{:}x_n,\ l{:}C_1,\ \ldots,\ l{:}C_n\}$$

and we write

$$l_1{:}\begin{array}{|c|}\hline l_{1_1}{:}DRS1 \langle{\text{QU} \atop x}\rangle l_{1_2}{:}DRS2 \\ \\ \hline\end{array} \quad \text{instead of} \quad \{l_{1_1}{:}DRS1,\ l_{1_2}{:}DRS2,\ l_1{:}\langle{\text{QU} \atop x}\rangle(l_{1_1},l_{1_2})\}$$

(where the latter implicitly subsumes the ordering constraints that under the assumptions of UDRT are inferable from the duplex conditions). Note that, up to now, this alteration is just (abbreviating) syntactic sugar without any impact on the expressivity of the language. The next sections provide more relevant alterations.

2.3 Neo-Davidsonian event descriptions

UDRT, following standard DRT ([Kamp(1981b), Kamp/Reyle(1993)]) in this respect, represents transitive and ditransitive verbs by more-place predicates. We deviate from this and assume one-place event predicates instead, where the referents of the subcategorized verbal functions are connected to the event variable via explicit thematic roles. Thus, when representing *Peter loves Mary* and *Peter gives Fido to Mary*, we write

s love(s) theme1(s)=peter theme2(s)=mary	instead of	s s:love(peter,mary)	and
e give(e) agent(e)=peter object(e)=fido recipient(e)=mary	instead of	e e:give(peter,fido,mary)	respectively.

The main reason for this decision is an argument known from AI knowledge representation. Provided one assumes that event descriptions (VP representations) introduce referents for the events according to Davidson's convincing arguments (cf. [Davidson(1967)]), as do all DRT-descendants, then more-place predicates about events can be defined by corresponding one-place predicates and two-place relations between the arguments and the event. The advantage of such one-place event predicates and two-place relations (which are the thematic roles) is that one can abstract away from different valency patterns of the verb and one can formulate general properties of the verb and of thematic roles, which allows more compact representations of lexical knowledge and of world knowledge about event descriptions and, as a consequence, for more efficient reasoning with regard to the properties of the events of the text and the connection between them. We do not want to go into detail with this here, nor do we want to evaluate other arguments that motivate this decision for one place predicates and explicit thematic roles. More detailed discussions can be found in [Krifka(1989)] and [Eberle(1991a)] among others. Further below, in section A, we spell out a set of thematic roles that is used in the lexicon of the system that we describe in this paper.

As intimated in the introduction, we use more-place event predicates for flat representations of VP representations which, next to the characterization of the event proper underspecify the role the arguments play with respect to the event.

(19) *a) Peter drives the car.*
b) Peter drives the woman.

(19.a_{rep})

e
α_{pn}(p, [p / peter(p)]
α_{def}(c, [c / car(c)]
e: drive(p,c)

(19.b_{rep})

e
α_{pn}(p, [p / peter(p)]
α_{def}(w, [w / woman(w)]
e: drive(p,w)

In (19.a_{rep}) the flat lexical representation e:drive(p,c) underspecifies the contribution of the arguments of subject and object as well as the corresponding representation e: drive(p,w) of (19.b_{rep}) does. Depending on the evaluation of contextual knowledge and the contextual conditions which trigger evaluation of the function drive, the argument of the object may be interpreted as *instrument* (as appropriate in the case of a)) or as *theme* (as appropriate in the case of b)), such that we may obtain:

(19.a_{rep}) (partially) evaluated (further)

e
α_{pn}(p, [p / peter(p)]
α_{def}(c, [c / car(c)]
drive(e) agent(e)=p instrument(e)=c

($19.b_{rep}$) (partially) evaluated (further)

e
α_{pn}(p, [p peter(p)]
α_{def}(w, [w woman(w)]
drive(e) agent(e)=p theme(e)=w

To be precise: e:verb_predicate($a_1,\ldots,a_n$) abbreviates the conjunction of literals verb_predicate(e), arg_1(e,a_1), ..., arg_n(a_n), where arg_i underspecifies the role a_i plays with respect to e by informing only about the syntactic function which provides the argument (*subj*, *obj* etc.). Often, if it is clear that the relation name doesn't stand for a specific n-place-predicate but for a functional term, for simplicity, we do without underlining the term.

We must stress that the well-known problems connected to thematic roles (how many are there, which are them) and, in particular, to appropriately linking syntactic functions to semantic roles is not the interest of this paper. Therefore, our modelling of this subject is highly tentative and rough. We think, however, that these problems arise with aiming at general solutions in the sense of universal grammar and disappear if the approach is used for being applied to describing specific purpose scenarios, as is intended. (For each of these, there might be reasonable specifications, though an overall solution summarizing all the different scenarios might be hard to design).

2.4 A functional perspective: underspecified representations as sets of semantic functors and application constraints

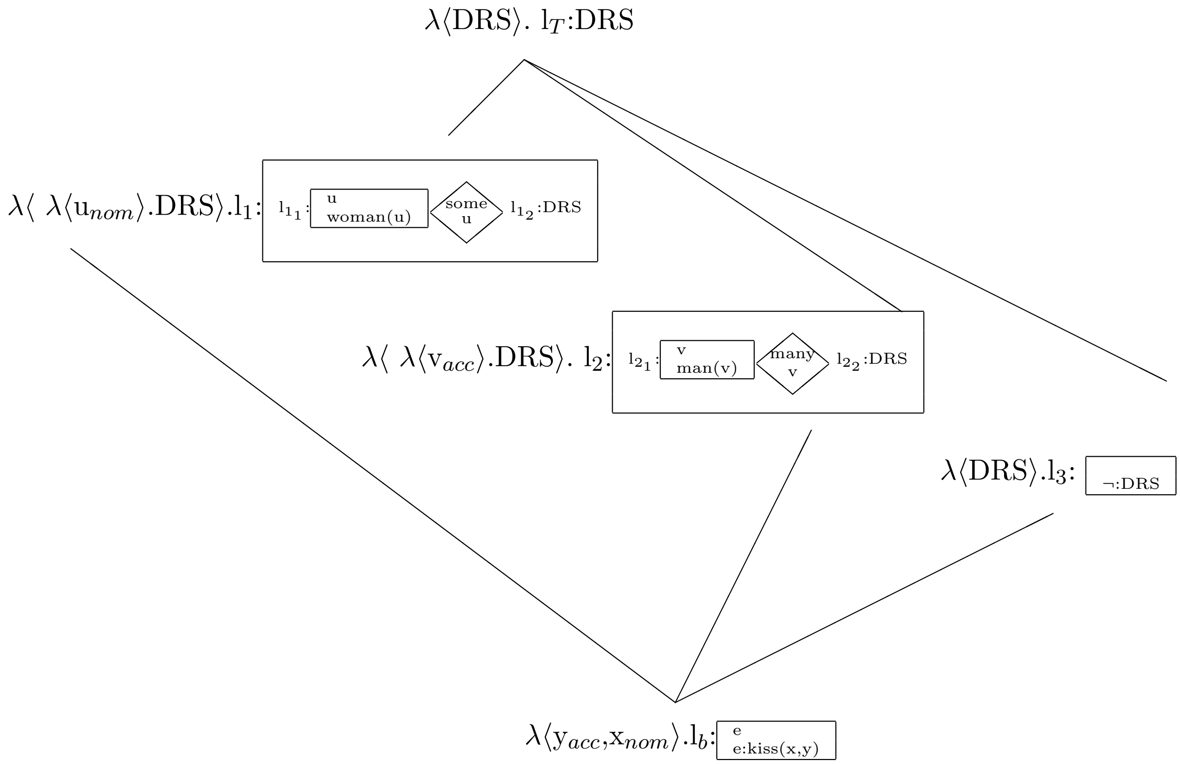
In essence, a UDRS K is a compact representation of a disjunction of those DRSs that develop from K, firstly, by strengthening the partial order of K to a maximally linearized partial order (i.e. an order with unique paths which satisfies the implication: $\forall l_b, l_x, l_y, l_T \quad (l_b \leq l_x \leq l_T \wedge l_b \leq l_y \leq l_T \rightarrow l_x \leq l_y \vee l_y \leq l_x)$), and, secondly, by merging the contents of labels which are neighbors with respect to the resulting order, except for labels that are explicitly kept separate via the impact of '$<$'- or '$\neq$'-constraints of the initial K-order. For instance, K = (18_{rep}(a,b)) accepts exactly two linearizations:

a) $l_b \leq l_{2_2} <_s l_2 \leq l_{1_2} <_s l_1 \leq l_T$ and b) $l_b \leq l_{1_2} <_s l_1 \leq l_{2_2} <_s l_2 \leq l_T$.

Other possibilities are ruled out by implicit constraints as are specific to UDRSs (which, amongst others, are: restrictor and scope of duplex conditions do not share any content, the labels of restrictor and scope immediately precede ($<_s$) the label pointing to the corresponding duplex condition etc.). Merging the contents of neighboring labels as described results in (18.a) in case of the solution (a) and in (18.b) in case of the solution (b).

It is easy and natural to interpret the successive merging operations along the linearized K-paths as successive functional applications where the lower element is consumed by its successor or by the structure which contains this successor as immediate constituent (where the latter is exemplified by a duplex condition whose scope will be identified as the lower representation). It is a simple exercise to translate the labeled descriptions of an UDRS into suitable semantic functors such that the successive merging of the labeled representations can be formulated as functional application. In order to illustrate this, we reformulate (18_{rep}(a,b)) correspondingly and add a negation operator for further exemplification of such a functional representation style. We can represent this by (18_{rep}(a,b)').

(18_{rep}(a,b)')



Here, the edges from the functors in the middle to the common daughter (and vice versa with respect to the common mother) determine underspecified application constraints: In a disambiguation, the bottom element, the l_b structure, is the argument of one of the structures that the underspecified representation provides as successors of the l_b-structure; i.e., it will be the argument of the l_1-, l_2- or the l_3-structure. The result of the corresponding application then is the argument of the structure that, according to the linearized order that is specific to the considered disambiguation, is the successor of the first functor structure and so forth. Note that, here, applying a DP-semantics to a VP-semantics during disambiguation means to make use of bidirectional lambda conversion and functional composition: The VP-semantics, depending on the (remaining) unsaturated subcategorized functions of the VP, is a function from individuals, pairs of individuals etc. into (presuppositional) propositions The DP-semantics is a function of properties into propositions. Allowing for functional composition, the DP-semantics, instead of one-place VP-semantics, will accept n-place VP-semantics also. It will bind the appropriate variable of the set of VP-arguments to its discourse referent and will return a (n-1)-place VP-semantics (which incorporates the DP-representation).

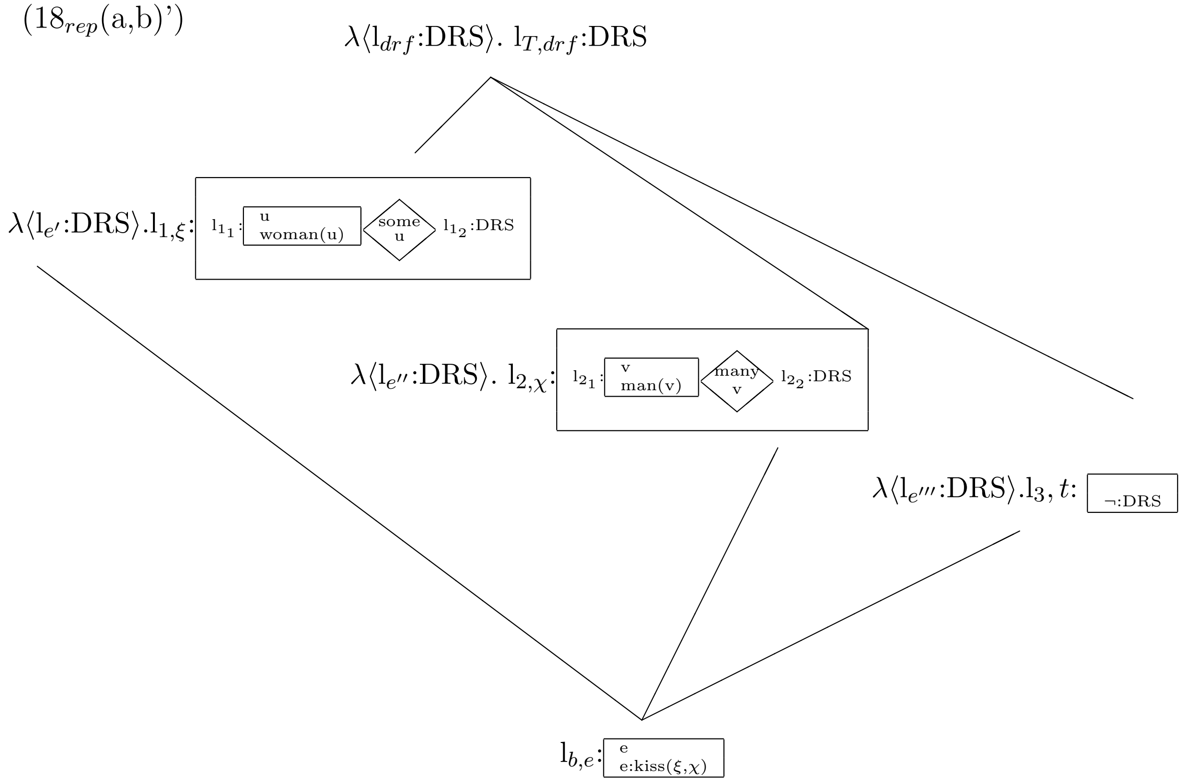
Such representations are rather complex. Why should we prefer functional representations to UDRSs? The main reason for doing this is that a number of partial representations, in particular representations of non-intersective modifiers like modal adverbs (see section 3.6.4 for this), do not only incorporate the argument representation somewhere in their contribution proper (via merging it to this contribution or identifying it to some sub-DRS of it), but take up the referent of the argument representation and add some new condition about it or build some new referents from it (by summation for instance in the case of frequency adverbs). This means, in order to correctly represent such conditions the functor representation must have the possibility to take up this referent. It goes without saying that this referent isn't always the one of the one bottom representation (which could be taken up easily of course by each of the modifiers). In the presence of several scope bearing elements, it depends on the evaluation which is the referent which the modification uses or characterizes. Compare (20) for this.

(20) *Oft schoss Peter nicht.*

(20) means either *It is not true that Peter often shot* or *Often, Peter didn't shoot.* In the first case, *oft/often* quantifies over shooting events of Peter. Its referential argument (which would be referred to by *this* in *Peter often shot. This happend last week.*) would be characterized best probably by a sum of events. Then, this quantificational structure is modified by the negation, which excludes the existence of such a sum of events for the considered reference time. The referential argument of the negated statement certainly is not an event or a sum of events, but a time which is contextually relevant (a reference- or perspective-time). In the second case, *oft/often* quantifies over times for which a shooting by Peter is excluded. We will consider such examples in greater detail later in section 3.6.8. For the moment, the argument should be clear: The referent which the representations of *oft/often* and *nicht/not* take up and modify is not the same and is different with regard to the two readings respectively. This motivates that modifiers should indeed be represented by semantic functors and that, additionally, their arguments should be decorated by the *distinguished discourse referent* which the argument provides for further characterization. The distinguished DRF of the verb representation will be the event introduced by this representation, the distinguished DRF of adverbials will be an event- or time-DRF which will be accessible for further (wide scope) modification etc. In the next section, we will try to motivate that for DPs the situation might be more complex. In any case, there will be a distinguished DRF which is the one which is unified to the argument of the verb representation which stems from the corresponding grammatical function. This feature is particularly helpful. It allows to reduce the complexity of the functional representation of underspecified structures significantly. We can reduce the type of the functors of the resulting (sentence) FUDRS by omitting the lambda operators over individuals with respect to VP-representations without losing the possibility of leaving open for what they stand exactly, because the DRF which, by the syntax-semntics-interface, is unified to the corresponding verb role is not necessarily the DRF from the DP-noun and can take over the role of mediator which, otherwise, is played by the dynamics of beta conversion in connection with ambiguous functors. In particular, this is important

in the presence of DPs which can be read distributively or collectively. Depending on the reading chosen, the corresponding argument of the verb representation will be a DRF which stands for a sum or an individual. In UDRT-representations the verb representation and the representation of the complements share the referents (compare (18_{rep}(a,b)), where the representations labeled by l_1, l_2 and l_b share the referents from subject and object). If one of the complements would be assigned a collective reading (what ever this would mean in the case at hand), x or y of the verb representation must be reinterpreted as some sum X or Y in the UDRT-case therefore. In contrast, when taking up the value of the attribute *distinguished DRF* of the decoration of the DP-representation, there is no decision yet about the nature of this value. If the DP is disambiguated to the distributive reading this value will be identified as the DRF introduced in the DP-duplex condition, otherwise, in the collective case, it will be identified as a sum created from the duplex condition. The definition of the multivalued function associated with the quantificational complement must and will rule the correct instantiation of this decorational attribute. (We will go into greater detail with this in the next section). Therefore, we can represent the extended (18) by (18_{rep}(a,b)"), which uses type-theoretically simpler partial representations than (18_{rep}(a,b)').

(18_{rep}(a,b)')



This says, that the 'bottom representation' of the FUDRS provides e as distinguished DRF and takes up the distinguished DRFs of the representations from subject and direct object as arguments of the event predicate. The complement representations are functors whose arguments are event representations (decorated by event DRFs). The argument of the negation is an event representation also. Its distinguished DRF is a time. The top representation is the identity.

(18_{rep}(a,b)”) is not the final version of the FUDRS-representation of the negated (18). After more detailed reflexions about distinguished DRFs in the next section, we will suggest a format of representation which reduces the types of the partial representations further. The reason for discussing the two ’more functional’ representations (18_{rep}(a,b)’) and (18_{rep}(a,b)”) was, firstly, to illustrate that UDRSs can be reformulated as a ’blueprint’ for the construction of a DRS from partial representations according to the compositional semantics approach of Montague grammar (where the bluprint leaves open some decisions about the order of application and composition). This means, that, in a way, they can be seen as a snapshot taken of the process of constructing the DRS of the sentence from its parts, where the ’design engineer’ has commited himself to some specific future application decisions. Secondly, we wanted to motivate that the type-theoretical reduction which UDRSs show when compared to their ’functional’ counterparts is responsible for that some phenomena of ambiguity, mainly related to adverbial modification and optional distributivity, cannot be represented through UDRSs as naturally as can be done when basing the representation on a more functional style. FUDRSs try to formulate a tradeoff between type-theoretical simplicity and expressivity in this respect of compact and appropriate representation of lexical and structural ambiguity (where most information load of lambda operators is taken over by the making use of distinguished DRFs). [1]

2.5 Distinguished discourse referents

2.5.1 The lower referential index

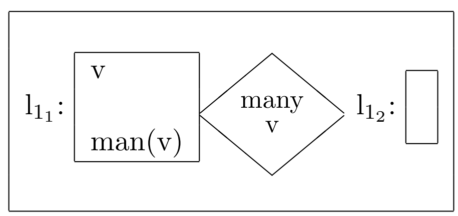
We have motivated the usefulness of annotating the representations of the subcategorized functions by a distinguished DRF which is ‘passed down’ to the verb representation. There are different possibilities for deciding about which DRF from the subcategorized functions instantiates which argument of the verbal predicate. The linking information of the syntax-semantics interface might be based on case information or the like However, it may be based on purely positional information also. Independent of this, semantic representation could do without any hint about

[1]Another approach to (underspecified) representation which emphasizes the functional aspect is lambda-DRT (which has been suggested firstly in [Bos et al.(1994)]). Though similar with respect to adopting a functional perspective, the approach developed here traces back to the suggestion of [Eberle(1995)] which was developed independently of [Bos et al.(1994)]. Also, more than it is done there, we try to focus on type-theoretical simplicity

the criteria which led to the decision taken, once the instantiation is executed. Repeatedly, we said that semantic construction should be as independent as possible of the syntactic analysis it is applied to. (It may be incorporated into the syntactic analysis and executed simultaneously or it may be completely postponed etc.). Therefore, we want that our semantic representations make explicit the type of information which is responsible for such choices and which, with regard to UDRT composition, is hidden in the syntax semantics interface. This means, next to providing the distinguished DRF the decoration of the semantic contribution proper shall show the relevant syntactic information connected to this DRF also. With respect to the distinguished referent which, in composition, by beta conversion, instantiates an argument position of the argument predicate of the DP, we call the totality of this information the *lower referential index*. In the appendix (A), we will represent such indices (and also other (saturated) information structures, which we define in the following) as terms of feature logic, i.e. as *attribute value matrices* (AVMs) in close parallel to the HPSG representation style. Here and in the following, we abstain from using explicit AVMs. Instead of representations which have attributes *label* and *lower referential index* and others with values which are pointers or AVMs, here, representations and DRFs come with a number of annotations, as in the following (preliminary) representation of the DP *many men*:

(21)

many men *(case nominative)* $\longrightarrow l_{1,v_{nom}}$:



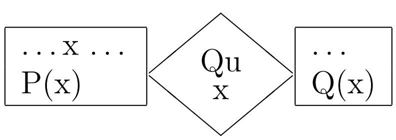
(21) says that the representation of the DP contains a duplex condition such that l_1, l_{1_1}, l_{1_2}, in turn, are the labels of the representation, its restrictor and its scope and such that its lower referential index is the DRF v which stems from a DP of case nominative. It will be convention to add and omit annotations as needed.

2.5.2 The upper referential index

According to generalized quantifier theory (cf. [Gärdenfors(ed.)(1987), Barwise/Cooper(1981)]), quantificational NP-modifiers like *exactly nine* or *few* are generally understood as describing the relation between the set of objects that satisfy the argument NP description and the set of those objects that, additionally, satisfy the property of the VP (which is the argument of the corresponding DP). In line with DRT and UDRT, we will adopt this position also and interprete the quantificational duplex conditions accordingly. A consequence of this is, that the VP-meaning is associated to the members of a (possibly empty) subset of the NP-meaning, where the quantified variable of this distribution is provided by the lower referential index of the DP. This corresponds to a distributional interpretation of the sentence and it means in particular, that, a priori, there is no DRF available for the sum of the individuals which satisfy to the statement. It is well-known, however that such DRFs can be referred to by descriptions of the succeeding context:

(22) *Genau neun Schuljungen ergatterten eine Karte für das Spiel.*
Sie waren überglücklich.
Exactly nine schoolboys got hold of a ticket for the match.
They were blissfully happy.

Note that in (22), the pronoun of the second sentence doesn't refer to schoolboys as such – though such references to the set which can be abstracted from the NP meaning are possible, it does refer to the set of 9 schoolboys who got hold of a ticket. It refers to what is called the *Refset* (*referential set*) which is introduced by the quantification (to the term, to the sets which develop from quantification and which can be referred to, compare [Corblin(1996)], also [Moxey/Sanford(1993)]). Normally, one assumes that this set is *abstracted* from the quantification statement, when it is needed as antecedent for a plural pronoun as in (22) (see [Kamp/Reyle(1993)] for this) – where, with respect to DRT, *abstraction* from a duplex condition



means to define this set, X, via

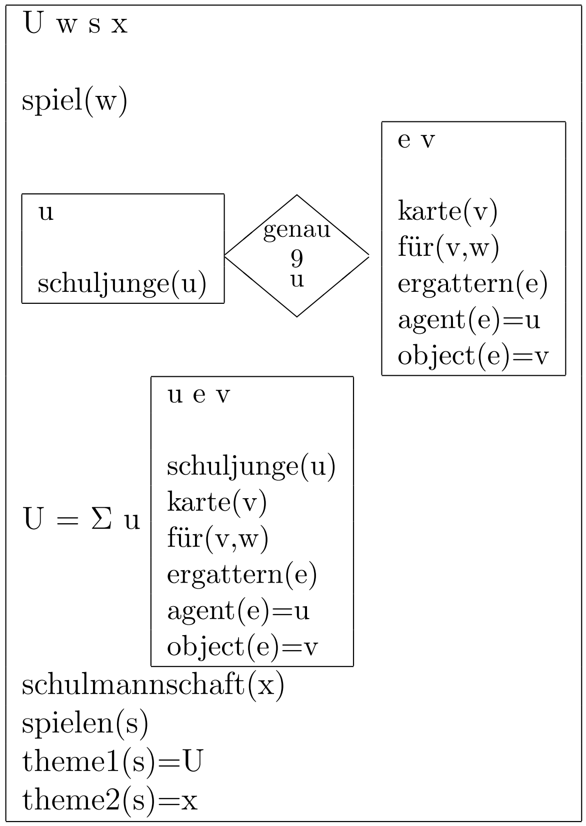
$$X = \Sigma\ x \begin{array}{|l|}\hline \ldots x \ldots \\ P(x) \\ Q(x) \\ \hline \end{array}\ .$$

However, it seems that there are cases, where such subsequent abstraction doesn't provide practicable solutions.

(23) *Genau neun Schuljungen, die wie sich herausstellte schon einmal in einer Schülermannschaft zusammen gespielt hatten, ergatterten eine Karte für das Spiel.*
Exactly nine schoolboys, who, as it became clear afterwards, once had been playing together in a school team, got hold of a ticket for the match.

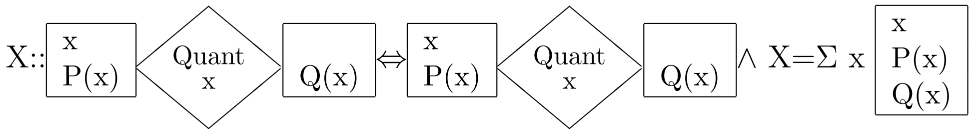
Obviously, (23) is a correct German sentence. What is specific to it is the fact that the relative clause doesn't modify the noun: It is used as an apposition to the DP and must modify the DP therefore. Also, because of the adverbial *zusammen*, it must be read collectively, to the consequence that the relative pronoun has to relate to a set or sum, which cannot be introduced by the noun or noun projection (given that *genau neun* is actually used here as a distributive quantifier which runs over individuals, not over sets of sets (or sums)). This additionally supports that it must relate to a set or a sum which must be provided by the DP as a whole. Compare the DRS of (23_{rep}), which, to our opinion, truly represents the meaning of (23). [2]

(23_{rep})



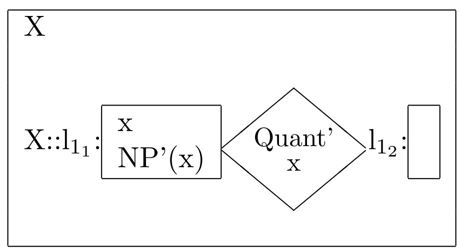
This means, firstly, the relative clause doesn't modify the NP but the DP in this case and, secondly, the DP must provide the DRF for the *Refset* before modification by the relative clause is executed, i.e. abstraction must happen simultaneously with constructing the DP from the determiner or quantifier and the NP. Thus, the result of applying the quantificational modifier to the NP is a duplex condition, where the restrictor is the representation of the NP and the scope the yet uninstantiated VP-representation and, additonally, a statement which abstracts the DP-Refset from scope and restrictor of the duplex condition. In order to represent this statement, we adopt a notational convenience suggested in [Eberle(1991a)] for abstracting sets from duplex condition, which bases upon the following extension by definition of the DRS-language:

[2]Note that the assumption that, here, the meaning of the noun, of *Schuljungen*, is a set of individuals, not a set of sets (or sums) accords to general composition assumptions of DRT, and other versions of Montague grammar based theories of compositional semantics. It is the determiner – or the quantifier in this case – which is responsible for the introduction of sets or relations between sets. For other, different, cases of quantifier use, compare section 3.4.1.



Here, of course, as above, P and Q are not necessarily basic predicates, but stand for partial DRSs of type 'function from individuals into (open) propositions'. It is also clear that the accessibility conditions for DRSs have to be formulated in such a way that DRFs which stem from such abstraction addenda aren't accessible from inside the structures that define them. Note that this is a constraint that must already hold for the special case of the 'traditional' explicit abstraction, i.e. for the summation condition. Using this new formal means, we assign quantified DPs like *many men, few party liners, exactly nine school boys* the following representation format (which is still provisional) :

(24) Quant NP $\longrightarrow l_{1,X,x}$:



As before, there may be annotations of the different distinguished DRFs. The right hand side distinguished referent of the labeled duplex condition is the DRF of the lower referential index described in the last section, the left hand side (sum-) DRF designates the so-called *upper referential index*. The DRF of the lower referential index is accessible from the scope of the duplex condition (by the VP-representation), the DRF of the upper referential index is accessible only from outside the duplex condition (where the DRF of the lower index is not). It is the DRF of the upper referential index which the considered DP modifying meaning of relative clauses picks up. (For our account of relative clauses as such, for other readings and especially for the contribution of relative pronouns, see section 3.12). It goes without saying that quantifier expressions obtain upper referential indices only if they accept corresponding (collective) DP modification, i.e. a quantifier like *every* or *each* will not, see section 3.4.1 for this. With respect to all non-distributive DPs, such as proper nouns for instance, lower and upper referential index will share their value (in this case we also speak of the one referential index).

According to DRT as is formulated in [Kamp/Reyle(1993)] and the suggestions of [Eberle(1991a)] for a background theory that accompanies the representation of natural language texts (that we assume to complete the axiomatic model-theoretic setting of the approach here), we adopt the semi-lattice approach of Link developed in [Link(1983), Link(1991)] and model sets of individuals as first order objects that, by means of a relation $\in_i$, subsume their 'members' as atomic parts. In the representations, upper case DRFs denote (non-atomic) sums, lower case DRFs denote atomic objects (classical individuals—and events etc.). We use greek letters, if the

DRF may denote either an atomic or a non-atomic object. $\in_i$ will be the specialisation of the semi lattice (subsum) relation, $\leq_i$, where the left argument is atomic. We use '*' as an operator that transforms predicates P into predicates whose extension consists of the sums that can be built from the extension of P.

2.5.3 The result index

Besides indices for the sums that can be abstracted from the thematic roles, it seems necessary to carry along a further type of index, for the distinguished DRF of VP projections this time, since this DRF isn't always identical to the DRF introduced by the verb. In order to see this, consider the case of some adverbials which modify the sentential predicate, not the sentence, and which, nevertheless, (can) have wide scope with respect to the meaning of the subcategorized verbal functions (and possibly other event modifying adverbials). [3] Consider (25).

(25) *a. In rascher Aufeinanderfolge immatrikulierten sich die meisten der Studenten.*
In quick succession, most of the students got matriculated.
b. Eng beieinander landeten die meisten seiner Geschosse.
Closely neighbored, most of his missiles went down.

In (25.a), the adverbial introduces an intersective predicate which must refer to a collection. It cannot relate to the single matriculation events. Obviously it characterizes the sum of these events.

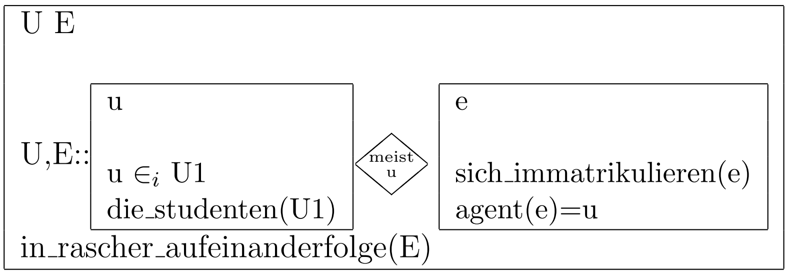
The adverbial of (25.b) is intersective also and refers to a collection too: The spatial arrangement that it claims for its argument excludes this to be a single object. The predication cannot relate to a single landing event, but must relate to the totality of these events. [4] Therefore, the following DRSs seem to adequately

[3] By sentence modifier, we mean adverbials which relate to the proposition described by the sentence, or according to theories like situation semantics or SDRT (cf. [Barwise/Perry(1983), Asher(1993)]), to the whole situation or fact that is described by the sentence. In contrast, a predicative modifier relates to the event introduced by the VP, whose existence the proposition, situation or fact claims. For representations which base upon this distinction, compare section 3.6.4.

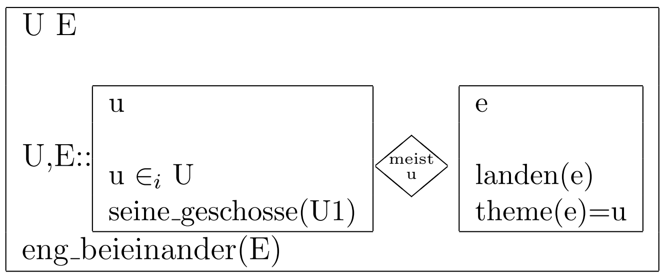
[4] One might think that the relevant final outcome of the adverbial contribution is to characterize the spatial structure of the ensemble of missiles at the end of the event and that, therefore, it would be sufficient to characterize this ensemble only. However, we think that this characterization, though present in the statement (25.b), is not at the heart of the statement, but is an entailment from the specific characterization of the spatial structure of the collection of landings together with additional knowledge about the event type *landing*. This seems supported by the fact that it is not always the same thematic role which is characterized by such adverbials. Knowing what follows for which set of partaking objects at which time depends on knowing the internal structure of the events of the considered type. In *sie flogen ihre (ferngesteuerten) Flugzeuge eng beieinander* (they flew their (distant control) planes closely neighbored) the entailment (from the fact that the simultaneous flying processes were spatially closely neighbored) is that it is the set of planes that is spatially characterized, and not the set of agents, and that this set satisfies to the predicate

represent the meaning of (25.a) and (25.b). For the introduction of the collection of events, we make use of the convenience that we have introduced in the last section. We obtain:

(25_{rep}.a)

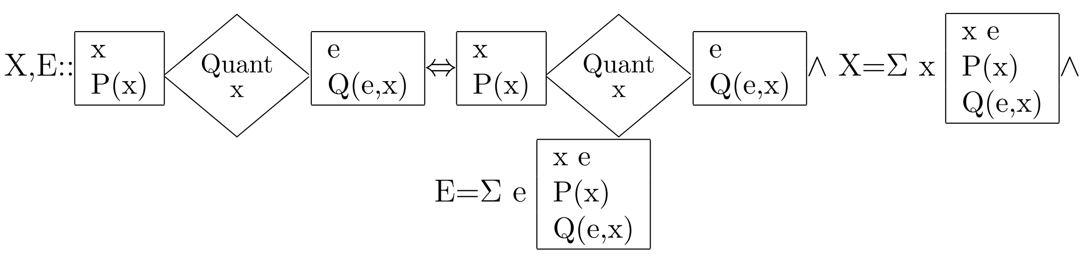


(25_{rep}.b)



With regard to duplex conditions with multiple abstractions as in (25_{rep}.a) and (25_{rep}.b), we make use of the convention that upper case DRFs sum up their lower case counterpart or the corresponding greek letter. If there is risk of confusion, we annotate the DRFs by distinguishing indices.

The abstractions of (25_{rep}.a) and (25_{rep}.b) conform to the following schema:



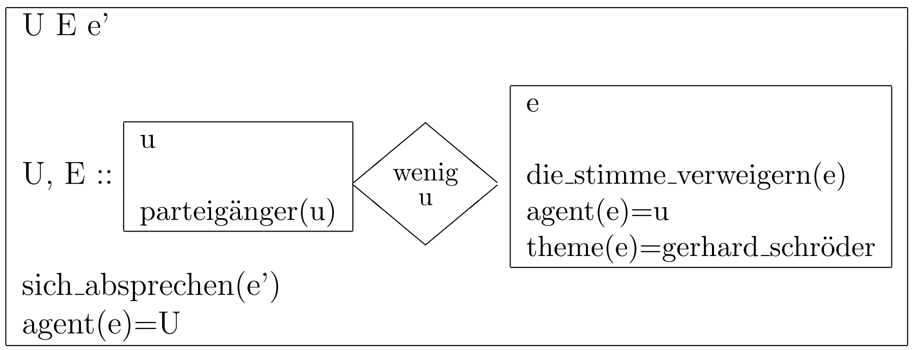
There is a problem connected to these abstractions that we have tacitly ignored in the last section, but which becomes obvious, when summing up events. Without suitable temporal restriction, we obtain wrong results, because the resulting event collection comprises all events in the past, present and future that satisfy the restrictor-scope predication, whereas the sum that is taken into account in the

being closely neighbored throughout the event (or process, to be precise), and not at the end only. If the adverbial would directly relate to a thematic role, this influence of the event type and its Aktionsart would not be adequately taken into account. But, of course, quite similarly to the case of PP-attachment, in certain syntactic constellations with adverbials which have an adjectival reading also, there might be ambiguity whether the modifier, as adverbial, modifies the VP or, as adjectival phrase, modifies some argument of the VP directly. This, however, is not relevant to the point here, which is to motivate that there are indeed cases of collective VP modification.

sentence is not this sum, but a subset of it: namely, it is the subset of these events which are located within a time which describes the present contextual temporal focus. From this overgeneration of the abstraction statement, so to speak, follows the corresponding overgeneration with regard to other abstractions. Consider the following example (26), which is built in close parallel to (22):

(26) *Wenige Parteigänger, die sich im übrigen zuvor abgesprochen hatten, verweigerten Gerhard Schröder die Stimme.*
Few party liners, who, by the way, had agreed upon this before, voted against Gerhard Schröder.

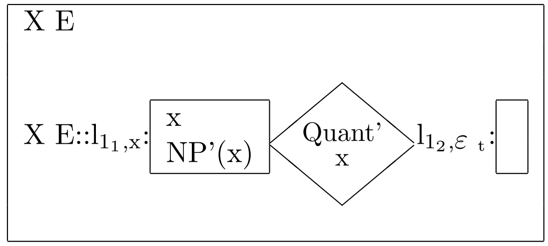
(26_{rep})



Without localizing the events, in (26_{rep}), we obtain the set of all those events where some party liner voted or will vote against Gerhard Schröder and, according to this, the set of those party liners who, **at some time** voted or will vote against Schröder. We do not obtain the smaller set of events which relate to the contextually relevant election, nor do we obtain the set of those party liners that, **at this contextually given occasion**, voted against Schröder. The bigger set of those party liners who at some time voted against Schröder is obviously not in focus and, most likely, it is not a *wenig*-subset when compared to the entire set of party liners. In addition, also most likely, it is not the set of those party liners who agreed upon voting against Schröder with respect to the one contextually relevant election. A remedy to this shortcoming consists in providing a location time for the events and restricting it to the focus time of the sentence. This focus time will be determined, i.e. resolved to a reference time provided by the context, when the sentence is incorporated into the context representation (for details of this temporal resolution see section 3.11). In order to avoid that the resolution of the focus time has to search embedded structures, we percolate the corresponding trigger (and its DRF) upwards, together with the event or event sum which it locates. We do this through a further index, namely the *result index*, which points to the distinguished event variable in case of VP representations and which, in case of DPs and VP modifiers determines the distinguished (event) referent of the resulting structures. It provides the corresponding focus time also.

Now, we are in a position to render the final indexical outcome of the semantic contribution of (quantifying) DPs:

(27) Quant NP $\longrightarrow l_{1,E_t,X,x}$:



Here, 't' is the focus time. As can be seen, it is taken from the result index of the scope specification of the duplex condition. Disambiguation of the sentence FUDRS will determine the content of this scope DRS, at the latest, and, with this, its result index (whose DRF will be included in the focus time).

Of course, as with other annotations, we may leave off the information about the focus time. Also, if not relevant we may omit the entire index information. Since the construction of NPs is quite similar to the construction of VPs, NPs and NP modifiers also show a result index (mostly without focus time since relating to individuals not events), and, of course, DP modifiers also. We postpone presenting examples of accordingly annotated representations of these classes to the corresponding parts of section 3.

2.6 Local domains, definites, indefinites and optional distributivity in UDRT

In UDRT, verbs explicitly introduce a pair of labels that mark the greatest lower bound (the *minimal label*) and the least upper bound (the *maximal label*) of the local domain that is associated with the verb representation. It is an always valid constraint of the theory that the labels of quantified verbal arguments and the labels of the VP modifiers must be ordered between these bounds – such that their representations are parts of the thus delimited substructure of the sentence representation, which is the local domain of the considered verb (see [Reyle(1993b), Frank/Reyle(1995)]).

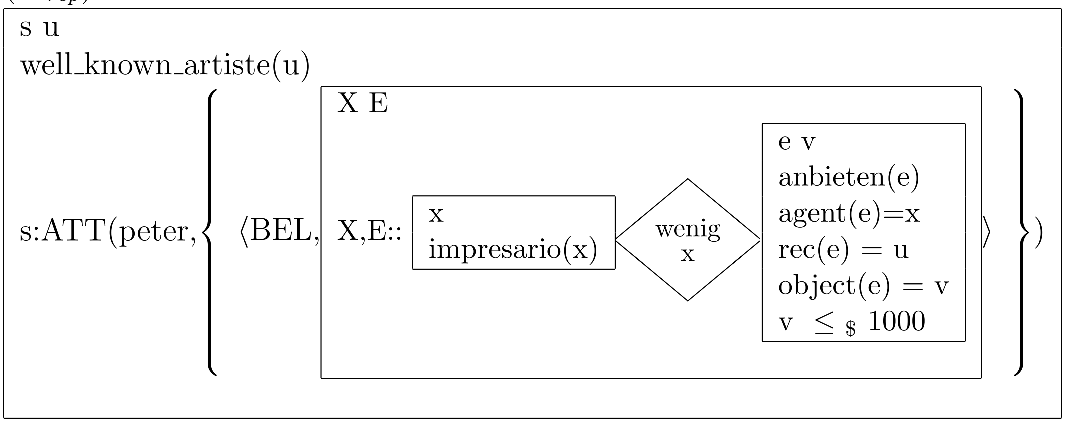
Now, as is known, definite descriptions and also indefinites (provided the *specific reading*) can behave differently. Thy can break through the boundaries set by the local domain. To be precise, they can do it in the sense that the structure that introduces the corresponding DRF and conditions about it contains this local domain as a substructure. Compare (28):

(28) *Peter glaubt, daß nur wenige Impresarios einem bekannten Artisten weniger als $ 1000 angeboten haben.*
Peter thinks that only few impresarios made an offer of less than $1000 to a well known artiste.

(28) obviously has a reading where the indefinite obtains a *de re* interpretation. UDRT treats this as a matter of scope, i.e. it assigns an existential interpre-

tation to the indefinite description and introduces the corresponding representation into the main level of the sentence representation. Using the convention of [Kamp(1995b), Kamp(2002)] for the representation of attitudinal states, we can represent the corresponding (specified) reading as follows:

(28_{rep})



According to (28_{rep}), the indefinite not only has scope over the quantified expression, it also leaves the local domain of the embedded verb and takes scope over the epistemic embedding which *think* introduces. In this specific reading, the indefinite plays the role of a so-called *runaway* (see [Reyle(1993b)]). Definites also can behave as runaways, when being used referentially. Thus, UDRT's specific compositional semantics of a sentence consists of collecting the partial representations and specifying a partial ordering of the corresponding labels such that, provided there are no further additional constraints, the labels of the verbal arguments are located within the boundaries of the verb specific local domain (and correspondingly with regard to the internal organization of noun phrases), except for representations of definites and indefinites whose scopal incorporation is restricted by the lower bound of the corresponding local verbal domain only.

We see that the problem of resolving (or accommodating) definite (and specific indefinite) descriptions is tackled by a kind of raising facility (plus equality statement with respect to the antecedent). More precisely, the fact that such (readings of) descriptions presuppose contextual antecedents which are accessible from the analyzed phrase, i.e. have wide scope with respect to this phrase as a whole, is taken as an argument for assigning them themselves wide scope with respect to the entire phrase.

There can be made an objection to this suggestion which is based on the fact that, under this assumption, assuming specificity of the description implies that optional distribution of the description must necessarily take wide scope also. Using examples like the following variant of (28) , (29) , we will try to motivate that this isn't intuitive to the consequence that UDRT's treatment of descriptions and optional distributivity should be replaced by an alternative modelling which we will suggest in the next section.

(29) *Peter glaubt, daß nur wenige Impresarios drei bekannten Artisten, Besitzer des Cirque Fatal, weniger als $1000 angeboten haben.*
Peter thinks that only few impresarios made an offer of less than $1000 to three well known artistes who are the owners of the Cirque Fatal.

(29) allows wide scope reading of the indefinite also, it even prefers it strongly because of the supplementary specifying material which has been added to the description. Also it is possible to interprete the indefinite distributively: It is very well possible that each of the three artistes is made an offer of less than $1000.

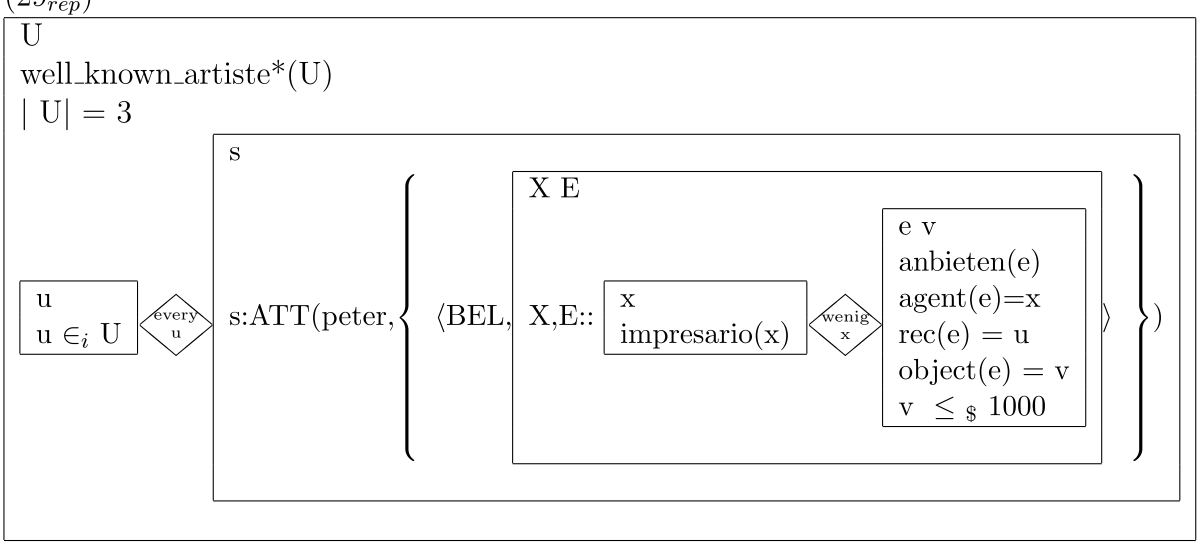
UDRT treats the ambiguity between the collective and the distributive reading of numeral DPs like *three artistes* as follows. In the first place, the contribution of the numeral consists of intersectively adding a cardinality statement to the noun predication, such that, for *three artistes*, something like the following is obtained:

l: [X | artiste*(X), |X| = 3]

At the same time, the lower referential index of this structure, as we would say, i.e. the referent that is identified as the bearer of the corresponding thematic role of the verb is stipulated to be a not further specified DRF α(X), not X. α(X) is to be seen as a functional term that can be assigned two values: X (we obtain the collective reading then) or x. In the latter case, a duplex condition is simultaneously incorporated into the structure designated by *l* that quantifies over the atomic parts x of X and takes the verb representation in its scope. In other words, the representation labelled by *l* is extended by a condition l_{1_1}: [x | x $\in_i$ X] ⟨every x⟩ l_{1_2} together with the supplementary constraint that the verb structure must be dominated by the l_{1_2}-structure.

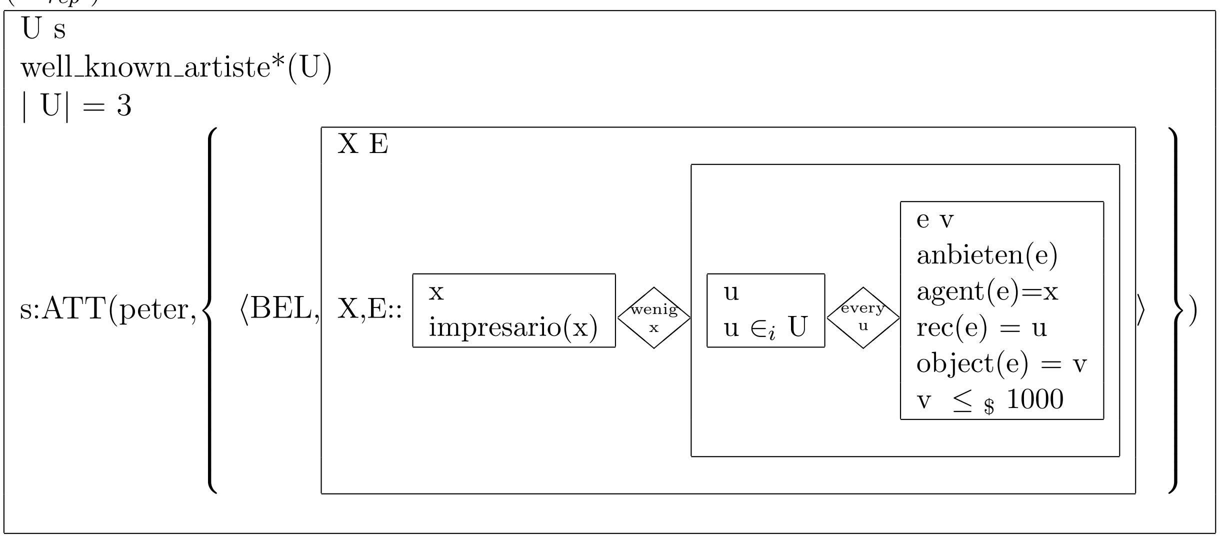
With this, we obtain the following representation for the above described reading:

(29$_{rep}$)



Note that (29_{rep}) is the only representation that can be obtained as a disambiguation from the UDRS of the sentence, provided the assumption that the artistes-DP obtains a specific and distributive interpretation. Clearly, given this assumption, (29_{rep}) is not the preferred reading. The following reading which still gives wide scope to the artistes, but which effectuates distribution within the scope of the epistemic operator, and also within the scope of the quantifier, seems to be much more natural:

(29_{rep}')



(29_{rep}') cannot be obtained within the framework of UDRT, as has been developed originally. Quite generally, UDRT fails to give a complete account of sentences with several scope bearing functors which contribute DRFs accessible from the wide scope representation level, as most definites, specific indefinites and deictic expressions do. (30) presents another (and unambiguous) example of this:

(30) *Die Kinder gaben uns jedes jeweils einen Apfel.*
The children each gave an apple to each of us.

Here, the floating quantifiers force the distributive reading of subject and indirect object, which, both, refer to wide scope accessible referents. This (unique) reading cannot be represented by the means for optional distribution that UDRT provides.

2.7 Definites, indefinites, collective and distributive readings of quantifiers - an alternative approach

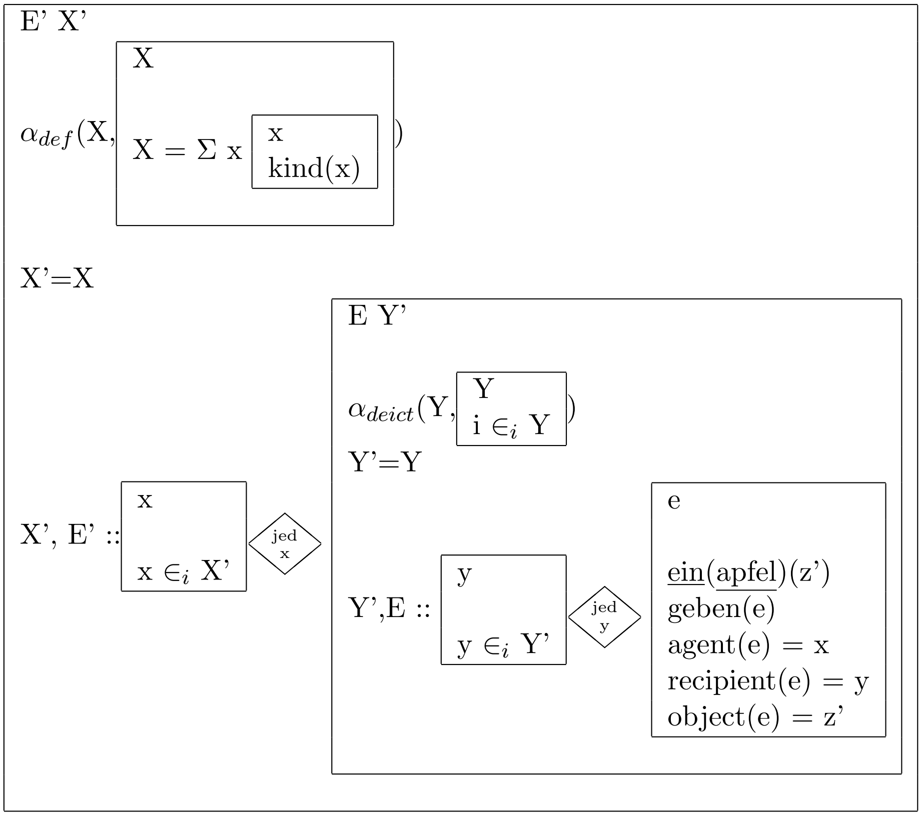
2.7.1 Presuppositions

Following considerations like [Kamp/Frey(1988)], we think that the determination of the landing site of the representation of definite and indefinite DPs is not a matter of relative scope order, in the sense that syntactic (or other) constraints that prescribe or recommend a particular scope order (the order that results from the obliqueness hierarchy of the verb arguments for example) might be overridden by a rule or tendency assigned to definite DPs to obtain wide scope, in particular by treating them as runaways and percolating their contribution upwards through the representation structure.

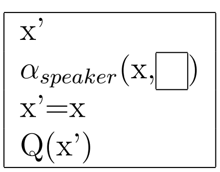
As opposed to such a 'raising by extended scrambling' treatment, we think that the definite and indefinite DPs have to be represented *in situ* say, within the local domain, where, for preferring a specific scope order. the relative syntactic position compared to the position within the obliqueness hierarchy and other criteria might exert an influence (cf. [Frey(1993), Pafel(1988)] for factors which may decide about scope order). If the description is assigned a referential meaning, this representation will contain a presupposition trigger. This trigger then has to be resolved to a contextually available and accessible antecedent or it has to be accommodated at an appropriate accessible representation level of the context, where both tasks are instances of presupposition resolution in the sense of the introduction, as inspired by van der Sandt's suggestion.

The structurally disambiguated representation of (30_{rep}) should help to make this understanding of the contribution of referential terms more precise. We represent according to what has been said in section 1.3 (omitting temporal information):

(30_{rep})



(30_{rep}) uses an α-condition for the definite as introduced in section 1.3. The type *deict* means that the trigger behaves as *deictic pronoun* and refers to parameters of the utterance situation, where, here, in particular, it must refer to a group which contains 'i', which refers to the speaker. We interprete the use of 'i' in a condition Q(i) as an abbreviation for:



i.e. for a representation which contains a presupposition trigger which refers to the speaker of the utterance (or author of the text).

(30_{rep}) claims that the representation of the subject of the sentence has scope over the indirect object which, in turn, has scope over the direct object. In particular, this means, that the distributive duplex condition as introduced by the subject has scope over the corresponding condition of the indirect object and correspondingly with respect to the place of the presupposition triggers. However, this nevertheless doesn't prevent the trigger of the deictic pronoun to be resolved or accommodated to the wide scope position. This is as wanted. Note that, in (30_{rep}), there is not yet decided about how the indefinite *einen Apfel/an apple* should be read. ein could be assigned the 'normal' existential reading of indefinites introducing a DRS

$$\begin{array}{|l|}\hline \text{z'} \\ \text{apfel(z')} \\ \hline\end{array}$$

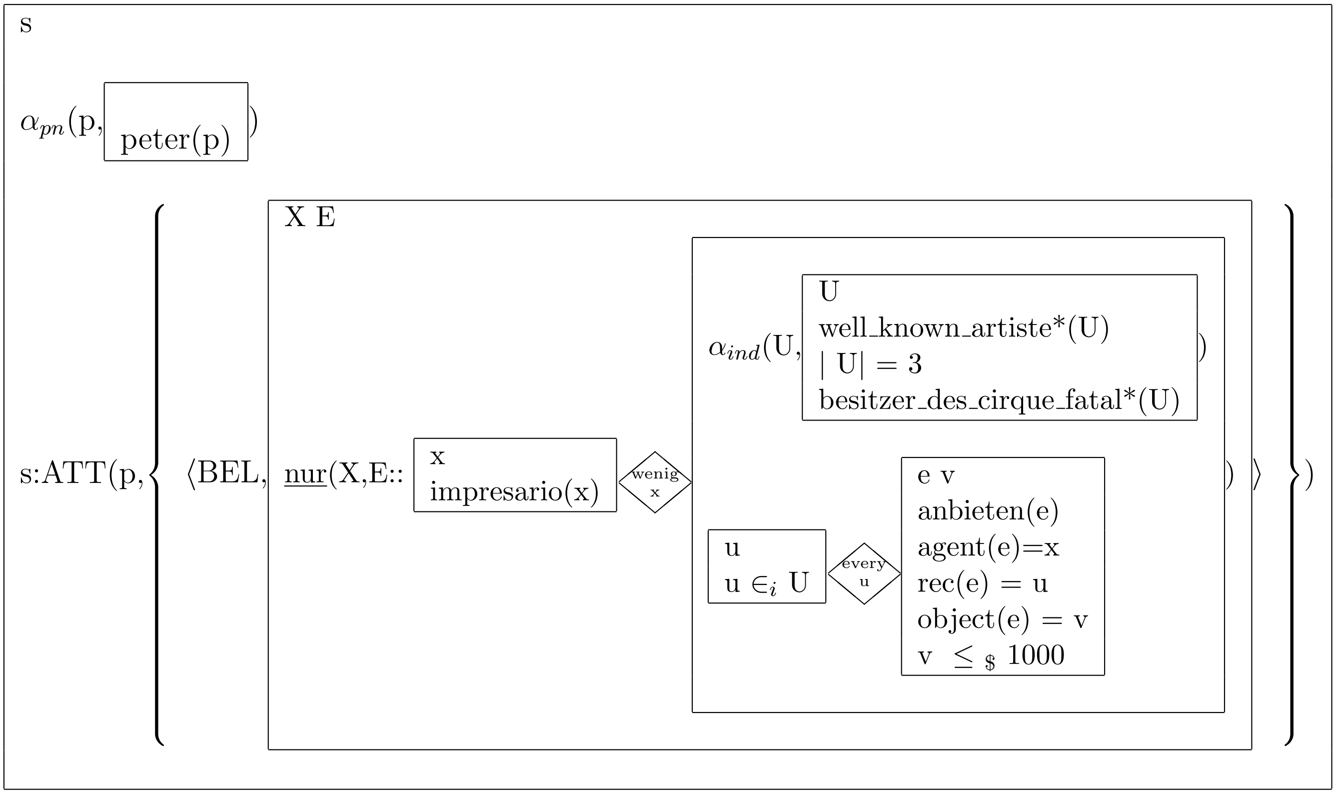
for the flat representation of the indefinite or it could be assigned a specific reading which would result in introducing a DRS

$$\begin{array}{|l|}\hline \text{z'} \\ \\ \alpha_{ind}(\text{z}, \begin{array}{|l|}\hline \text{z} \\ \text{apfel(z)} \\ \hline\end{array}) \\ \text{z'} = \text{z} \\ \hline\end{array}$$

(where, in both cases, the evaluation would be merged to the local context, i.e. would just replace the flat representation). In the latter case, the disambiguating resolution algorithm, which, as said, is kept separate from compositional semantics and its constraining of the scope order, could take from linguistic and world knowledge, that the wide scope specific reading that assumes a unique apple is not very likely for the case at hand. What is relevant with respect to this type of representing the contribution of referential terms is that assertional and presuppositional part are distinguished such that assertional distribution may be in the scope of some other scope bearing representation, though the corresponding Refset is assumed to be introduced at some wide scope position via presupposition resolution.

We can exploit this partitioning of the information in order to construct a (structurally disambiguated) representation of (29) which allows (presuppositional) disambiguation according to the desired (29_{rep}'). The following (29_{rep}") satisfies to this. (It uses the abbreviating notational convenience of section 1.3 for α-conditions, according to which, instead of introducing a new DRF and relating it to the presupposed DRF via an explicit equation statement, these DRFs are identified; it also omits representing temporal information).

(29_{rep}")



(29_{rep}”) shows narrow scope distribution with respect to the recipient, but allows wide scope resolution of the corresponding set or sum U.

Summarizing, separating the contribution of (the referential use of) definites, indefinites, pronouns and other presuppositional phrases into presuppositional triggers and assertional representations allows representing natural readings of sentences with several referential terms which may obtain distributive interpretation. We have nothing said yet, how we will represent *optional distributivity* as such. We will do this in the next section.

2.7.2 Collective and distributive readings

UDRT interpretes numerals similar to the (existential, non-specific) interpretation of the indefinite article *a*, with the one difference that they turn their argument into a plural predicate (via the operator '*'), introducing a sum, instead of an individual into the universe of the DRS (except for the numeral *one*). Basically, this representation is collective. We have seen how it is accounted for the ambiguity between collective and distributive reading by incorporating an additional duplex condition which distributes the VP representation to the members of the Refset. We don't adopt this type of modelling for two reasons. Firstly, it doesn't treat the ambiguity between collective and distributive reading by some refinement of the underspecified representation (in terms of additional ordering constraints, as is the case with respect to other structural phenomena of ambiguity or by resolving predicates into more detailed characterizations, as in the case of lexical ambiguity), but by a real add-on, which is introduced subsequently. This is a pecularity which separates the treatment of this ambiguity from all others and which we would like to avoid in favour of a treatment which is more in line with the refinement philosophy which underlies the treatment of all the other amiguities. Also, the asymmetry of the modelling doesn't seem to truly reflect the data which certainly present a more balanced picture with respect to the frequency of the two readings. Secondly, the treatment as existential indefinite article opposes numerals against quantifiers like *wenige/few* and *viele/many* which UDRT, as well as DRT, treats as generalized quantifiers (i.e. via duplex conditions), though there are several similarities: Both, numerals and such quantifiers, accept further adverbial modification by intensifiers and delimiters respectively and they accept (additional) determination by the definite article. Also, in exactly the same way as numerals have an optional distributive reading, these quantifiers have an optional collective reading. Compare (31).

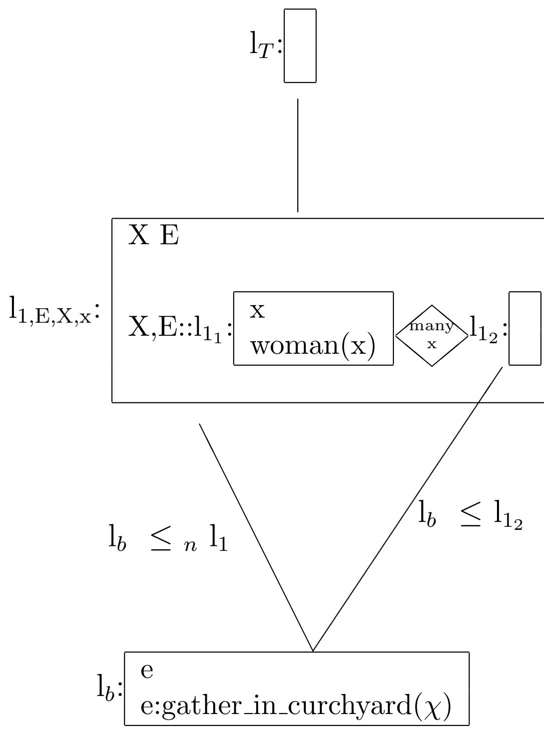
(31) *Viele Frauen versammelten sich auf dem Kirchplatz .*
Many women gathered in the churchyard.

Because of these similarities, we will try to treat these NP modifiers in close similarity, such that their adjectival properties are taken into account as well as their quantifying and determining potential. Primarily, this means to suggest a uniform representation schema which can be specified into the collective reading as well as into the distributive one, possibly with different preference, rather than different representations with casual (reciprocal) reinterpretation. (For preferences with respect to quantifier readings, see section 3.4).

For designing the schema, we have to decide whether the ambiguity is of type lexical or structural ambiguity, this means, whether it is more appropriate to model it via ordering statements or via multivalued lexical functions.

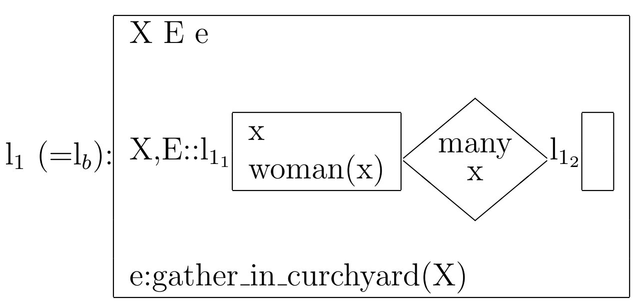
Remark that DPs like *drei Artisten, einige Impresarios, viele Künstler / three artistes, some impresarios, many etc.* are not ambiguous at all, when taken in isolation (and when considered with respect to collectivity and distributivity only). The ambiguity arises only in connection with predications, which is not surprising of course, since it is exactly this that makes up the dichotomy between distributivity and collectivity. What is relevant is the interplay between the DP and the predication. Therefore, we must model this ambiguity as a structural ambiguity. The most natural way to do this is to make it an instance of the type 'scope ambiguity'. How can we do it? Let's have a look at the example (31) and the representation of its relevant parts on the basis of the present quantifier representation as given in (27):

(31_{rep})



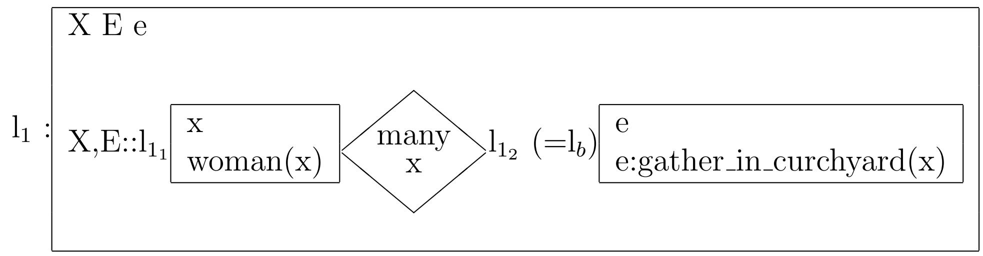
The two alternative specifications of the ordering of the partial representations as depicted by the two edges describe the two readings. In the one case, $l_b \leq_n l_1$, FUDRS-evaluation merges the VP representation to the l_1 representation. This yields the collective reading, provided χ is instantiated by X. We obtain (31_{rep_c}):

(31_{rep_c})



In the other case, $l_b \leq l_{1_2}$, the VP-representation must be located within the scope of the quantifier duplex condition. Since, with respect to sentence evaluation, there are no other partial representations between the l_{1_2}- and the l_b-representation, FUDRS-evaluation merges the VP-representation to the (empty) scope representation. This yields the distributive reading, provided χ is instantiated by x. We obtain (31_{rep_d}), which, we admit, is more than unlikely, given the collective meaning of *versammeln/gather*. However, at present, for the discussion of representational means, this is irrelevant.

(31_{rep_d})



Some remarks seem to be appropriate here. Beforehand, let us assume that in the following and throughout the rest of the text, convention is that 'L' is the representation labelled by 'l', 'L1' the one labelled by 'l1' and so forth.

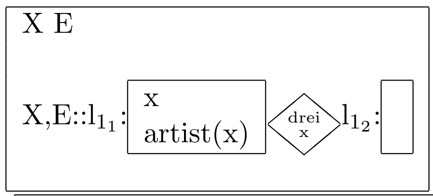
Firstly, what about the duplex condition of the so-called collective reading which shows an empty scope representation? Informally, canonical DRT model-theory tells us that the duplex condition from a generalized quantifier QU with quantified variable x is satisfied, if the set of objects of the domain of the model which, as instantiation of x, satisfy the restrictor representation, and the set of objects which additionally satisfy the scope representation are an instance of the QU-relation. Since, here, the scope is the empty constraint, this would be true for the universal quantifiers *all* and *every* only. Since we want to base the FUDRT approach onto DRT as far as possible, we don't want to modify the interpretation of duplex conditions in this respect. Instead we give up the assumption that the scope of the duplex condition is the empty DRS and assume it to be a DRS variable. This means, if FUDRT-evaluation doesn't unify it to some other DRS, for example, because the collective reading is chosen, it must instantiate it in such a way that the condition as a whole is satisfiable, on the basis of the given context. In other words, putting this new feature in terms of a slight extension of the DRT vocabulary and model-theory: A duplex condition with variable scope is verified, if the scope is instantiatable in such a way that the resulting duplex condition can be verified (on the basis of the given context). With respect to abstracting sets from duplex conditions, there is nothing specific to say to this, besides that, when evaluating the abbreviating '::'-decoration of the duplex condition into an additional condition of summation over restrictor and scope, one has to instantiate the scope description within the summation equation as a copy of the instantiation of the scope of the duplex condition in exactly the same way as is done with common duplex conditions.

A second remark. The alternative arrangements of the partial representations must be echoed by alternative decorations of the representations. In the collective case, the new result index must describe the event of the argument VP representation, whereas, in the distributive case, it must describe the sum event as is abstracted from the duplex condition. By the way, in the collective case, we will assume this set to be empty (more precisely, we will assume this sum to be the null-element of the object (semi-) lattice). Also, the (lower) referential indices must vary, according to the χ-instantiations above. We will say more to this in a minute, when defining the representations of the considered quantifiers exactly.

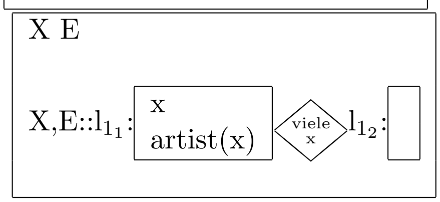
A third remark. The representation (31_{rep}) is an underspecified representation of the sentence. How should we represent the quantifier which allows this representation? We can stick to the representation type as spelled out in (27) which says nothing about the alternative orderings with respect to the DP-argument. (32) repeats this representation type applied to the sample quantifiers *drei/three* and *viele/many*):

(32)

a. Drei Artisten $\longrightarrow l_{1,E,X,x}$:



b. Viele Artisten $\longrightarrow l_{1,E,X,x}$:

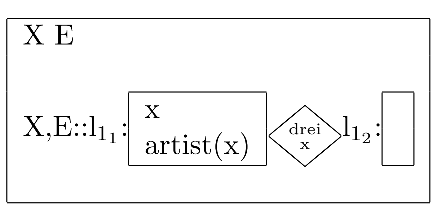


Here, compositional semantics must introduce the specific alternative possibilities of ordering and the corresponding consequences with respect to decoration, in contrast to the other quantifiers, which don't need a similiar special treatment, because of the missing ambiguity. However, on the basis of what we said in the beginning of this section, that, because of the fact that modifiers may change distinguished referents, they must have access to (sketchy) representations of their arguments, we think that the considered pecularity is not a matter of compositional semantics (a specific DP-VP-conversion), but an intrinsic quality of the DP which relates to its knowledge about what it effectuates with respect to its argument. We mean therefore, that the additional degree of freedom we are interested in requires that we explicitly introduce the argument of the DP and that the representation comes with additional ordering statements which exactly reflect the two possible configurations with respect to argument and DP scope and DP representation as a whole respectively. Formally, for the sample DPs, this yields (33).

(33)

a.

Drei Artisten $\longrightarrow l_{1,\ \underline{\text{res}}(\langle\langle E,\ ①\rangle,\langle\varepsilon\ ,②\rangle\rangle),\ X,\ \underline{\text{res}}(\langle\langle x,\ ①\rangle,\langle X\ ,②\rangle\rangle)}$:



$\{①(l \leq_n l_{1_2}) \vee ②(l \leq_n l_1)\}$
L_ε

b.

Viele Artisten $\longrightarrow l_1$, <u>res</u>(⟨⟨E, ①⟩,⟨ε ,②⟩⟩), <u>X</u>, <u>res</u>(⟨⟨x, ①⟩,⟨X ,②⟩⟩) :

X E
X,E::l_{1_1}: [x / artist(x)] ⟨viele x⟩ l_{1_2}: [ ]

$\{①(l \leq_n l_{1_2}) \vee ②(l \leq_n l_1)\}$
L_ε

As before in (27), the representation is labelled and annotated by resulting, referential and lower referential index. In addition, by convention, there are two further annotations to the right of the representation. The lower one designates the BOTTOM representation of the complete DP contribution, which is a labelled structure L . In a disambiguating FUDRS-evaluation, L will be identified to a VP semantics. The upper annotation to the right is the so-called *Oset*, the *set of ordering constraints*. By definition, the bottom representation will be always below the top representation of the functor representation. Therefore, there is no need to keep track of the corresponding label relation (which, here, is $l \leq l_1$) within Oset in general. (In (33), of course, it follows from the disjunction). Oset contains all other relational statements which specify the order of the different parts of the entire functor representation further.

In the representations of (33), Oset consists of one element only which, extending the expressivity of the ordering language of UDRT, is a disjunction of order literals, where, w.r.t. disambiguations, the relation $\leq_n$ functions as a strengthening of $\leq$ in that it disallows for intervening structures. That is, in a disambiguation that chooses $l \leq_n l_1$ (choice ②), no order is accepted that orders another label l' between l and l_1, in particular l_{1_2} cannot be placed between and similarly for l_{1_1}. Below, we will call $\leq_n$ 'anticipated equality' (which, in linearization, requires identification of the structures, where the distinguished DRF of the result is the DRF from the result index of the upper representation). In short, ② guarantees that whatever VP-representation will be unified to L, it will be merged to L_1. We obtain the collective reading this way. In contrast, according to choice ①, L will be unified to the scope of the duplex condition, which results in the distributive reading. Because of this Oset-alternative, the result index and the lower referential index cannot be assigned an unambiguous value. In case of ①, i.e. in the distributive case, the result index's referent will be the abstracted sum E and the lower referential index the x of the duplex condition. In case of ②, the scope box of the duplex condition will remain variable. We repeat what we have said about this above, that the disambiguation routine of section 5 will interpret L_{1_2} as a predicate over the lower referential referent and the abstracted E as the (dummy) empty DRF , i.e. as the empty sum. The truth conditions then will ensure that this predicate is interpreted in such a way that X is a sum that stands in the *three* relation to the sum of artistes in the (33.a)-case, that it is a sum of three artistes so, and that it is a sum that stands in the *viele* relation to the sum of artistes in the (33.b)-case, and correspondingly for other quantifiers. We use underlining in order to mark that the evaluation of the choice function *res* (for resolution) is delayed to the time where ① ∨ ② is decided.

Remark that there is an interesting difference about the interpretation of the

Refset of this type of quantifiers connected to the collective/distributive distinction: In the collective case, the Refset is built through choice of a subset from the restrictor set where the criterion of choice is the dimensional information of the quantifier seen as an intersective adjectival modifier over *-predicates only, whereas in the distributive case, the Refset is built from the information from the scope. In the first case, the scope information is guessed a posteriori so to speak, as a kind of presupposition to accommodate, providing the quantifier with the flavour of a classical existential quantifier, whereas in the second case, it is the other way round: the Refset specifies the quantifier relation so to speak (if it accords to the expectation of this relation, otherwise the assertion from the duplex condition is false, which, in the first case, never can happen). Of course, the difference is more obvious with respect to quantifiers like *viele, wenige, ...* than with respect to numerals because the contribution proper of *viele, wenige, ...* is vague, whereas the contribution of the numerals is not.

We will present further discussion about the distributive and collective reading of numerals and quantifiers in section 3.4. In particular, we will consider the reading of the numeral quantifier as specific indefinite determiner also, as rendered in (29_{rep}") . We will assume that this reading develops from the collective variant of the generalized quantifier reading through taking this representation as the defining content of the correponding α-condition and adding a supplementary distribution statement, similar to (33), in order to represent the ambiguity between collective and distributive reading in this case also. We mention that this modelling will nicely explain differences between the referential and the quantifier reading with respect to what can be entailed about the predication of the sentence.

As a last remark in this section, note that (33) represents the contribution proper of the considered type of quantifying DP in the sentence representation, not the meaning of the DP as such. The latter will show a VP representation bound by the lambda operator and the result will be a FUDRS which locates the VP representation below this contribution proper.

2.8 Labelled structures, clustering and granularity levels

In UDRT, the sentence representation is a set of labelled partial representations and a set of ordering conditions over the labels that constrain the set of possible readings that can be built from the underspecified representation. There is no additional substructuring, except for the implicit ordering expressed by the UDRT-specific representation of complex conditions like duplex conditions, negation, disjunction. In contrast, in the approach here, we try to bundle the information by designing representations of different types, where some of them are hierarchical recursive structures. The most general type of a labelled structure is called *label_s*. The typical *label_s*-representation of a sentence is a structure that,

1. bears a number (that corresponds to the label in the sense of a pointer of the original UDRT);

2. lists the representations of the subcategorized functions and modifiers (that are labelled structures themselves) in the so called *Fset* (the functor set);

3. provides ordering conditions about the set of (functor-)labels (the above introduced *Oset*);

4. represents the V semantics, which also is a labelled structure, at a distinguished position (the so called *bottom* position).

Thus, in this structure, the ordering conditions just refer to the numbers (labels) of the structures that are applied to the verb semantics. On this level, the internal structuring of a verb role or an adjunct is not visible. One obtains information about it by 'looking inside' its labelled description. In a way, one can understand this design as introducing different levels of granularity. From the sentence perspective, DPs are just points, from the DP perspective they are structures (introducing a noun phrase structure with a bottom structure that comes from the (head) noun and, possibly, with a (F)set of modifier structures, like adjective-, PP- and relative clause-structures, together with constraints (Oset) that restrict the scopal outcome in disambiguations of the DP).

We emphasize that this score keeping of the subordination constraints, which, by bundling the information, eases comprehension of the representation, is legitimated only by the proposed presuppositional treatment of what in UDRT is called 'runaway'. Without this, the expressive power of the hierarchical structuring with different levels (call them layers of granularity), where the internal structures of the elements of a level are independent of each other, would be too weak. From the standpoint of efficiency, these clusterings are very helpful. Compare for instance [Allen(1983)], where, in order to increase efficiency of retrieval, a very similar suggestion for clusterings in connection with temporal databases is suggested.

Formally, we account for this, by subclassifying *label_s* into different types. As said, some of them will be defined recursively.

First of all, we require that all labelled structures are decorated by a result index. [5] Secondly, we distinguish labelled structures whose semantic contribution is a variable, *labelvar*, from those which introduce a concrete description, *labeldescr*. Thirdly, such *labeldescr*-representations may be shaped differently: there are basic structures (typed *basic_l*) which are structurally disambiguated and saturated structures, i.e.

[5] In the appendix, on the basis of a language of feature logic using AVM notation, we will define such statements exactly via definitions like *label_s* :: [*RIND: ind*] – saying that *label_s*-structures are in the domain of a feature RIND (for result index) with values which are indices. Here, as said further above, we will do with rather sketchy semi-formal definitions and representations which, for reasons of simplicity and readabality, try to relate to classical DRT-notation as far as possible. The reader which is immediately interested in formal details is recommanded to use the appendix simultaneously therefore.

classical DRSs in the sense that the consist of a universe and a set of conditions, where this doesn't prevent the conditions from possibly containing structures which aren't basic. Thus, basic labelled structures are given the following shape:

basic labelled structure: ${}^{\text{basic\_l}}\mathrm{l}_x$:DRS,

where x, the result index, is the distinguished DRF of the representation DRS, and where DRS is a DRS that may contain complex conditions of the form L1 DRT-OPERATOR L2 or DRT-OPERATOR L1, where L1, L2 are labelled structures. A typical example of a *basic_l*-representation is the semantic contribution of a verb, as in the following:

$$\mathrm{l}_{b_e}: \boxed{\begin{array}{l} \text{e} \\ \text{kiss(e)} \\ \text{agent(e)=m} \\ \text{object(e)=w} \end{array}}$$

If a representation isn't basic nor a a variable, it must show internal structure: It must consist of different partial representations. The type of these representations, which build a subset of the *labeldescr*-representations also, is called *struct_l*). There are two ways how such representations can be structured into partial representations: They can consist of the contribution proper of a modifier (an adverbial, a quantifier etc.) and a bottom representation, where, in a disambiguation, an argument representation is unified to the bottom representation and where it depends on the Oset conditions where, in the result, this representation must be located. A typical example of such a structure, called a *pDRS labelled structure*, is a quantifier representation like (33.a). We stipulate:

pDRS labelled structure: ${}^{\text{pdrs\_l}}\mathrm{l}_{1_x}$:pDRS $^{\text{Oset}}_{\text{L}}$

We repeat that L is a DRS variable for the so-called bottom representation, where Oset defines whether its location with respect to L1 is constrained further than stipulated by the default (which says that $\mathrm{l} \leq \mathrm{l}_1$).

Oset ordering statements use the ordering symbols of ord_rel:

ord_rel = $<_s \mid \; < \mid \; \leq \mid \; \leq_n$

where, with respect to constructing a DRS from the FUDRS,
• $\mathrm{l}_1 <_s \mathrm{l}_2$ means that L1 is an immediate sub-DRS of L2 (in particular L1 and L2 cannot be merged),
where
• $\mathrm{l}_1 < \mathrm{l}_2$ means that L1 is a sub-DRS of L2 (but not necessarily an immediate sub-DRS),
where
• $\mathrm{l}_1 \leq \mathrm{l}_2$ means that L1 can be a sub-DRS of L2 or can be unified to L2 (if not prevented by some other intervening DRS) and
where

• $l_1 \leq_n l_2$ means 'anticipated equality' in the sense that, in all linearizations of the FUDRS, (the content of) L1 and L2 must be merged (and the distinguished DRF of the result is the result index of L2).

Oset consists of disjunctions of such relation literals. The annotation x is the distinguished DRF of the DRS that results from applying pDRS to the representation of L under the constraints of Oset. It may be assigned syntactic or semantic information to it, thus, providing a more complex picture of the result index it stands for.

The second type of a structured description is the *functor set* type, which we call *funct_l*. Structures of this type are just like *pdrs_l*-structures, except that, instead of one resulting representation at the top position, they show an empty top representation and a set of functors, called *Fset*. The members of Fset are labelled structures which are ordered corresponding to the constraints of Oset. As usual, the bottom value is assumed to be the minimum in each linearization of the structure. (Oset doesn't need to carry along a corresponding statement therefore). We write:

functor set labelled structure: $^{\text{funct\_l}}l1_{1_x}$: [ ] Fset Oset L ,

Here, x, the DRF of the result index, is the distinguished DRF of the DRS that results from applying the functors of Fset in an order satisfying the constraints of Oset to the respective argument representation, which, for the first functor, is L. As before, Oset uses the ordering symbols of ord_rel and allows disjunctions of literals.

Typically, functor set structures are used for representing sentences, where L represents the V contribution and where Fset collects the representations of the quantifiers and adverbials. The following representation of the sentence *Peter kissed a girl* gives an example:

$^{\text{funct\_l}}l_{e_t}$: [ ]

{ $^{\text{pdrs\_l}}l1_{e,p,p}$: [α_{name}(p, [p | peter(p)])] {l ≤ l1} L_e , $^{\text{pdrs\_l}}l1'_{e,g,g}$: [α_{ind}(g, [g | girl(g)])] {l' ≤ l1'} L'_e }

{}

$^{\text{basic\_l}}lb_e$: [e | kiss(e) agent(e)=p object(e)=g]

.

If the bottom of a structured representation is instantiated and the top is empty, as an abbreviation, we will also use the representation format that we have already made use of in the introduction (where the set of functors appears as superscript placed to the right of the bottom, to which the ordering constraints are connected by '&'), see section 1.4. Also, we may use flat representations for entire functors if the details of their representation are not relevant to the subject. For the *funct_l*-structure above, therefore, we can also write as follows:

$$\mathrm{lb}_e{:}\boxed{\begin{array}{l}\mathrm{e}\\ \mathrm{kiss(e)}\\ \mathrm{agent(e)=p}\\ \mathrm{object(e)=g}\end{array}}\left\{\begin{array}{l}\mathrm{l}_{1,p}{:}\underline{\mathrm{peter}}_p\\ \mathrm{l}_{2,g}{:}\underline{\mathrm{a}}(\underline{\mathrm{girl}})_g\end{array}\right\}\&\mathrm{OC}$$

In addition to the presented subclassification of *label_s*, we distinguish labelled structures with (upper) referential index, *refind_l*, from those without, *nrefind_l*. Quantized descriptions, which we call *qind_l*, next to result- and (upper) referential index, even show a third index, the lower referential index. Examples of quantized descriptions are DPs.

We introduce further types of structure for those parts of speech also which haven't been considered yet, which, however, are relevant and classify them with respect to the presented formal distinctions. This yields the following typology of labelled structures:

label_s	=	labelvar	|	labeldescr.
labeldescr	=	basic_l	|	struct_l.
struct_l	=	refind_l	|	nrefind_l.
refind_l	=	qind_l	|	nqind_l.
struct_l	=	pdrs_l	|	funct_l.
xtype_l	=	etype_l	|	itype_l.
itype_l	=	npsem_l	|	dpsem_l.
npsem_l	<	basicnpsem_l	|	structnpsem_l.
basicnpsem_l	<	basic_l.		
structnpsem_l	<	struct_l.		
nsem_l	<	basicnpsem_l .		
npsem_l	<	nqind_l.		
dpsem_l	<	qind_l.		
etype_l	=	vpsem_l	|	ssem_l.
vpsem_l	<	satvpsem_l	|	nsatvpsem_l.
vpsem_l	<	basicvpsem_l	|	structvpsem_l.
basicvpsem_l	<	basic_l.		
structvpsem_l	<	struct_l.		
vsem_l	<	nsatvpsem_l	&	basicvpsem_l.
vpsem_l	<	nqind_l.		

Examples of labelled variables are the bottom representations of DPs and, if present, the scope representations of the corresponding duplex conditions. In the disambiguation routine of section 5.1, which translates underspecified representations into classical DRSs, the labelled variables of the first type are place holders of the arguments of the representation. In this sense, they correspond more or less to the *holes* of the LUD approach of [Bos et al.(1994)]. As described in the last section, with respect to collective quantifiers, the variables of the second type may remain uninstantiated. We repeat that, here, we do not go into detail with attribute value notations of labelled structures and further (more specified) type definitions. This will be postponed to section A. We repeat also that the indices that decorate the labelled structures are not discourse referents as such, but structures that characterize relevant information connected to the corresponding DRF. In particular, they provide (syntactic) categorial information about the corresponding constituent. Indices are subdivided into

- I-indices (*iind*) and
- E-indices (*eind*),

where indices help to subclassify the labelled structures according to the partitioning given above: I-indices are the result indices of nouns (*nsem_l*), noun projections (*npsem_l*) and NP-modifiers and E-indices are the result indices of verbs (*vsem_l*), verb projections (*vpsem_l*) and VP-modifiers.

The partitioning of the representations which characterize objects (individuals, events and corresponding sets) into *itype_l* and *etype_l* generalizes this distinction of I-index and E-index structures, taking into account DPs on the one hand, *dpsem_l*, and sentences, *ssem_l*, on the other. Note that, in contrast to nouns and their projections, the I-index is not the result index of the DP structure. Notwithstanding, the DP characterizes an individual or set, i.e. an I-object also. This is similar with respect to VPs and sentences: though binding the E-variable by evaluating the tense conditions, the sentence, nevertheless, characterizes this E-object next to using it within the proposition. We add that, depending on the structure to be characterized, referential indices may be I- or E-indices.

Next to the information about the focus time, as given in (27), E-indices summarize information about the Aktionsart, about mood, tense and diathesis of the characterized verbal phrase. The same is true for the subclass of those I-indices which characterize event nominalizations (*enomind*). Using rather self-explanatory names for types, we obtain the following partition of the *ind* structure:

ind	=	iind | eind.
iind	=	enomind | obj_ind.
sit_ind	=	enomind | eind.

The types *mood*, *akt* (for *Aktionsart*), *diathesis* and *t_level* (for *tense level*) that are used as values of corresponding features in *sit_ind*-descriptions (situational descriptions) are subclassified as follows:

mood	=	indi | conj | imp | quest.
akt	=	hom | het.
akt	=	ext | punct.
hom	=	act | stative.
het	=	acc | ach.
diathesis	=	passive | active | res_passive.
t_level	=	past | pres | fut.

Note that we make use of Vendler's classification of Aktionsarten into *ach(ievements)*, *acc(omplishments)*, *act(ivities)* and *stative* events, i.e. *states* (see [Vendler(1967)]). In addition, we partition *akt* into *ext(ended)* and *punct(ual)* event (types) and into *het(erogeneous)* and *hom(ogeneous)* event (types), where activities and states are homogeneous and achievements and accomplishments are heterogeneous. According to the suggestions of [Kamp/Rohrer(1983), Kamp/Rohrer(1985)] among others, we assume a three dimensional tense analysis consisting of the information about the tense level (*t_level*) and boolean descriptions of progressivity and perfectivity. For further details of the *situational index* (*sit_ind*), see section 3.11.

2.9 Flat semantics

We said in the introduction that lexical items which are ambiguous will be represented by functional terms which put together the different readings in the sense that the range of this term enumerates representations of them. We said also, that these representations may contain conditions which use such terms too, such that (lexical) disambiguation can be a cascaded process. These terms have been characterized by *multivalued*, meaning that often there cannot been given exact contextual conditions which determine a specific evaluation. However, if this is the case with respect to disambiguating the FUDRS of a sentence or paragraph, the specific evaluation chosen of the term is assumed to (non-monotonically) hold with respect to all occurrences of the term within the context. We mark the unevaluated expressions by the underlining of the function symbol.

Semi-formally, we can sketch what we mean by the following schema for the evaluation of an ambiguous predicate λx.P(x). Let us assume that λx.P(x) is an ambiguous predicate from a noun and may mean λx.P1(x), λx.P2(x), λx.P3(x) or λ.P4(x) and that in the first two cases there is some clear idea about the circumstances which disambiguate the predicate respectively, in the latter two cases not. We will write then:
$\underline{\text{P}}$: ind $\Rightarrow$nsem_l

$\underline{\text{P}}$(x) = P1(x), if C1
$\underline{\text{P}}$(x) = P2(x), if C2
$\underline{\text{P}}$(x) = P3(x), (if ?C3)
$\underline{\text{P}}$(x) = P3(x), (if ?C4)

This says, P is a function from indices into representations of type *nsem_l*, where, if the context is known to be an instance of the context description C1, $\underline{\text{P}}$ means P1 and correspondingly with respect to C2 and P2. P3 and P4 don't show such disambiguation conditions: the corresponding contextual descriptions are variables. The conditions may be complex descriptions of information states or they may be simple, as the ones that we will give in the next section with respect to the prototypical ambiguous *Bank*, that we discussed in the introduction already, where we base the disambiguation on sortal knowledge about the argument: If the DRF is of type FURNITURE, the predicate is assigned the bench-representation, if the DRF is of type INSTITUTION, the predicate is assigned the financial institution-representation etc. With respect to evaluating the term without contextual justification, we try to adapt common assumptions of non-monotonic reasoning to the considered scenario. Primarily, this relates to revision. When a predicate is evaluated without concrete justification, we assume its context (the surrounding representation) to provide the justification (without that the knowledge engineer knows how). Applied to P3, this means that ?C3 is instantiated by the corresponding $\underline{\text{P}}$-context. With respect to a later occurrence, we will assume the same evaluation then, because the context of this occurrence contains the context of the first one, which, at present is seen as a substantial disambiguation criterion in the sense of P3. If we learn, however, that this later $\underline{\text{P}}$-occurrence cannot be P3, but must be P4, (by some entailment from the (recent) context) we must revise the conclusions about justifying critera and we will restrict the ?C3 context such that it doesn't contain the parts which justify P4 and will add these parts as instantiation of ?C4.

Three comments about this setting. Firstly, it is clear that the non-monotonic project sketched here is in line with the abduction approach, as suggested firstly in [Hobbs et al.(1993)]. We decided to relate to this approach of reasoning for the lexical ambiguity subject, because of its very nice logical properties and its elegant simplicity.

Secondly, the approach easily allows to design the functions in such a way that the explanations (in terms of abduction theory) of the values of the function, i.e. the contextual C-constraints, can be interpreted additionally as conditions which trigger evaluation. This shall mean that, under this perspective, evaluation is delayed till some triggering condition is satisfied and, then, executed without further interaction by the user of the system. [6]

Thirdly, a priori, there is no need to assign more than one value to the functional terms or, to turn it a bit differently, there is no need to evaluate them at all, provided they, as such, can obtain an interpretation which, type-theoretically, satisfies the expectation about the values of the term. Thus, the approach supports common strategies of software engineeering: The user of the system is free to revise the definitions of the lexical functions, to simplify them, to rearrange them or to extend them, depending on the purposes he or she has, without that there would be any need for revising the system as a whole, or even for to know details of the system

[6] Sample implementations of the theory that have been made in the middle of the nineties on the basis of the grammar formalism CUF (categorial unification formalism, cf. [Dörre/Dorna(1989)]), which provided such a feature, showed very encouraging results, CUF and its successors provide a so-called *wait*-statement, which allows to mark evaluations of CUF-sorts (i.e. functions) to be delayed to a state of the system in which the arguments of the sort are known to satisfy the specific conditions of the corresponding wait declaration. Section A documents a CUF implementation of the suggested semantics. See section A.4 for problems that are connected to this solution via wait statements. Note that some Prolog-dialects know a corresponding 'freeze'-statement and other programming languages too.

the user, the lexicographer, is not concerned with. In short, the approach is very modular in this respect and modules for lexical evaluation can be changed or can be exchanged for each other easily.

An example of this type of representation is also the delayed resolution of index information as introduced via res in the last section. Here, the triggering information is to know whether ordering constraint ① or ② holds (see section 2.7.2 above). It goes without saying that this design of flattend representations which allow for being worked out or 'unfolded' into deeper semantics, which, in turn, may be worked out further and so on, very closely relates to (and is inspired by) the perspective on granularity as presented in [Hobbs(1985a)]. In this vein, we can imagine an architecture of the semantics that connects linguistic and world knowledge to the lexical items such that different degrees of the semantic evaluation of the lexical terms may come with particular background theories of different granularity. In this scenario, for example, non further evaluated bank(x) may stand for an unambiguous relational expression against the background of a world that does not know the distinction of seats, institutions etc. It would be only through the transition to a more fine-grained representation that the background theory would be 'articulated' (Hobbs' term) into a more detailed theory that describes worlds that know such differences. Conversely, the term becomes ambiguous only against a background theory which is more articulated. Of course, spelling out the logic of the different semantic layers and the transitions via articulation and the opposite 'simplification' are the objective and ambition of a future project.

Chapter 3

Fragment

In section 3.1, we present the semantic typology of the parts of speech that we will investigate in the rest of this section. These investigations should direct the reader's attention to the existence of relevant subclasses and will result into specific representational accounts of the considered phenomena. This also should present a motivation for the design of the different macros that we introduce in section A in connection with the incorporation of the described semantics into a HPSG grammar for German.

3.1 Semantic types

The following taxonomy of semantic types,*sem_t*, spans the range of parts of speech that we will consider in the following sections and makes the distinctions which we think to be indispensable with respect to representations using the types of labelled structures introduced in sectionlabel.

```
sem_t          =   detorquant_t | xtype_t | mod_xtype_t | compssem_t | prepsem_t |
                   relpro_t | complementizer_t | funcmod_t | coord_t | subord_t.

detorquant_t   =   detsem_t | quantop_t.

xtype_t        =   itype_t | etype_t.
etype_t        =   vpsem_t | ssem_t.
itype_t        =   npsem_t | dpsem_t.
npsem_t        =   basicnsem_t | structnpsem_t.
nsem_t         <   basicnpsem_t .
vpsem_t        =   basicvpsem_t | structvpsem_t.
basicvpsem_t   >   vsem_t | cop_t.

mod_xtype_t    =   mod_itype_t | mod_etype_t.
mod_xtype_t    =   ppsem_t | nppmod_xtype_t.
mod_itype_t    =   mod_npsem_t | mod_dpsem_t.
mod_etype_t    =   mod_vpsem_t | mod_ssem_t.
mod_npsem_t    =   pred_mod_npsem_t | npred_mod_npsem_t.
funcmod_t              =   quantop_modifier_t | mod_xtype_modifier_t.
mod_xtype_modifier_t   =   mod_npsem_modifier_t | mod_vpsem_modifier_t.

coord_t                =   npcoord_t | dpcoord_t | vpcoord_t.
```

Thus, we will consider *determiners* and *quantifiers*, *Xtypes*, which are either *Itypes* or *Etypes*, where *Itypes* subsume *NPsem* types (representations of noun projections) and *DPsem* types (representations of DPs) and where *Etypes* subsume *VPsem* types (representations of verb projections) and *Ssem* types (representations of saturated verb projections with resolved tense information). We will consider the corresponding Xtype modifiers, where we make a distinction between modifiers which are prepositional phrases (*PPsem* types) and those that are not, and where, with regard to NPsem modifiers, we distinguish the modifiers that can be used predicatively from those that cannot. In addition, we will consider *complement sentences* and corresponding *complementizers*. We will consider *prepositions*, *relative pronouns*, a restricted set of *coordinations*, *subordinations* and a number of *modifiers of quantifiers and modifiers*. We will introduce further types, when appropriate.

As can be seen, we make a distinction between the representations of nouns and noun projections. This is convenient with regard to assumptions about the internal structure of the corresponding labelled structures (nouns will introduce basic labelled structures, whereas noun projections – without supplementary structural simplification via disambiguation – will be assigned *struct_l* structures). This is similar in the case of VP representations. Here, in addition, we provide a subtype for the copula.

In order to have available a common format for functors and saturated representations of parts of speech, we assume that all semantic types are assigned a *lambda prefix*, λ, and a *result*, RES), where the former is a (possibly empty) list of those DRFs (presented by the corresponding indices) and representations (labelled structures) which the considered item consumes and where the latter is a semantic type or a labelled structure. For this, we stipulate:

$$\text{sem\_t} \quad < \quad \begin{bmatrix} \lambda: & \text{list(ind ; label\_s)} \\ \text{RES:} & \text{(label\_s ; sem\_t)} \end{bmatrix}$$

One might ask what the relation is between *sem_t* and *label_s* representations, in particular, what the difference is between lambda operators of *sem_t*-structures and variable bottom structures of *label_s*-representations and whether these distinctions are necessary. In our theory, application of a DP, say, to a VP means that the DP representation is ordered with respect to the VP representation, but not, in case the DP introduces a duplex condition, that the VP representation is unified to the scope of this condition, as in classical DRT. This latter kind of application (or another) is postponed until disambiguation takes place (see section 5.1 for this). Therefore, after FUDRT-application of the DP, the DP contribution proper still exists, and, thus, still shows a variable (bottom) VP argument, i.e. a VP labelled variable structure, in contrast to classical (DRT-)composition. We use, so to speak, two layers: the one handles the composition of sem_t structures into underspecified structures, i.e. into labelled structures. The other treats the development of possible readings from the labelled structures which are the results of the compositional process. The first relates to the level of *sem_t*, the second to the level of *label_s*. Anticipating the working out of the composition rules in section ??, we can illustrate this 'two-level-compositionality', applied to a simplified DP-representation of the type of the quantifying sample (33) and to some VP-representation, as follows:

The DP as such is represented by something like:

$$\text{dpsem\_t} \begin{bmatrix} \lambda: & \langle\rangle \\ \text{RES:} & \text{l}_{1,\_,\_,I_x} : \boxed{\begin{array}{l} \ldots \\ \text{RESTR} \diamond \ldots \diamond \text{l}_{1_2}\text{:SCOPE} \end{array}} \begin{array}{l} \{①(\text{l} \leq_n \text{l}_{1_2}) \vee ②(\text{l} \leq_n \text{l}_1)\} \\ \text{L}_\varepsilon \end{array} \end{bmatrix}$$

The VP obtains a representation as follows (provided it is neither a verb nor a VP where the functors, via linearization and reduction, have been applied already):

$$\text{structvpsem\_t} \begin{bmatrix} \lambda: & \langle I_x | \text{ IL}\rangle \\ \text{RES:} & \text{LV}^{\{\text{F1},\ldots,\text{Fn}\}\&OC} \end{bmatrix}$$

Composition will add the DP contribution proper, which is the value of the RES-feature of the DP-representation, as a further element to the functors of the VP-representation, with or without introducing further constraints to VP's Oset, which, here, is OC. Assume there is no such constraint inferable from the specific syntactic structure, then we will obtain:

$$\text{structvpsem\_t}\begin{bmatrix} \lambda: & \langle \text{IL} \rangle \\ \text{RES:} & \text{LV}\{\text{F1},\ldots,\text{Fn, L1}\}_{\&OC} \end{bmatrix}$$

We see that the result of composition is a structured VP representation which develops from the original VP representation by stripping off the x-index from the lambda prefix (thereby executing the corresponding unifications correctly) and by adding the DP-contribution L1 to the set of functors of the VP. We see that composition doesn't alter the 'verbal argument', so to speak, of the DP, which is its (still uninstantiated) 'bottom' representation L. L will be instantiated only when local linearization identifies this argument and corresponding structural reduction is executed.

3.2 Nouns

We consider predicative (one-place) common nouns and relational common nouns, that subcategorize for one or more nominal roles. An example of the first type is a noun like *Sessel/armchair*. *Freund / friend*, which subcategorizes for a genitive DP or a von-PP, is an example of the second type. A subclass are event nominalizations, where we distinguish between different Aktionsart patterns (*hom* for *homogeneous* and *het* for *heterogeneous*):

$$\text{Sessel} \longrightarrow \text{nsem\_t}\begin{bmatrix} \lambda: & \langle\rangle \\ \text{RES:} & {}^{nsem\_l}\text{l}_x\text{:}\boxed{\begin{array}{l}\text{x @ furn}\\ \text{sessel(x)}\end{array}} \end{bmatrix}$$

$$\text{Freund} \longrightarrow \text{nsem\_t}\begin{bmatrix} \lambda: & \langle \chi_{GenDP;vonPP} \rangle \\ \text{RES:} & {}^{nsem\_l}\text{l}_x\text{:}\boxed{\begin{array}{l}\text{x @ human}\\ \text{freund(x)}\\ \text{freund\_von(x,}\chi\text{)}\end{array}} \end{bmatrix}$$

$$\text{Fahrt} \longrightarrow \text{nsem\_t}\begin{bmatrix} \lambda: & \langle \chi_{GenDP;vonPP} \rangle \\ \text{RES:} & {}^{nsem\_l}\ \text{l}_{e_{het}}\text{:}\boxed{\begin{array}{l}\text{e @ event}\\ \text{fahrt(e)}\\ \text{agent}_{const}\text{(e)=}\chi\end{array}} \end{bmatrix}$$

$$\text{Fahren} \longrightarrow \text{nsem\_t}\begin{bmatrix} \lambda: & \langle \chi_{GenDP;vonPP} \rangle \\ \text{RES:} & {}^{nsem\_l}\ \text{l}_{e_{hom}}\text{:}\boxed{\begin{array}{l}\text{e @ process}\\ \text{fahren(e)}\\ \text{agent}_{const}\text{(e)=}\chi\end{array}} \end{bmatrix}$$

The representations should be rather self-explanatory on the basis of what has been said so far. It should be clear that for most relational nouns and nominalizations the subcategorized roles, syntactically, are not obligatory but optional. In case the sentence does not realize such a role the corresponding DRF in the representation should be marked as non accessible for pronominal resolution. We omit the handling of such details here and in the following. The index of verb nominalizations provide an Aktionsart feature like the E-index does (therefore, we have introduced the *sit_ind*-type and its *enomind*-subtype). We will come back to the assignment of Aktionsarten (and to annotations of thematic roles like *const*) in greater detail in sections 3.11 and 5.1. (However, see also the next section for this). Note that not all nominalizations are of the type relational noun. The (admittedly small) class of nominalizations of 0-place verbs, which. grosso modo, are identical to the weather verbs, have an empty λ-list.

There are ambiguous nouns. As mentioned further above in section 2.9, *Bank (bank)* can relate to a seat, a work bench or a banking house among other things. We have introduced the means of functional terms, in order to treat such cases of lexical ambiguity. For *Bank* we obtain the following:

$$\text{Bank} \longrightarrow \text{nsem\_t} \begin{bmatrix} \lambda: & \langle\rangle \\ \text{RES:} & \underline{\text{bank}}(\text{x}) \end{bmatrix}$$

The assumption is that this is the complete representation that we find in the semantic lexicon for *Bank*, but that there is a separate knowledge base which provides the definition of such functional terms (possibly equipped with corresponding triggering conditions). A possible definition reads as follows:

$\underline{\text{bank}}(\text{ref}) \Rightarrow \text{nsem\_l}$

$\underline{\text{bank}}(\text{x @ seat}) := \text{l}_x\text{:}\boxed{\begin{array}{l}\text{x}\\ \text{bank1(x)}\end{array}}$

$\underline{\text{bank}}(\text{x @ workbench}) := \text{l}_x\text{:}\boxed{\begin{array}{l}\text{x}\\ \text{bank2(x)}\end{array}}$

$\underline{\text{bank}}(\text{x @ institution}) := \text{l}_x\text{:}\boxed{\begin{array}{l}\text{x}\\ \text{bank3(x)}\end{array}}$

Here, the disambiguating context is just respective sortal knowledge about the DRF. In this example, we have tacitly assumed that DRFs show implicit sorting, which comes as value of a feature SORT that is defined for DRFs and which, in the representations, is abbreviated by '@'. The precise specification of the formal means of the theory in section A will account for this.

As mentioned in section 2.9, the respective contextual requirements of the different readings (or parts of them) can be seen as evaluation triggers. If, with respect to this example, we do so, a corresponding implementation (in the CUF environment) could have the following shape:

wait(($\underline{\text{bank}}$(SORT: seat) $\rightarrow$_)).
wait(($\underline{\text{bank}}$(SORT: workbench) $\rightarrow$_)).

wait(($\underline{\text{bank}}$(SORT: institution) $\rightarrow_{\_}$)).

Similar are examples like *Birne* or *Strom* etc. where the reading is known, if the sort of the DRF is known, provided some common every day sort hierarchy, which is not too coarse-grained (where we obtain *pear* for *Birne*, if the DRF is *food* or *bulb*, if it is *instr* and *river* for *Strom*, if the DRF is *water* or *current*, if it is *electric*).

We have also mentioned that transitions to deeper analyses may be controlled by more complex contextual assumptions. Generally, if we want to make transparent the sensitivity of the term for some (type of) contextual constraint C, we will add this constraint (which marks relevant lexical 'articulation') as a corresponding argument. We do this as follows: $\underline{\text{bank}}$(x) $\triangle$ C.

We stick to the functional term representation even in cases where, at least for the purposes of this paper, we can assume that the term is not ambiguous. Altogether, this allows for simpler representations and for keeping separate the information which is type-theoretically relevant for the local context (information about the type and decoration) from the details about the contribution proper, which means that, besides contributing to efficient system design, this modularization should contribute to supporting comprehensibility of the representations also. Therefore, throughout the rest of this paper, the RES-value of a semantic type always introduces a functional term which is defined separately.

There are some problems connected to lexical ambiguity in connection with subcategorized roles:

Subcategorization may depend on the lexical meaning of the item. For example, *Mann* can be short for *Ehemann*, which means *husband*, in which case it is relational and subcategorizes for a genitive-DP or von-PP or it can mean *man*, in which case the subcategorization frame is empty. (Of course, the case is much more frequent with respect to verbs). Assuming empty instantiations, we can treat this problem within the formalism as is, where empty instantiation means that the corresponding role cannot be filled in the sentence (or by resolution in the sense of zero-anaphora). The representation of *Mann* below uses this feature. If we do not start out from such an assumption, we must provide different flat representations for the same word in this case. Note that we must do this anyway with respect to syntactically different subcategorization frames (provided the factorized disjunctive description entails disjuncts which aren't allowed).

$$\text{Mann} \longrightarrow \text{nsem\_t} \begin{bmatrix} \lambda\text{:} & \langle \chi_{GenDP;vonPP} \rangle \\ \text{RES:} & \underline{\text{mann}}(\text{x},\chi) \end{bmatrix}$$

where:

$\underline{\text{mann}}$(ref,ref) $\Rightarrow$nsem_l

$$\underline{\text{mann}}(\text{x},\emptyset) := \text{l}_x\text{:}\boxed{\begin{array}{l} \text{x @ human \& male} \\ \text{mann(x)} \end{array}}$$

$\underline{\text{mann}}(x,y) := l_x$: [x @ human & male | ehemann(x) | ehemann_von(x,χ)]

It may be that it is not clear which role is filled by some modifier of the head. In (34), it is not clear whether Peter is the agent or the source of the movement.

(34) *Die Fahrt von Peter in die Stadt.*
The drive of/from Peter to the city.

Since, here, we cannot treat syntactic underspecification except for functional underspecification in the sense as is considerd in section 1.2, we must assume that syntactic analysis determines whether *Peter* fills the genitive-DP/von-PP-role of *Fahrt* or not. If it does, in accordance with the representation of *Fahrt* above, it can be entailed that Peter is the agent, if it does not, it can be entailed that it is **not** the agent. Depending on the stipulations about the preposition *von* (and the fact that there is another PP which can be read as *goal*), we might infer then, that Peter is the source of the drive. If, in contrast to our definition of *Fahrt*, we assume that there is more than one role which can be realized by a von-PP (one for the agent and one for the source), we are still confronted with an ambiguity which is decided by the syntactic analysis, since the instantiation of the arguments by the (lower) distinguished DRFs of the complements is executed by the syntax-semantics-interface. By the way, we assume that localization roles like *source* and *goal* aren't subcategorized normally (since their prepositions normally show enough intrinsic information about the type of modification) , unless the phrase without the corresponding information sounds really odd.

Remains the case where it is clear which argument is instantiated by some complement, where, however, it is not clear, which role the corresponding DRF plays exactly with respect to the DRF from the head. But this is the case described in 1.2: It is a matter of assigning elaborated representations to the flat representation which refine the meaning of the relations to the arguments also, depending on some specific contextual constraint or not and possibly with respect to more than one such argument relation.

3.3 Verbs I

We distinguish *relational verbs* from *embedding verbs*, where, by the latter, we understand verbs whose representation takes the entire representation of a verbal argument (or of several arguments) into the scope of an embedding operator. Examples are modal verbs (*müssen / to have to*, *können / to be able to*, *dürfen / to be allowed to* etc.), also the copula and others.

In the following, we analyze relational verbs, i.e. verbs that introduce relations whose arguments are the DRFs of the lower referential indices of the verb arguments (for the embedding verbs, see 3.9). In particular, we document the semantic contribution of representatives of different Aktionsart classes with different valency patterns:

fahren$\longrightarrow$vsem_t $\begin{bmatrix} \lambda: & \langle \chi_{NomDP} \rangle \\ \text{RES:} & \underline{\text{fahren}}(\text{e},\chi) \end{bmatrix}$

$\underline{\text{fahren}}$(ind,ind) $\Rightarrow$vsem_l

$\underline{\text{fahren}}(\text{e},\chi) := \text{l}_{e_{t,hom}}$:

e @ process
fahren(e)
$\text{agent}_{const}(\text{e})=\chi$
$\text{e} \subseteq \text{t}$

geben $\longrightarrow$vsem_t $\begin{bmatrix} \lambda: & \langle \chi_{NomDP},\, \xi_{AccDP},\, \zeta_{DatDP} \rangle \\ \text{RES:} & \underline{\text{geben}}(\text{e},\chi,\xi,\zeta) \end{bmatrix}$

$\underline{\text{geben}}$(ind,ind,ind,ind) $\Rightarrow$vsem_l

$\underline{\text{geben}}(\text{e},\chi,\xi,\zeta) := \text{l}_{e_{t,het}}$:

e @ event
geben(e)
$\text{agent}_{const}(\text{e})=\chi$
$\text{object}_{char}(\text{e})=\xi$
$\text{rec}_{const}(\text{e})=\zeta$
$\text{e} \subseteq \text{t}$

essen $\longrightarrow$vsem_t $\begin{bmatrix} \lambda: & \langle \chi_{NomDP},\, \xi_{AccDP} \rangle \\ \text{RES:} & \underline{\text{essen}}(\text{e},\chi,\xi) \end{bmatrix}$

$\underline{\text{essen}}$(ind,ind,ind) $\Rightarrow$vsem_l

$\underline{\text{essen}}(\text{e},\chi,\xi) := \text{l}_{e_{t,het}}$:

e @ process
essen(e)
$\text{agent}_{const}(\text{e}) = \chi$ @ human*
$\text{object}_{grad}(\text{e}) = \xi$ @ food*
$\text{e} \subseteq \text{t}$

We see that the verb entry identifies the referential arguments of the subcategorized grammatical functions as the bearers of the thematic roles that are introduced by the verb. Besides this linking, the thematic roles are classified (by the subscripts *const, char, grad*) along the lines of the Aktionsart theory developed in [Eberle(1991a)] and [Eberle(1998)] (where *const* means that the bearer of the corresponding role is *constantly* present during the entire event, process or state, where *grad* means that it is *gradually* present – i.e. it is consumed or created, and where *char* means that it is *characteristic* for the event – i.e. some change of state is connected to it). In addition, the result index of the verb, more precisely the event type that is introduced by the verb, is assigned a specific Aktionsart class. This information is part of the verb index. In section 3.11 we will sketch how from this and the information about the thematic roles the Aktionsart of the sentence is computed. Also, the focus time *t* is part of the verb index. It localizes the distinguished DRF via a condition of inclusion and it will be identified to a contextually available reference time through temporal resolution (see section 2.5.3 for the motivation of this, also section 3.11). It must be emphasized that an additional feature of the linking is the selectional restriction that the verb predicts for the roles via sortal specification. The entry for *essen*, for instance, claims the bearer of the object role (i.e. the distinguished DRF of the subcategorized accusative DP) to be an instance of the *food**- sort. Here, of course, the operator '*' is just an extension of Link's '*'-operator to sorts. Generalizing what we have said in section 2.5.2 with respect to its impact on predicates, we assume that, when applied to a predicate or sort P, it returns a predicate or sort P* that, besides the instances of P, denotes the sums that can be built from P-instances. [1]

Verbs like *sich versammeln / meet* require that the bearer of a thematic role be a collection. With respect to *sich versammeln*, it is the agent. This constraint can be expressed by sortal restriction also, viz. the following entry:

$$\text{sich\_versammeln} \longrightarrow \text{vsem\_t} \begin{bmatrix} \lambda\text{:} & \langle \chi_{NomDP} \rangle \\ \text{RES:} & \underline{\text{sich\_versammeln}}(\text{e},\chi) \end{bmatrix}$$

$\underline{\text{sich\_versammeln}}(\text{ind},\text{ind}) \Rightarrow \text{vsem\_l}$

$$\underline{\text{sich\_versammeln}}(\text{e},\chi) := \text{l}_{e_{t,het}}: \boxed{\begin{array}{l} \text{e @ event} \\ \\ \text{sich\_versammeln(e)} \\ \text{agent}_{const}(\text{e}) = \chi \text{ @ (object}^{+} \text{ ; group)} \\ \text{e} \subseteq \text{t} \end{array}}$$

Here, we use '+' according to the definition: '$P^+ = P^* - P$', where P is a predicate (or sort) of atoms. I.e. the corresponding predicate (sort) holds for proper sums only. *group* subsumes objects like *football team* which are single objects, but to which, nevertheless, a set of members is assigned.

The opposite case – the stipulation that the bearer of the role be an atomic object - seems less frequent. In a number of cases that apparently prescribe such a restriction, *sterben / to die* is often mentioned as an example of a *distributive verb*, we nevertheless observe collective readings. (Here and in the following we understand by the *collective reading* of a complex event description not solely simultaneous occurrence of acts associated with the partaking individuals, but something like a *gestalt* that is more than the sum of the thus defined spatio-temporal parts of the described eventuality). Often such collective readings are forced or made explicit by adverbs like *zusammen*. Thus, though *Philemon und Baucis starben zusammen / Philemon and Baucis died together* says that there is a dying of Philemon and a more or less simultaneous dying of Baucis, this is not the whole story. There is a reading which says that, in addition, they did it related to each other by some collective quality, by desire, by love, by solidarity say. Of course, as is illustrated by this example, from the collective reading of a distributive verb (if this reading is possible at all), we can infer the corresponding verb-predications for the members of the characterized sum. However, the conjunction of these predications, as said,

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[1] We repeat that with respect to summation and the conception of spatio-temporal relations and corresponding interpreting structures, the approach is based upon the integrated axiomatization and interpretation suggested in the mentioned [Eberle(1991a)].

doesn't make up the entire assertion of the sentence in this case. Since it is not easy to spell out what the essence is of this additional quality of a collective predication which uses a verb, which otherwise is distributive and since such predication seems possible nearly always, we skip working out the lexical semantics in this respect of distributivity and collectivity any further. Instead, we conclude this section with an example of an ambiguous verb that is assigned a flat semantics that can be disambiguated by sortal information, similarly to the case of the nouns *Bank, Birne, Strom*. (The sorts used here and throughout the chapter stem from the sample domain sort hierarchy of section A.1):

$$\text{auftreten} \longrightarrow \text{vsem\_t} \begin{bmatrix} \lambda: & \langle \chi_{NomNP} \rangle \\ \text{RES:} & \underline{\text{auftreten}}(\text{e},\chi) \end{bmatrix}$$

$$\underline{\text{auftreten}}(\text{ind},\text{ind}) \Rightarrow \text{vsem\_l}$$

$$\underline{\text{auftreten}}(\text{e @ cultural},\chi \text{ @ animal0*}) := {}^{vsem\_l}\text{l}_{e_{t,het}}\text{:} \boxed{\begin{array}{l} \text{e} \\ \\ \text{auftreten1(e)} \\ \text{agens}_{const}(\text{e})=\chi \\ \text{e} \subseteq \text{t} \end{array}}$$

(*im Theater auftreten / appear at the theatre*)

$$\underline{\text{auftreten}}(\text{e @ natural},\chi \text{ @ animal0*}) := {}^{vsem\_l}\text{l}_{e_{t,het}}\text{:} \boxed{\begin{array}{l} \text{e} \\ \\ \text{auftreten2(e)} \\ \text{agens}_{const}(\text{e})=\chi \\ \text{e} \subseteq \text{t} \end{array}}$$

(*auf das Bein auftreten / to step onto*)

$$\underline{\text{auftreten}}(\text{e @ cultural},\chi \text{ @ abstract*}) := {}^{vsem\_l}\text{l}_{e_{t,het}}\text{:} \boxed{\begin{array}{l} \text{e} \\ \\ \text{auftreten3(e)} \\ \text{theme}_{const}(\text{e})=\chi \\ \text{e} \subseteq \text{t} \end{array}}$$

(*Schwierigkeiten auftreten / difficulties arise*)

Here, the information about the sort of the event, which is decisive with respect to distinguish between the first and the second reading, is assumed to be extracted from contextual restrictions as given in the prototypical uses presented, which, when considering sortal classification, are often provided, as there, by additional PPs. With respect to this example, it would have been possible to treat the ambiguities by different subcategorization frames also (by assuming additional PP-arguments). As mentioned above, we could provide several frames (a one-place frame for the last reading, a two-place frame with auf-PP restricted to *Bein* or *bodypart* for the second reading and a two-place frame with in- or auf-PP restricted to locations for the first reading) and correspondingly unambiguous verb-terms. We could try to factorize the different frames into one frame (into a two-place frame in this case with optional in- or auf–PP-argument) where the different readings depend on the sortal specification of both arguments (and not of the type of the distinguished DRF). A corresponding formalization could look as follows:

$$\text{auftreten} \longrightarrow \text{vsem\_t} \begin{bmatrix} \lambda\text{:} & \langle \chi_{NomNP}, \xi_{in-PP;auf-PP} \rangle \\ \text{RES:} & \underline{\text{auftreten}}(\text{e},\chi,\xi) \end{bmatrix}$$

$\underline{\text{auftreten}}(\text{ind,ind,ind}) \Rightarrow \text{vsem\_l}$

$$\underline{\text{auftreten}}(\text{e},\chi \text{ @ animal0*},\xi \text{ @ local}) := {}^{vsem\_l}\text{l}_{e_{t,het}}\text{:} \boxed{\begin{array}{l} \text{e @ cultural} \\ \\ \text{auftreten1(e)} \\ \text{agens}_{const}(\text{e})=\chi \\ \text{spat\_loc(e},\xi) \\ \text{e} \subseteq \text{t} \end{array}}$$

(*im Theater auftreten / appear at the theatre*)

$$\underline{\text{auftreten}}(\text{e},\chi \text{ @ animal0*},\xi \text{ @ bodypart}) := {}^{vsem\_l}\text{l}_{e_{t,het}}\text{:} \boxed{\begin{array}{l} \text{e @ natural} \\ \\ \text{auftreten2(e)} \\ \text{agens}_{const}(\text{e})=\chi \\ \text{instr(e},\xi) \\ \text{e} \subseteq \text{t} \end{array}}$$

(*auf das Bein auftreten / to step onto*)

$$\underline{\text{auftreten}}(\text{e},\chi \text{ @ abstract*},\emptyset) := {}^{vsem\_l}\text{l}_{e_{t,het}}\text{:} \boxed{\begin{array}{l} \text{e @ cultural} \\ \\ \text{auftreten3(e)} \\ \text{theme}_{const}(\text{e})=\chi \\ \text{e} \subseteq \text{t} \end{array}}$$

(*Schwierigkeiten auftreten / difficulties arise*)

We have said that we try to avoid subcategorizing roles of localization as far as possible. Next to the mentioned reason that such PP-modifiers, in contrast to other complements, normally determine the type of modification by themselves, the reason is that syntax then has to decide about the contribution of modifiers which may be read (but need not) as such complements, instead of leaving the decision about the role of the modifier to semantic disambiguation. Unless there is syntactic underspecification also, against the background of functional ambiguity, it is necessary to be as stingy as possible with respect to subcategorizing roles therefore, since, for the sake of (syntactic) completeness and coherence, the identity of such roles must be determined (early). We prefer the first type of representation therefore, as exemplified for *auftreten*, and, by this try to minimize premature commitment with respect to extreme examples like (3 (*Il passe des clients au restaurant*) also.

3.4 Quantifiers

3.4.1 General representation issues

Some quantifiers accept collective readings, others do not. Compare the following examples:

(35)

a. *Drei/wenigstens vier/einige/manche/wenige/viele/die meisten/alle Artisten versammelten sich in der Manege.*
Three/at least four/some/few/many/most/all artistes gathered in the manège.

b. **Kein/*mancher/*jeder Artist versammelte sich in der Manege.*
*No/*many a/*each artiste gathered in the manège.

We take from (35), that, obviously, quantifiers that select singular noun phrases cannot have a collective reading. In case such quantifiers are applied to collective verb predicates the result is incorrect or, if not, there is relatively extensive reinterpretation triggered by Grice's cooperation maxim which tries to assume a collection for each of the individuals x from the domain of quantification. For the (35.b)-examples ths comes to saying that for each x it is true that *x and some other people gather*. Note that, with respect to the DP, this is nevertheless a distributive interpretation. Quantifiers that select plural noun phrases accept a collective interpretation, most of them at least, as it seems. Though for some of them this must be softly forced by verbal predicates suggesting collective reading.

In connection with neutral verbs like *auftreten*, numerals tend to prefer the collective reading , but accept the distributive reading also. The other plural quantifiers show a very strong preference for the distributive reading. See the examples of (36). [2]

(36)

a. *Drei/wenigstens vier/einige/manche/wenige/viele/die meisten alle Artisten traten auf.*
Three/at least four/some/few/many/most/all artistes appeared on stage.

b. *Kein/mancher/jeder Artist trat auf.*
No/many a/each artiste appeared on stage.

[2] This behavior has been one of the reasons for treating numerals separately and differently from (other) quantifiers in original UDRT, as mentioned further above. (Note that there is made a similar categorial distinction in [Kamp/Reyle(1993)]).

However, the non-numerals are not as homogeneous as one might think. The degree of preferring the distributive reading is quite different. This can be made explicit by testing the ease of obtaining a collective interpretation when adverbials that support collective interpretations at different degrees are added, see (37).

(37)

a. *Danach traten drei/wenigstens zehn/einige/manche/wenige/viele/die meisten/alle Artisten mit einem Hund auf.*
After that, three/at least ten/some/few/many/most/all artistes appeared on stage with a dog.

b. *Danach traten drei/wenigstens zehn/einige/manche/wenige/viele/die meisten/alle Artisten gemeinsam als chaotische Kurkapelle auf.*
After that, three/at least ten/some/few/many/most/all artistes jointly appeared on stage as chaotic kurhaus orchestra.

In (37.a), *drei* and *einige* very easily accept the relevant collective reading according to which they jointly appearded on stage with a dog, probably for demonstrating some tricks they taught to the dog. Also, *wenigstens zehn, wenige, viele* seem to accept this reading relatively easily. Though, for obtaining the collective reading, the sentence would be better with an additional *zusammen / conjointly* in this case. Such an addendum is felt to be even more necessary for *alle / all*. However, in contrast to *manche* and *die meisten*, this quantifier accepts the collective reading of (37.a) as is.

There even remain doubts whether *manche* and *die meisten* accept the collective reading in examples like (37.b) where two adverbials strongly require collective interpretation, to the effect that all other mentioned quantifiers easily accept it.

Note that the diverging distribution patterns of the different quantifiers that we observe have an interesting counterpart at the level of nominal modification via relative clauses: Those quantifiers that easily accept a collective reading also easily allow relative clauses that relate to the entire range of the quantification. It seems that this does not even depend on whether the main clause is actually read collectively:

(38)

Einige Artisten(,) die letztes Jahr in Moskau aufgetreten waren(,) hielten eine Fackel hoch.
Some artistes(,) that had a performance last year in Moscow(,) presented a torch.

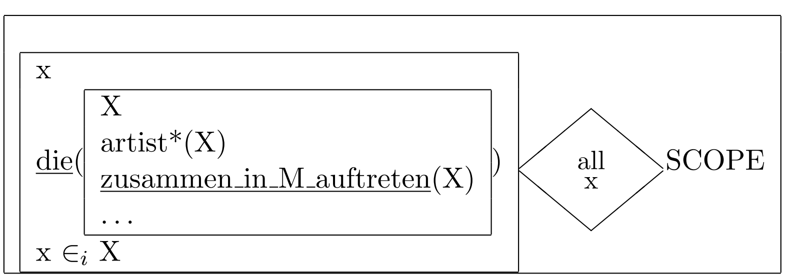
(38) accepts intrepretations according to which there are several performances in Moscow (one for each artist) or just one (relating to the group a s a whole) and where there are several acts of presenting some torch (one for each artist) or with just one

such event of conjointly presenting one single torch. Note that, under the assumption of a quantifying interpretation of *einige*, the solution with one collective performance cannot be obtained by making the relative clause part of the restrictor of *einige*, i.e. cannot be obtained by interpreting it as NP modifier. The DP as such must provide a sum referent that can be modified by the relative clause, this is what we came to state in section 2.5.2: The relative clause can obtain a collective interpretation in such cases only if it modifies the DP, not the NP, and if this DP provides a DRF for the Refset. The relative clause of (38) cleary has a collective reading (also), which can be made more prominent by adding adverbials with collective meaning similarly to the examples of (37). It has a purely amplifying or decorating meaning in this case, i.e. it is used referentially, as an apposition to the DP. This means, provided correct orthography, this reading presupposes that the relative clause is put between commas. Note that the implication is not inversible: Under the same use as apposition (bracketed by commas), modifying the Refset of the DP, we can obtain also a distributive reading (where each of the set of *some artistes* had an appearance in Moscow at his own). Next to this, there is also another distributive reading of the relative clause, the one where the contribution of the relative clause is introduced in the restrictor of the *einige*-duplex-condition. This, however, means that the relative clause plays the role of an NP-modifier and partakes in defining the DP. It cannot be an apposition, it must be used attributively in this case.

However, what about examples like (39)?

(39)
Alle Artisten die letztes Jahr zusammen in Moskau aufgetreten waren hielten eine Fackel hoch.
All artistes who had a conjoint performance last year in Moscow presented a torch.

Here, as it seems, there is a relative clause with collective meaning which modifies the NP, not the DP. A closer look makes clear that, in this type of example, the quantified DP is a kind of abbreviation for a genitive construction (*alle der(jenigen) Artisten die .../ all of those artistes who ...*) where the quantifier determines a subset of the set which is built (or referenced) by the remaining description. This is a use of the quantifier we are not concerned with here. For (39), it can be represented as follows:



Here, die means that the determiner still can be specified to the referential interpretation (introducing X via an α_{def}-condition) or to the attributive meaning (introducing X via something like the ι-operation). (To the distinction of referential and attributive use with respect to definite descriptions compare [Donnellan(1966)], for the representation of definites, see below section 3.5). Note that, when constructing the representation of the implict definite description, we are again faced with the problem of collective-relative-clause-modification. Presumably, here (i.e. with respect to the attributive characterization *Artisten die zusammen in Moskau aufgetreten waren*), we cannot avoid admitting that this be an example of collective NP-modification. Here, the domain of the determiner actually is the set of sets (or sums) of artistes and its assertion (or presupposition) is that there is exactly one such set of artistes which satisfies to the condition from the relative clause. It is known that quantifiers (and determiners, as here) can run over sets of sets instead of running over sets of individuals. Another example for this is the following:

(40)

Viele Männer und Frauen die lange miteinander verheiratet sind lieben sich immer noch.

Many men and women who have been married to each other for a long time still love each other.

In (40, the domain of the quantifier is a subset of the married couple-groups. In order to enable representation of such examples also, we must assume that quantifiers (and determiners) can take predicates as arguments whose extensions are sets of sums (*Männer und Frauen* in the sense of an NP λx $\oplus$ y. mann_&_frau($\oplus$ y)) or that they can apply summation to there argument (turning individual predicates P into predicates P*). We must also assume that collective relative clauses may apply '*'-operation to their NP-argument. The problem with such representations is that, on the basis of the semi-lattice modelling of summation, which reifies sets into sums and which underlies the approach here (see section 2.5.2), the individuation criteria are not fine-grained enough in order to obtain satisfactory interpretations in the presence of summation over sums. (Sums of sums don't show a similarly fine-grained internal structuring than the corresponding sets of sets, see [Krifka(1991)] for this problem and suggestions for (tentative) solutions). However, sticking to the 'conservative' modelling with sets, we are forced to distinguish between first-order- and second-order-predicates etc., which complicates the approach and its model theory a lot. To avoid this, we neglect treating the phenomenon of quantification ranging over sets or sums. Note that such quantificational structures aren't really relevant with respect to what we are concerned with in this section: If we carefully filter out the reintrepration uses which we called abbreviations of genitive constructions, with respect to examples like examples (35) - (38) we can do with quantification over individuals only. The only problem which is presented by such examples with respect to quantification therefore is that relative clauses can modify DPs also if these DPs obtain a quantificational interpretation in the sentence, what, in DRT, commonly is represented by a duplex condition. In section 2.5.2 we have shown how it can be made possible that even such DPs can provide a DRF as is needed for instantiating the relative pronoun on the fly during composition of the DP as a whole. According to this sugegstion, this is done by abstraction from the duplex condition. The examples as considered so far also show that this procedure of abstracting a DRF for Refset shouldn't be applied in disregard of the nature of the quantifier. At least singular quantifiers don't accept corresponding modification, viz (41):

(41)

a. / * *Mancher Artist, die letztes Jahr zusammen in Moskau aufgetreten waren, hielt eine Fackel hoch.*
Many an artiste, who had a conjoint performance last year in Moscow, presented a torch.

b. / * *Mancher Artist, sie waren letztes Jahr zusammen in Moskau aufgetreten, hielt eine Fackel hoch.*
Many an artiste – they had a conjoint performance last year in Moscow – presented a torch.

c. / * *Mancher Artist, der letztes Jahr in Moskau aufgetreten war, hielt eine Fackel hoch.*
Many an artiste, who had a performance last year in Moscow, presented a torch.

d. / *Mancher Artist der letztes Jahr in Moskau aufgetreten war hielt eine Fackel hoch.*
Many an artiste who had a performance last year in Moscow presented a torch.

(41) illustrates that, in such cases, a collective relative clause is out for the reason alone that agreement clashes (compare a). Reformulation of the relative clause as a main clause avoids such clashes, but is also out (b). An apposition to the DP which is a singular relative clause seems out, because, interestingly, one apparently expects some predication about a sum from such a contribution, which, as (b) shows, is out for other reasons (c). Note that the quantified variable (a single artiste) is not accessible from the position of the apposition condition in the representation. Remains variant (d), which is acceptable, but which is the attributive NP-modifying variant.

As things stand, though the considered representants of different types of plural quantifiers present a rather differentiated picture with respect to the collective reading, we repeat that, to our oppinion, for most, if not all, (one-place) plural quantifiers (running over individuals) there can be given circumstances under which they must obtain a true collective interpretation (i.e. not in the genitive construction sense of examples (39 or another clandestine distributive reading). In principle, allowing collective reading is a prerequisite for allowing DP-modification, which is equivalent to providing a DRF for the Refset.

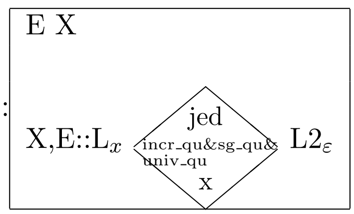
Summarizing, we record the distinction of quantifiers that distribute always (containing the class of singular quantifiers) and those that do not. The first class does not provide a referential index which is accessible from outside the quantification, the second does provide such an index and, therefore, the second class allows for intersective DP-modification (via relative clauses), whereas the first class does not. The second class is a subclass of the plural quantifiers.

Taking up the suggestions of section 2.7.2 for the representation of quantified NPs, we can represent the entries of two typical representatives of the two classes as follows:

jeder $\longrightarrow$quantop_t $\begin{bmatrix} \lambda\text{:} & \langle^{\text{npsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{jed}}(\text{L}) \end{bmatrix}$

$\underline{\text{jed}}$(npsem_l) $\Rightarrow$detpsem_l

$\underline{\text{jed}}$(L) := $\text{l1}_{\text{E},\emptyset,\text{x}}$:

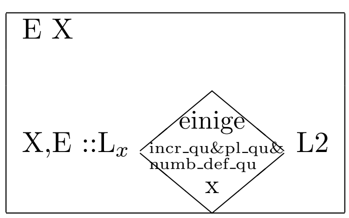


{l3 ≤ l2}
L3

einige $\longrightarrow$quantop_t $\begin{bmatrix} \lambda\text{:} & \langle^{\text{npsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{einige}}(\text{L}) \end{bmatrix}$

$\underline{\text{einige}}$(npsem_l) $\Rightarrow$detpsem_l
$\underline{\text{einige}}$(L) :=

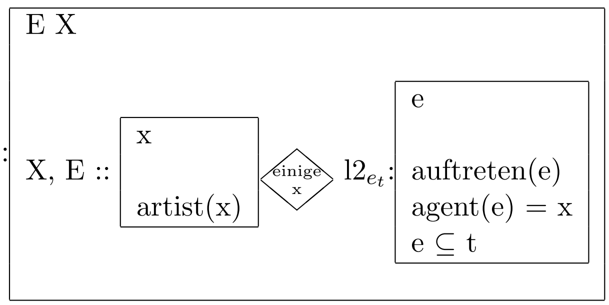
l1 $_{\underline{\text{res}}(\langle\langle \text{E},①\rangle,\langle,\varepsilon\ ,②\rangle\rangle),\ \text{X},\ \underline{\text{res}}(\langle\langle \text{x},①\rangle,\langle,\text{X},②\rangle\rangle)}$:

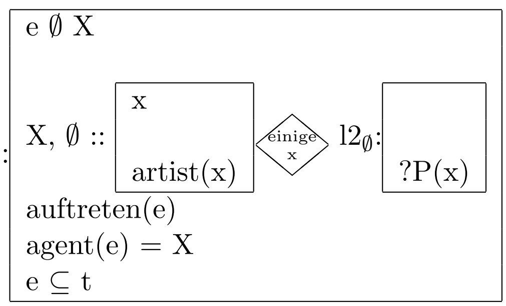


{①(l3 ≤ l2) ∨ ②(l3 $\leq_n$ l1)}
$L3_\varepsilon$

We see that the distinction between the class of always distributive quantifiers and its counterpart is reflected by the different instantiation of the upper referential index: With respect to *jed-* the corresponding DRF is ∅, meaning that there is no such DRF available. With respect to *einige*, the corresponding DRF stands for the set which exhausts the NP-meaning. In both cases the quantifiers are classified (or more precisely; evaluated) as determiners. (The resulting labelled structure is therefore of type *detpsem_l*; compare the following section 3.4.2 to the distinction of this subclass of *dpsem_l*.) In addition, the always distributive quantifier requires its argument to be in the scope of the introduced duplex condition. The quantifier that might also obtain a collective reading leaves the decision open whether its argument is in the scope of the duplex condition or whether it is allowed to be merged to the top structure in a particular disambiguation. The delayed res retraces these alternatives according to what we have said in 2.7.2 what the outcome should be with respect to the indices.

Anticipating the Det+NP- and DP+VP-composition rules of section 4 and the disambiguation routine of section 5.1, for (36), case *einige*, we obtain the following two representations from the scopal ambiguity which the quantifier introduces:

($36_{rep_{dist}}$) $l1_{E_t}$:


($36_{rep_{coll}}$) $l1_{e_t}$:


The sample lexicon entries of *jeder* and *einige* illustrate that the implementation will make use of a fine grained classification of quantifier types. More surface oriented classifications like *sing_qu*, *pl_qu*, *numb_qu*, *numb_def_qu* (that is, singular and plural quantifiers and quantifiers directly referring to numbers or indirectly being defined by numbers) are related to and contrasted with distinctions that are relevant information for an inference component like the *increasing/decreasing* distinction *incr_qu: decr_qu.* [3]

Two comments about these representations. Firstly, in section 2.7.2, we have tried to motivate why we represent the ambiguity between collective and distributive reading with respect to quantifiers as illustrated by the represntations above. We must not repeat this here. Note however, that under the collective interpretation, where the representation of the VP-argument complements the duplex condition of the quantifier by additional conditions, the sentence statement is a kind of contraction of two statements. The first introduces and characterizes the Refset of the Quantfier. For ($36_{rep_{coll}}$), it could be paraphrased by something like *Es gibt einige Artisten / There are some artistes.* The second statement is the predication from

[3] If not relevant to the subject discussed, we omit such details in the informal descriptions of representations that we present in this section. For a more detailed picture of the classifications used in the implementation, see the listing of the corresponding AVM descriptions in the appendix.

the VP about the Refset (*Sie traten auf / They appeared on stage*). One might bring this one step further and might say that, generally, in the presence of quantifiers which commonly are classified as distributive and which, forced by context, must obtain a collective reading, the collective interpretation might result from a complex interpretation process, which goes as follows: We assume a true analytical interpretation of the quantifier where the duplex condition, instead of 'idling' so to speak, as here, distributively assigns actions to the members of the quantified DP, such that the collection of these actions (that is available from the duplex condition through abstraction) build the sentence event, which, then, being a sum, can be characterized by the collective predication. (All members of the DP-quantification do something such that the sum of these doings can be considered to be a *gathering in the market* or to be an *appearance as kurhaus orchestra* etc.). [4] In this case, instead of abstracting $\emptyset$ from the duplex condition, we would assume that the DRS-variable which is the scope of the duplex condition in the representation, instead of being instantiated by a one-place predicate holding for the quantified variable (as indicated by ?P(x)), must describe an event of the quantified individual (? P(e,x)), such that we can abstract a real sum of events from the condition, which, then, is identified with the event of the VP-predication. We abstain from stipulating this strengthening however, because we are not sure whether this type of representation always gives a correct account of the described situations or whether it over-interpretes sometimes. Here, it suffices to have shown that we can obtain it easily. (With respect to over-interpretation, think of topicalization structures of quantified DPs like *there are many people who ...* which once again illustrate that there are cases where the quality that makes the Refset to a *many, few, ...*-set of the restrictor set has nothing to do with the predication from the matrix sentence. Nevertheless, our interpretation of collectivity leaves a trace of distributivity with the quantifier also.

Secondly, we emphasize that there is a certain asymmetry accompanying the distinction between the collective and the distributive reading of a (generalized) quantifier (independent of what we have just said): The distributive reading exhausts all events and corresponding role bearers that, with regard to the considered stretch of time (the focus time), satisfy the considered predication, whereas, in the collective reading, it is an open question whether the result DRF is the only event or the maximal event, respectively, that satisfies to the sentence description with regard to the considered reference time (and similarly for the corresponding bearer of the role that is abstracted from the quantifier condition). However, we think that this asymmetry that comes with the model theoretic evaluation of quantifier duplex conditions (see section 5.3) is legitimate and is confirmed by the data. To our opinion, the asymmetry is explained by the fact that, in the collective case, the decision criterion that extracts a subset S of the restrictor set R that is stipulated to be a einige/viele/wenige/die meisten/drei-set with regard to R cannot be the predication

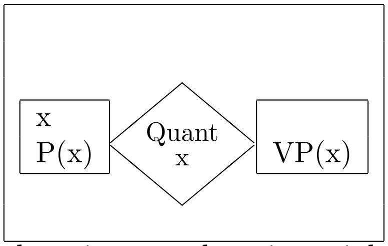
[4] The author owes this idea to Hans Kamp by personal communication.

from the matrix clause (since, qua definition of the collective case, this predication is a predication of a collection and, thus, cannot function as a test predicate for classifying the R-individuals at the same time). This quality of identification, therefore, must be some other, not mentioned (contextually inferable?) predication In order to be very explicit on this point, this means: The predication of the matrix clause is not the quality which determines the specific instance of the relation between sets that the sentence introduces as an item of the *einige/viele/wenige/die meisten/kein/drei*-relation and, as a consequence, the quantifier does not put a maximality constraint onto S with regard to the predication and against the background of the considered (restrictor) domain R. We think that, from this, it can be concluded that the use and meaning of a sentence like *gestern traten einige Artisten mit einer Kraftsport-Nummer auf (yesterday some (a number of/a group of) artistes appeared on stage with a heavy-athletics event)* is twofold with respect to the pragmatic purposes of the speaker. The sentence can be used in order to inform about how many people of the type *artiste* appeared on stage with a heavy-athletics event yesterday (or within a further restricted contextually given reference time). This is a kind of summary or 'statistics' information. We call this use also the *true quantifier reading.* Under this reading, an anaphor of a following sentence (*they*, better *all of them*, *these artistes*) picks up the set of **all** artistes that satisfy the restrictor and scope conditions of the duplex condition introduced by the first sentence (see section 2.5.2 for this picking up of REFSET). In contrast, this sentence also can be used with the quantifier more or less playing the role of an indefinite. Then, it just informs about the existence of an event of the given predication within the contextually relevant reference time. There might be other events of the same type. But whether this is so is outside the interest of speaker (and hearer). Thus, sentences with this 'indefinite' use of a quantifier typically appear in narratives (*then some artistes appeared...*) and inform about an item of the episode that is reported. (The 'statistics' reading is more likely to be used as background information.) Under this collective reading of the quantifier, an anaphor of a following sentence picks up just the set of those individuals that partake in the one event reported by the sentence, independently of whether this set exhausts the set of individuals that satisfy the VP predication for the given reference situation or not. [5]

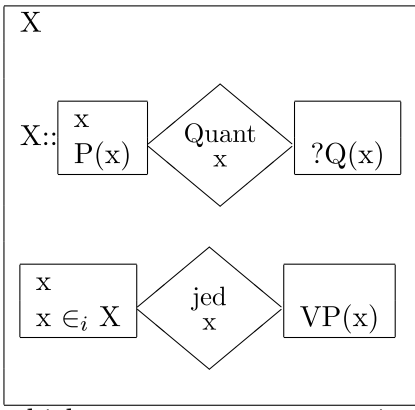
3.4.2 Peculiarities of numeral quantifiers

It is still an open question whether the distributive reading of the quantifiers can obtain an 'indefinite' reading also. Schematically, this means, whether next to

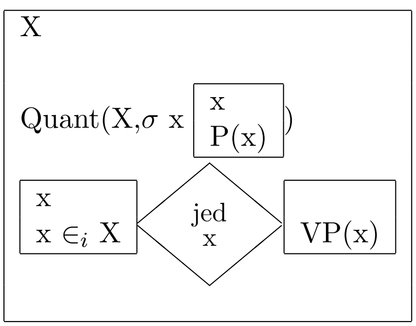
[5]Note that the alternative representation mentioned above does not alter these reflexions: By the identification of the abstracted E with the event of the VP-representation, the size and quality of E, so to speak, is made dependent on this VP-event and, by this, constrains the possible instantiations of ?P(e,x). Also here therefore, it is not the case that, for a specific P, all possible denotations are enumerated. It is the other way round: the chosen denotations define the predicate. Compare also what we have said in section 2.7.2 about the different flow of information with respect to distributive and collective reading.



there is a purely existential reading of the type:



which is equivalent to the following representation which uses a more conventional notation for the relation between Refset and domain which avoids abstraction:



Here, in contrast to the so-called 'statistics'-reading of the last section, there is no constraint of maximality with respect to exhausting whatsoever predication. We think that this is not true in general, but is a (further) pecularity of the numeral DPs (where a prerequisite of this behavior may be the fact that numeral operators, like the precise universal and negative quantifiers, more than quantifying operators like *many, few* etc., carry an intrinsic criterion of choice). Therefore, when compared to the entire range of quantifiers, numerals are specific: Firstly, they can easily obtain and mostly prefer the collective reading. Secondly, they can obtain a reading which corresponds to that of a specific indefinite. We investigated this in detail, when discussing the 'classical (U)DRT-approach' to numerals, which (for this reason) interpretes them as existential quantifiers (and allows that they *run away* from their local domain, see sections 2.6- 2.7.2). Thirdly, even if used unspecifically and distributively, they can obtain a purely existential reading as represented above. In short, next to the distributive 'statistics'-reading, they show all readings of indefinite DPs proper. Syntax confirms this pecularity and gives us a hint about how we represent this best. Numeral DPs allow further determination/modification by the definite determiner, in contrast to many other quantifiers, in particular in contrast to the quantifiers which are defined from numbers (like *at least / exactly / at most three*). Therefore, numerals are often classified as adjectives also. Inspired by this, we will classify numerals as quantifying operators which take NPs and return such DPs which allow further modification by determiners, where, next to definite determiners, we assume the existence of a (syntactically empty) plural indefinite determiner. Note that we would need such an indefinite operator anyway for the representation of bare plurals if we do not assume that plural nouns are ambiguous between a noun reading and a DP reading (in contrast to the singular-case), which we want to avoid. Of course, as in the singular-case, this determiner will be ambiguous. It may obtain an existential reading or a referential reading (via an α-condition), very similar to the attributive/referential-distinction of definites (compare [Donnellan(1966)], also [Searle(1979)], [Partee(1970)]), where both alternatives allow collective or distributive interpretation. Because of this relating to indefinites we postpone spelling out the complete semantic contribution of numeral quantifiers to the section 3.5, where the representation of determiners is treated. We conclude this section with the non-indefinite interpretation of numerals. It repeats the representation of section 2.7.2, except for the fact that it makes the type of the quantification more precise. Again, the example is *drei / three*:

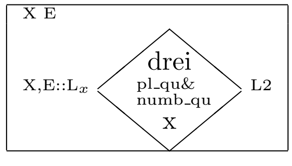
$$\text{drei} \longrightarrow \text{det\_t} \begin{bmatrix} \lambda\text{:} & \langle^{\text{npsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{drei}}(\text{L}) \end{bmatrix}$$

$\underline{\text{drei}}(\text{npsem\_l}) \Rightarrow \text{dpsem\_l}$
$\underline{\text{drei}}(\text{L}) := \underline{\text{q\_drei}}(\text{L}).$

where:

$\underline{\text{q\_drei}}(\text{npsem\_l}) \Rightarrow \text{qpsem\_l}$

$\underline{\text{q\_drei}}(\text{L}) := \text{l1}_{\text{res}(\langle\langle \text{E},①\rangle,\langle\varepsilon,②\rangle\rangle),\ \text{X},\ \text{res}(\langle\langle \text{x},①\rangle,\langle \text{X},②\rangle\rangle)}$:



$\{①(\text{l3} \leq \text{l2}) \vee ②(\text{l3} \leq_n \text{l1})\}$
L3_ε

According to this, the quantifying operator from *drei* is of type *pl_qu* (a plural quantifier) and of type *numb_qu* (a numeral quantifier). The type of the result *qpsem_l* means that the quantified expression is a DP of the particular form *quantized nominal phrase*. In contrast to the other DPs, which are typed *detpsem_l*, such DPs are admissable as arguments of a (definite or indefinite) article (*die drei Artisten, ∅*

drei Artisten). Note that this modelling properly accounts for the observation that numerals, often, next to saying that X NP-instances do something, in the sense of *exactly X*, can mean that *at least X* NP-instances do such and such: The second meaning develops from the application of the meaning of the indefinite article to the qpsem_l-DP. Note also that, in this case, as is true with respect to the quantifiers which we call *number-defined* (*numb_def_qu*, i.e. *at least three, at most four*, etc.), (further) assignment of an article isn't possible. This means, the result is of type detpsem_l.

It remains to stipulate the following partitioning of the DP-contribution:

dpsem_l = detpsem_l | qpsem_l.

3.4.3 Contextually defined quantifiers

Quantifiers like *viele* and *wenige* are not defined in terms of the ratio of the extensions of restrictor and scope (as is true for quantifiers like *kein, mindestens drei, die meisten, alle*, etc). [6] Compare (42) for this.

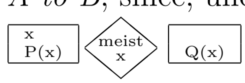
(42)
a. *Viele CSU-Parteigänger wählten damals SPD (nämlich immerhin 10 %).*
Many CSU partyliners voted SPD at that time (namely 10 %).
b. *Nicht viele SPD-Anhnger haben Schröder die Stimme verweigert (gerade 10 %).*
Not many SPD supporters had refused to vote Schröder.

Whereas, in (a), a 10%-subset is presented as a *viele*-subset, in (b), 10% obviously are nout enough to be *viele*.

It is known that, often, the referential set meant is not what is available by the predication of the restrictor, but by some subset which is distinguished by unmentioned, but contextually available constraints that further restrict the predication of the restrictor (see [Westerståhl(1985)] for this, and the suggestion of so-called *context sets* as introduced there). Compare (43), which exemplifies this:

(43) *Gestern fuhren die meisten Autos über die Brücke.*
Yesterday, most cars crossed the bridge.

In the case of (43), the context set is not *cars*, but probably something like *cars which went from A to B*, since, under the assumption that



is interpreted as

$$\frac{|\lambda x(P(x) \wedge Q(x))|}{|\lambda x P(x)|} \geq 0.5,$$

[6]For a study of the definition problem connected to generalized quantifiers, see [Kamp(1996)].

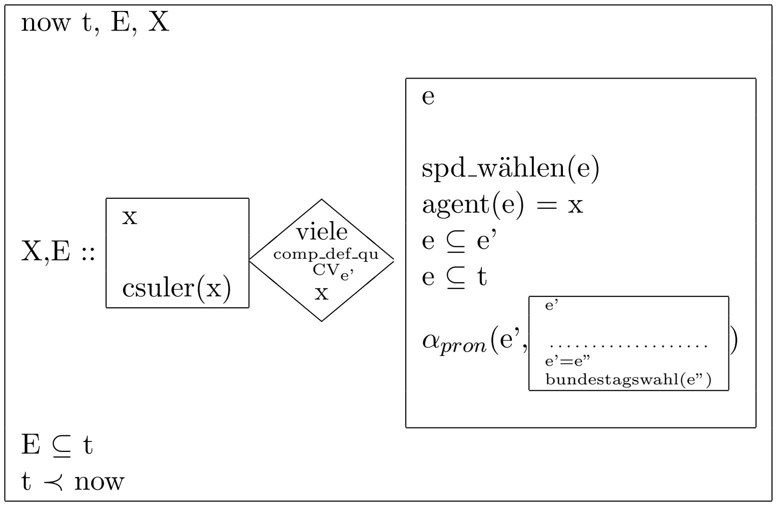
as is common (see [Kamp(1996)] for instance), it is not convincing that the cardinality of the set of cars crossing the bridge should be more than half of the cardinality of the set of all cars. Therefore, the assumption of a contextual restriction of the domain of quantification is very natural. Now, compare (44).

(44) *Gestern fuhren viele Autos über die Brücke.*
Yesterday, many cars crossed the bridge.

In contrast to (43), here, there is the strong feeling that it is not an instance of the described accommodation of context that is necessary in order to grasp what the speaker had in mind when uttering the sentence. The same is true with respect to (42). It is not a further restriction of the predication from the restrictor that makes that the denotation of restrictor and scope is 'many' with respect to the restrictor set alone. In the case of (42.a), it is even pretty clear that **all** CSU partyliners are in focus and not a contextually restricted subset of them. It seems much more adequate to assume that the considered partyliners are 'many' when compared to what could be **expected** to be the proportion of *CSU-partyliners* and *CSU-partyliners voting SPD*. Thus, we claim that quantifiers like *viele* are evaluated model-theoretically by contrasting the actual ratio of scope and restrictor extension to some suitable comparison value. Then, a particular scope extension might be *viele* w.r.t. the corresponding restrictor extension, in case the fraction of the corresponding cardinalities is greater than this value, or it might be *wenige* in case the fraction is less than this value. The problem is how to obtain this value. It seems that, very often, this value is due to the knowledge of similar situations: The speaker might characterize the ratio of two sets as *viele*, because it is greater than the average of the ratios of the two sets in comparable situations, or because it is greater than the ratio of a corresponding 'normal' or 'typical' or 'expected' situation (that 'normally' arises by abstraction over the set of known similar situations). Thus, we think that at the basis of the computation of the relevant comparison value, that almost never will be explicitly stated in the text but has to be accommodated by the recipient via presupposition resolution or accommodation, one needs an idea about the relevant situation type the reported situation is an instance of. Technically, this means that we need a situational parameter; a parameter one can abstract over, in order to obtain the set of the relevant comparable situations. What should be the quality and the place of this parameter in DRT representations? In (44), provided neutral intonation, it is clearly the temporal adjunct that provides the distinguishing criterion of the reported situation with regard to the relevant situation type. In (42.a) it is (via anaphoric link) a particular election, probably a Bundestagswahl, that provides the distinguishing criterion. In examples like *Dort fanden viele Rennen statt / There, many races took place*, it is the spatial specification that provides the varying parameter of the relevant situation type. In all of these cases it is a referential term which helps to situate the considered event. Obviously, information structure helps to determine the relevant parameter and the corresponding situation type.

Using this parameter, we represent (42.a) by (42.a$_{rep}$) as follows:

(42.a$_{rep}$):

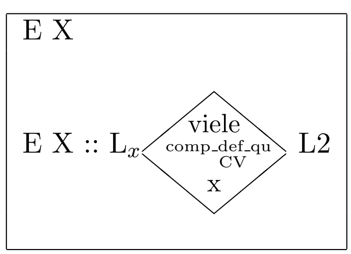


(42.a$_{rep}$) says that the ratio of the set of CSU partyliners to the set of those CSU partyliners that vote SPD *damals* is a *viele*-ratio with regard to CV$_{e'}$ (where *damals* is designated by e' which is contextually resolved to a specific Bundestagswahl e'' and where CV stands for *comparison value* which is obtained by considering similar situations, i.e. other Bundestagswahlen). According to this representation, we stipulate the following lexical representation *viele*, which specifies the corresponding representation of section 2.7.2 by corresponding typing. It exemplifies the representations of those quantifiers that are defined by comparison to similar situations (*comp_def_qu*):

viele ⟶quantop_t $\begin{bmatrix} \lambda: & \langle^{\text{npsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{viele}}(\text{L}) \end{bmatrix}$

<u>viele</u>(npsem_l) ⇒qpsem_l

<u>viele</u>(L) := l1 <u>res</u>(⟨E,①⟩,⟨ε ,②⟩)), X, <u>res</u>(⟨x,①⟩,⟨X,②⟩)) :



{①(l3 ≤ l2) ∨ ②(l3 $\leq_n$ l1)}
L3$_\varepsilon$

Since the type of the DP-contribution is *qpsem_l*, modification by a determiner is allowed (*die vielen Artisten*). Note that, by this, application of the syntactically empty indefinite article is not excluded. Next some redundancy (which does no harm), it provides us with the existential, distributive reading which we discussed in the last section with respect to numerals (the non-exhaustive non-'statistics'-reading so to speak) and with referential readings. We are free to restrict this further (to allowing the definite determiner only) if we think that this overgenerates.

Normally, the lexical entry will say nothing concrete about CV. In the following, we pretty informally illustrate how CV should be computed. The example is the prototypical (42.a).

The first question to answer is how to characterize the reference situations. On the basis of what we have said so far, under the assumption that *damals* is the focus and is resolved to a particular Bundestagswahl, we can define the set of reference situations, RefS, as follows (with '$=_t$' for *temporally equivalent*):

$$\text{RefS} := \lambda \text{s} \boxed{\begin{array}{l} \text{s} \\ \\ \text{s:} \boxed{\begin{array}{l} \text{t e' U U}_s \text{ E} \\ \\ \text{t} =_t \text{e'} \\ \text{bundestagswahl(e')} \\ \text{U} = \Sigma \text{ u} \boxed{\begin{array}{l} \text{u} \\ \text{csuler(u)} \end{array}} \\ \text{U}_s = \Sigma \text{ u K} \\ \text{E} = \Sigma \text{ e K} \\ \text{K} = \boxed{\begin{array}{l} \text{u e} \\ \\ \text{csuler(u)} \\ \text{spd\_wählen(e)} \\ \text{agent(e)=u} \\ \text{e} \subseteq \text{e'} \end{array}} \end{array}} \end{array}}$$

Choosing the average approach for the computation of the comparison value CV, we obtain:

$$\text{CV} = \frac{\Sigma_{s \in \|[RefS]\|} \frac{|P_s \cap Q_s|}{|P_s|}}{|\|[RefS]\||}, \text{ where } \text{P}_s = \|[\ \lambda\text{u} \boxed{\begin{array}{l} \text{u} \\ \text{csuler(u)} \end{array}}]\|_s \text{ and } \text{P}_s \cap \text{ Q}_s = \|[\ \lambda\text{u} \boxed{\begin{array}{l} \text{now e' u e} \\ \\ \text{now} =_t \text{e'} \\ \text{bundestagswahl(e')} \\ \text{csuler(u)} \\ \text{spd\_wählen(e)} \\ \text{agent(e)=x} \\ \text{e} \subseteq \text{e'} \end{array}}]\|_s.$$

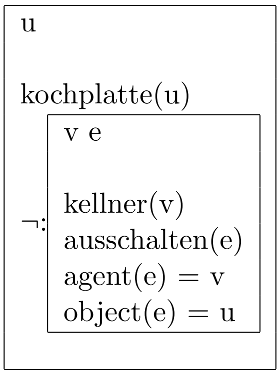
We leave this as it stands. In particular, we do not define the interpretation function used, $\|[\cdot]\|$, (the simplest solution would be the extension in the actual world) andwe do not introduce the necessary relativization to s of the predicates P and Q (see section 5.3 for this).

3.4.4 The negative quantifier

The negative quantifier *kein* excludes the validity of the VP predication for its domain. Compare (45) and the corresponding representation (45_{rep1}) in order to see this.

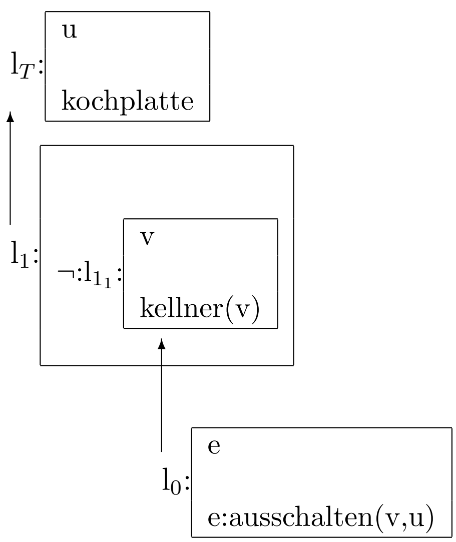
(45) *Kein Kellner hat die Kochplatte ausgeschaltet.*
No waiter turned off the stove.

(45_{rep1})



(45_{rep1}) is the reading that is obtained from ($45_{rep_{UDRT}}$), which is the UDRT style representation of this example.

($45_{rep_{UDRT}}$):



The (original) fragment of the UDRT framework does not encompass temporal and aspectual phenomena. As it stands, representations like ($45_{rep_{UDRT}}$) and the semantically equivalent (45_{rep1}), which do not use temporal focus parameters, cannot be sufficient. Without additional modification, they wrongly exclude the existence of events of the unnegated sentence description for the entire time line (*there is no* *turning off of the stove at a time whatsoever*). Note that in order to truly evaluate the tense information, it is not sufficient to define the DRF of the verb representation as a past event (by a condition 'e $\prec$ now' added to the verb representation for instance, in accordance with canonical tense operator interpretation of classical temporal logics). In [Partee(1973)], Partee discusses at length example (46) which is very similar to (45)

(46) *I didn't turn off the stove.*

There, she convincingly argues that the exclusion of an event as effectuated by the negation operator must be restricted to some contextually given reference time. We agree with this position (which, in the meantime, has become rather common) and adopt it for the negative quantifier case.

Examples like (47) show that negated phrases like (45) must nevertheless introduce a referential argument (that can be further characterized by modifiers as in (47). This is in line with the arguments of section 2.5.3.

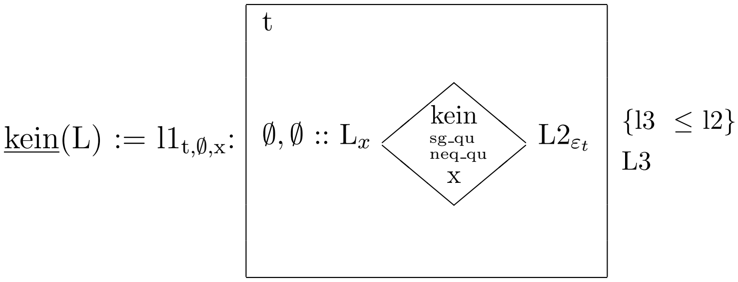
(47) *Stundenlang hat kein Kellner die Kochplatte ausgeschaltet.*
For hours no waiter turned off the stove.

Stundenlang / For hours must apply to an event or time. Since, in at least one reading of (47), *stundenlang* takes wide scope, *kein Kellner hat die Kochplatte ausgeschaltet*, though negated, must provide a corresponding event or time. Of course, in this case, as well as in the case of adverbial negation, this referential argument is the time for which a realization of the considered event type is excluded. Since, corresponding to the verb modeling of section 3.3 and to the conception of quantifiers in the preceding sections, the event of the verb representation comes with a focus time that is percolated through the verbal arguments, the negative quantifier just has to pick up this DRF from its bottom structure and define it as the referent of the result index (and similarly for the case of adverbial negation). This referent will be identified to a suitable contextual reference time via temporal resolution when the sentence representation is incorporated into the text representation (see section 3.11 for this).

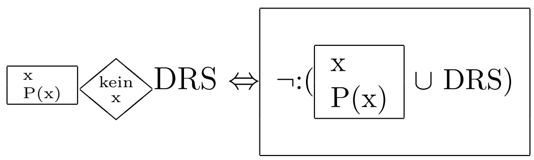
Therefore, in order to obtain the correct conditions of exclusion, it suffices to stipulate the following representation for the negative quantifier:

$$\text{kein} \longrightarrow \text{quantop\_t} \begin{bmatrix} \lambda\text{:} & \langle^{\text{npsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{kein}}(\text{L}) \end{bmatrix}$$

$$\underline{\text{kein}}(\text{npsem\_l}) \Rightarrow \text{detpsem\_l}$$



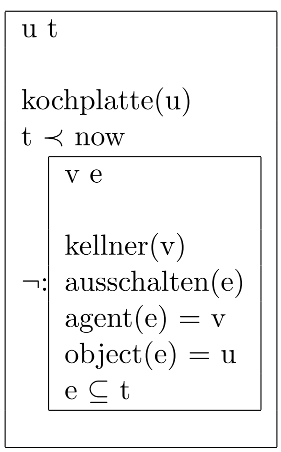
Of course, we assume the following equivalence:



We note that, like the other singular quantifiers, the negative quantifier does not introduce an upper referential index.

With this, suitably accommodating the definite description and a reference time (that identifies the focus time), we obtain the following correct representation of (45) as (unique) disambiguation of the underspecified representation that will be constructed from (45):

(45_{rep2})



3.4.5 The quantifier types—summary

As a kind of intermediate summary of the quantifier phenomena, as considered so far, the following typology reflects the distinctions which, to our opinion, must be made in any case:

- We distinguish positive from negative quantifiers:
  neq_qu: kein
  pos_qu: drei, einige, mancher, viele, jeder, alle ...

- We distinguish singular from plural quantifiers:
  sg_qu: kein, mancher, jeder ...
  pl_qu: drei, einige, viele, alle ...

- We distinguish increasing from decreasing quantifiers:
  decr_qu: kein, höchstens drei ...
  incr_qu: wenigstens drei, einige, alle ...

  incr_qu < *pos_qu*

- We are free to use other logical criteria if needed (persistency, for example).

- We introduce the subtype *universal quantifier*:
  univ_qu < *incr_qu*

- We introduce the subtype of quantifiers that are defined via comparison to contextually salient situations:
  comp_def_qu: wenige, viele ...
  comp_def_qu < *pos_qu*

- We introduce the subtype of numeral quantifiers:
  numb_qu: drei, vier ...
  (*numb_qu* < *pos_qu*)

- We introduce the subtype of quantifiers that are defined via cardinality:
  numb_def_qu: wenigstens drei, höchstens vier, einige, alle ...
  numb_def_qu < *pos_qu*

Depending on the purpose there might be used finer typologies.

3.5 Determiners

Consider the following examples:

(48)

a. Nicht jeder Impresario kennt einen Artisten.
It is not the case that every impresario knows an artiste.

b. Nicht jeder Impresario kennt den Artisten.
It is not the case that every impresario knows the artiste.

c. *Nicht jeder Impresario kennt einen berühmten Artisten (aus Hannover (der heute abend (hier (in der Talkshow (als Gaststar)) auftreten soll))). (Der Artist kennt aber jeden der Impresarios.)*
It is not the case that every impresario knows a famous artiste (from Hannover (that should appear this evening (here (in the talk show (as star guest))))). (The artiste, however, knows each of the impresarios.)

d. *Jeder Impresario hatte einen Artisten und einen Musiker verpflichtet und den Musiker besser bezahlt als den Artisten.*
Every impresario had engaged an artiste and a musician and had payed the musician better than the artiste.

e. *Jeder Impresario verpflichtet den Artisten der ihm am besten gefällt.*
Every impresario engages the artiste whom he likes best.

The examples (48) again illustrate the typical behaviors of definites and indefinites. (48.a) illustrates the existiential meaning of the indefinite DP and shows that the introduction of the corresponding DRF and conditions is dependent on the scopal structure of the sentence. The preferred reading of (48.a) introduces the content of the accusative DP within the scope of the representation of the nominative DP and the latter one within the scope of the negation. However, if there is enough material accompanying the semantic head of the indefinite, the indefinite DP can get a *specific reading*; i.e., the content of the indefinite DP can be accommodated at the highest (/some higher) level of the sentence representation (or its DRF can be identified to some suitable contextually available DRF of this level respectively). This is the preferred reading of (48.c), at least if a sufficient portion of the optional (parenthesized) material is taken into account.

Definite DPs are normally understood anaphorically, referring back to some previously introduced discourse referent (which is a specific reading, if the antecedent is member of the universe of the main DRS). However, if there is no suitable antecedent, via the presuppositional force of the same referential use, the DRF of the DP and its description can be accommodated also. Often this is the case if the sentence which introduces the definite DP is the first of a text or section or chapter of a longer text and tries to relate to common knowledge of author and recipient. This might be the preferred interpretation of (48.b), in case the sentence is used as such an introductory statement. To be precise, it is likely that in this particular case where there aren't given sufficient distinguishing criteria, it can be expected a supplementary description of the same individual in a later sentence which helps choosing it from the set of known individuals. In this case, instead of accommodating the antecedent we can *cataphorically* relate it to the DRF of this second description (which probably must be accommodated). Since, in this study, we will not treat problems of nominal resolution, we mustn't differentiate the referential use thus far.

It is clear, however, that the definite of the second sentence of (48.c) can be related anaphorically to an antecedent, namely the artiste, provided the indefinite of the first sentence obtains a specific interpretation. (Since, normally, resolution is preferred to accommodation, the presence of this second sentence contributes to preferring the specific reading of the indefinite while evaluating the first sentence therefore). All this is as discussed in section 2.7.1, and we will stipulate lexical entries for the definite and indefinite articles that introduce corresponding referential and thus presuppositional α-conditions.

(48.d) shows that the referential use of definites is not equivalent to specificity of the reading. Here, in contrast to the normal outcome, the definite is not resolved to the (or to a) wide scope position, it is resolved to a DRF introduced in the restrictor of a duplex condition. Provided the referential use of the definite, the same is true with respect to (48.e): The definite cannot be read specifically because its description uses a referential element, the pronoun, that must be bound to the *impresario*-DRF, which is introduced in the restrictor of the corresponding duplex condition. Under this interpretation, the definite description does not refer to a DRF for an artiste that is accessible from the main level of the sentence DRS, but to an individual of whom it is assumed that the impresario in question is familiar with. However, another reading of (48.e) seems to be much more likely: the one, in which the description is not referential, but is an attributive characterization of an individual in the perspective of the different impresarios such that the sentence means that, as a rule, an impresario is willing to engage just **the one** (not yet known) artiste who will please him most. Against the background of the approach as developed so far, which tries to explain aspects of quantification by the relational generalized quantifier modelling as far as possible, we will express this attributive meaning via a quantificational duplex condition, instead of using a *iota*-operator, as is suggested often. (This doesn't exclude defining such an operator from a corresponding duplex condition as a kind of abbreviating 'syntactic sugar'). Therefore, we will use a quantifier *der / the* and will interprete the corresponding duplex condition (which comes with empty or variable scope) according to the semantics of the *iota*-operator. A more serious question is presented by the fact that, as in (48.e), the attributive use of a definite description should obtain an intensional interpretation. (It is not necessary that for each of the impresarios there is such an artiste in the actual world, see section 5.3 for this).

With respect to indefinites, we must take into account what we have said in section 3.4.2. Next to the existential and the presuppositional (specific) meaning of the indefinite article *ein*, illustrated above, we must treat the (indefinite) specific use of numeral DPs also. Conversely, we must realize that *ein*, as a member of the number paradigme, has a reading as numeral quantifier also (*ein* in the sense of *one* instead of *a*, as in *genau ein Artist . . . (exactly one artiste . . .)*). Note that the distribution of the readings of numeral DPs into specific and (distributive) quantifier reading (which we've called the 'statistics' interpretation) corresponds to the referential-attributive-distinction of the definites. Finally, we have to take into account bare plurals. Here, without discussing this further, we assume that there is no other reading next to the exitstential one.

In the following, we list the indefinites and the extended definition of our sample numeral *three*:

• Indefinites and Numerals

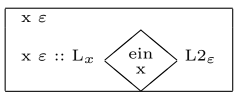
$\text{ein} \longrightarrow \text{det\_t}\begin{bmatrix} \lambda: & \langle^{\text{npsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{ein}}(\text{L}) \end{bmatrix}$

$\underline{\text{ein}}(\text{npsem\_l}) \Rightarrow \text{dpsem\_l}$
$\underline{\text{ein}}(\text{L}) := \underline{\text{det}_{ind,sg}}(\text{L}).$
$\quad := \underline{\text{q\_ein}}(\text{L}).$

where:

$\underline{\text{q\_ein}}(\text{npsem\_l}) \Rightarrow \text{qpsem\_l}$

$\underline{\text{q\_ein}}(\text{L}) := \text{l1}_{\varepsilon,x,x}$:



$\{\text{l3} \leq \text{l2}\}$
L3

$\underline{\text{det}_{ind,sg}}(\text{npsem\_l}) \Rightarrow \text{detpsem\_l}$

$\underline{\text{det}_{ind,sg}}(\text{L}_x) := \text{l1}_{\varepsilon,x,x}\text{: L} \; \{\text{l2} \leq \text{l1}\} \; \text{L2}_\varepsilon$

$\underline{\text{det}_{ind,sg}}(\text{L}_x) := \text{l1}_{\varepsilon,x,x}\text{: } \boxed{\alpha_{ind}(\text{x,L})} \; \{\text{l2} \leq \text{l1}\} \; \text{L2}_\varepsilon$.

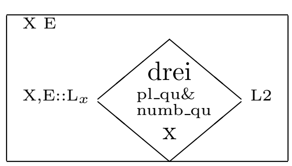
$\text{drei} \longrightarrow \text{det\_t}\begin{bmatrix} \lambda: & \langle^{\text{npsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{drei}}(\text{L}) \end{bmatrix}$

$\underline{\text{drei}}(\text{npsem\_l}) \Rightarrow \text{dpsem\_l}$
$\underline{\text{drei}}(\text{L}) := \underline{\text{det}_{ind,pl}}(\underline{\text{q\_drei}}(\text{L})).$
$\quad := \underline{\text{q\_drei}}(\text{L}).$

where:

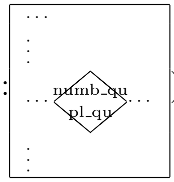
$\underline{\text{q\_drei}}(\text{npsem\_l}) \Rightarrow \text{qpsem\_l}$

$\underline{\text{q\_drei}}(\text{L}) := \text{l1}_{\text{res}(\langle\langle \text{E},①\rangle,\langle\varepsilon,②\rangle\rangle),\ \text{X},\ \text{res}(\langle\langle \text{x},①\rangle,\langle \text{X},②\rangle\rangle)}$:

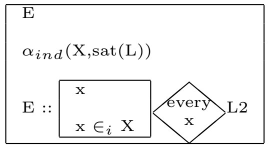


$\{①(\text{l3} \leq \text{l2}) \vee ②(\text{l3} \leq_n \text{l1})\}$
L3_ε

$\underline{\text{det}_{ind,pl}}(\text{qpsem\_l ; npsem\_l}) \Rightarrow \text{detpsem\_l}$

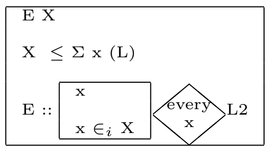
$\underline{\text{det}_{ind,pl}}(^{qpsem\_l}\text{L\&l}_{\_,X,\_}$: 

) :=

l1 res(⟨⟨E,①⟩,⟨ε,②⟩⟩), X, res(⟨⟨x,①⟩,⟨X,②⟩⟩): 

$\{①(l3 \leq l2) \vee ②(l3 \leq_n l1)\}$ $L3_\varepsilon$.

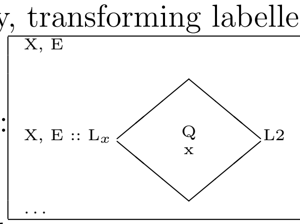
$\underline{\text{det}_{ind,pl}}(^{npsem\_l}\text{L}_x)$:=

l1 res(⟨⟨E,①⟩,⟨ε,②⟩⟩), X, res(⟨⟨x,①⟩,⟨X,②⟩⟩): 

$\{①(l3 \leq l2) \vee ②(l3 \leq_n l1)\}$ $L3_\varepsilon$.

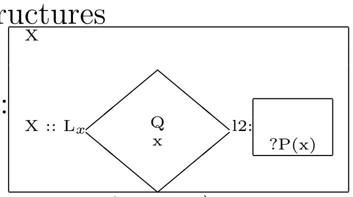
The entries reflect the ambiguity of the numerals including *ein*. *ein* as well as the plural numerals are assigned ‘true’ quantifier readings, via functions q_ein, q_drei and correspondingly q_zwei, q_vier, q_fünf, etc. A peculiarity is that the results are of a specific subtype of *dpsem_l*, namely *qpsem_l* (see section 3.4.3 for the introduction of this type). *qpsem_l*-labelled structures, in contrast to *detpsem_l*-labelled structures, can be modified by the definite determiner semantics, as we will stipulate formally below Thus, *der eine, die zwei, die drei, die wenigen, die vielen, ...* are accepted, not *die einige, etc.* Also, the (syntactically empty) indefinite plural determiner accepts quantized phrases . However, in this case, these phrases can be built from (plural) *numb_qu* quantifiers only as the first $\underline{\text{det}_{ind,pl}}$-definition above makes clear.

In case a determiner accepts a quantized phrase, this phrase is *saturated*, before it is plugged into the α-condition that is introduced by the determiner. Being saturated means that the disambiguation routine is applied under a specifically defined functionality, transforming labelled structures

$^{\text{dpsem\_l}}\text{l1}_{\_,X,\_}$: 

{...} L3

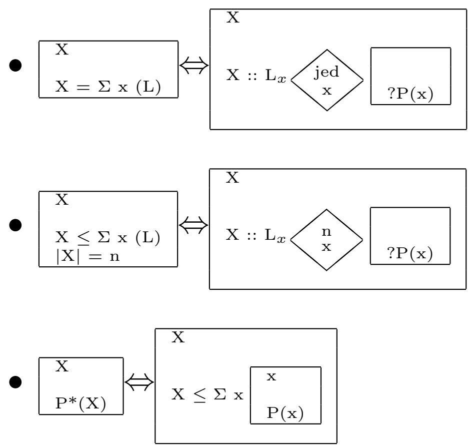
into labelled structures

$^{\text{satdpsem\_l}}\text{l1'}_{\emptyset,X,X}$: 

(see §A for a formal definition).

If the $\underline{\text{det}_{ind,pl}}$-determiner is applied to a NP representation, it obtains an existential meaning which can be specified into a collective and a distributive reading using the same formal means as introduced with respect to the collective-distributive ambiguity of numerals. It cannot obtain a referential meaning. In contrast, the singular indefinite determiner shows such a reading, besides the existential reading (which, of course, is unique in this case). In order to obtain a sum from the NP-representation the $\underline{\mathrm{det}}_{ind,pl}$-determiner exercises summation over its argument.

We remind the reader that, on the basis of the assumed underlying logic (see §5.3, also §2.7.2 and §A), there are certain equivalences that, as a consequence, signify that certain representations are notational variants of some others only, i.e. that they are syntactic sugar. Next to the one used above, in the following we list the cardinality statement about sums and Kleene-star. statements and the



(Here as before and throughout the paper, ?P, is a predicate (meta)variable which, according to the model theory of §5.3 will be assigned a set by the variable assignment of the sentence interpretation. Through this, it always obtains a wide scope interpretation. Instead of ?P(x), we also simply write ?(x) or use a DRS-variable).

The (syntactically empty) $\underline{\mathrm{det}}_{ind,pl}$-semantics enables constructing the bare plural semantics from noun phrases:

$$\text{impresarios} \longrightarrow (\text{dpsem\_t} \;;\; \text{npsem\_t}) \begin{bmatrix} \lambda\text{:} & \langle\rangle \\ \text{RES:} & \underline{\text{impresarios}}(\chi) \end{bmatrix}$$

$\underline{\text{impresarios}}(\text{ind}) \Rightarrow \text{itype\_l}$
$\underline{\text{impresarios}}(\text{x}) := \underline{\text{impresario}}(\text{x})$
$\underline{\text{impresarios}}(\text{X}) := \underline{\text{det}}_{ind,pl}(\underline{\text{impresario}}(\text{x}))_{\_,X,\_}$

According to this, the entries of plural nouns do not decide whether the corresponding item plays the role of a noun or of a DP. Depending on this decision, we obtain the semantics of the singular noun phrase counterpart or, via application of the indefinite determiner semantics, the DP semantics. The choice will depend on the sentential context. This strategy of flat entries that postpones categorial decisions is particularly relevant in case the suggested semantics is interfaced with a similarly flat or underspecified syntax.

Summarizing, from the above stipulations, we obtain semantic entries for numerals *ein, zwei, drei, ...* that, depending on the specific preconditions, are flat with respect to the distinction existential versus 'true' distributive quantifier versus referential (distributive or collective) determiner.

• Definites

We skip occupying with gender distinctions and restrict ourselves to represent the masculine singular determiner and the plural determiner. der $\longrightarrow$det_t $\begin{bmatrix} \lambda\text{:} & \langle^{\text{npsem\_l;qpsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{der}}(\text{L}) \end{bmatrix}$

$\underline{\text{der}}$(npsem_l;qpsem_l) $\Rightarrow$detpsem_l
$\underline{\text{der}}$(L) := $\underline{\text{det}_{def,sg}}$(L).
$\underline{\text{der}}$($^{\text{npsem_l}}$L):= $\underline{\text{q\_der}}$(L).

where:

$\underline{\text{q\_der}}$(npsem_l) $\Rightarrow$detpsem_l
$\underline{\text{q\_der}}$(L) := $\text{l1}_{\varepsilon,x,x}$: [x ε | x ε :: L_x ◇(der x) L2] $\{\text{l3} \leq_n \text{l1}\}$ L3_ε

$\underline{\text{det}_{def,sg}}$(npsem_l;qpsem_l) $\Rightarrow$detpsem_l
$\underline{\text{det}_{def,sg}}$($^{\text{npsem\_l}}\text{L}_x$) := $\text{l1}_{\varepsilon,x,x}$: [α_{def}(x,L)] $\{\text{l2} \leq \text{l1}\}$ L2_ε .
$\underline{\text{det}_{def,sg}}$($^{\text{qpsem\_l}}\text{L}_{\_,x,x}$) := $\text{l1}_{\varepsilon,x,x}$: [α_{def}(x,sat(L))] $\{\text{l2} \leq \text{l1}\}$ L2_ε .

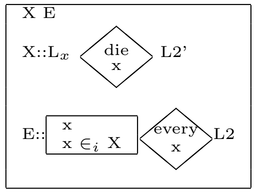
die $\longrightarrow$det_t $\begin{bmatrix} \lambda\text{:} & \langle^{\text{npsem\_l;qpsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{die}}(\text{L}) \end{bmatrix}$

$\underline{\text{die}}$(npsem_l;qpsem_l) $\Rightarrow$detpsem_l
$\underline{\text{die}}$(L) := $\underline{\text{det}_{def,pl}}$(L).
$\underline{\text{die}}$($^{\text{npsem_l}}$L):= $\underline{\text{q\_die}}$(L).

where:

$\underline{\text{q\_die}}$(npsem_l) $\Rightarrow$detpsem_l

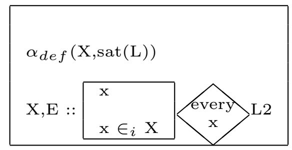
$\underline{\text{q\_die}}(\text{L}) := \text{l1}_{\substack{\text{res}(\langle\langle \text{E},①\rangle,\langle \varepsilon,②\rangle\rangle), \\ \text{X}, \\ \text{res}(\langle\langle \text{x},①\rangle,\langle \text{X},②\rangle\rangle)}} :$



$\{①(\text{l3} \leq \text{l2}) \vee ②(\text{l3} \leq_n \text{l1})\}$
L3_ε

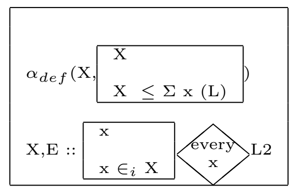
$\underline{\text{det}_{def,pl}}$(qpsem_l ; npsem_l) ⇒detpsem_l

$\underline{\text{det}_{def,pl}}(^{qpsem\_l}\text{L}_{\_,X,\_}) \quad := \quad \text{l1}_{\substack{\text{res}(\langle\langle \text{E},①\rangle,\langle \varepsilon,②\rangle\rangle), \\ \text{X}, \\ \text{res}(\langle\langle \text{x},①\rangle,\langle \text{X},②\rangle\rangle)}} :$



$\{①(\text{l3} \leq \text{l2}) \vee ②(\text{l3} \leq_n \text{l1})\}$
L3_ε .

$\underline{\text{det}_{def,pl}}(^{npsem\_l}\text{L}_x) \quad := \quad \text{l1}\ \substack{\text{res}(\langle\langle \text{E},①\rangle,\langle \varepsilon,②\rangle\rangle), \\ \text{X}, \\ \text{res}(\langle\langle \text{x},①\rangle,\langle \text{X},②\rangle\rangle)} :$



$\{①(\text{l3} \leq \text{l2}) \vee ②(\text{l3} \leq_n \text{l1})\}$
L3_ε .

Both , the singular and the plural definite determiner have an attributive reading which is restricted to NP-arguments, where the representation of the NP-argument instantiates the restrictor of a corresponding attributive condition, the scope of which is not instantiated. The VP-argument is merged to the resulting DP-representation or, in the plural case, similarly to the quantifier reading of indefinites or numerals, it can instantiate the scope of an alternative universal quantification.

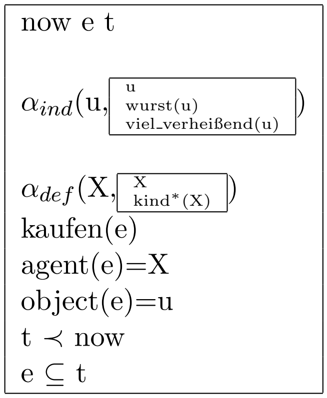
Both determiners show also referential readings, where in both cases, these readings can be obtained from application to NPs and to qpsem_l-structures also (*der eine Mann, die vier Männer*). In this latter case, quite similarly to the corresponding $\underline{\text{det}_{ind,pl}}$-application, the qpsem_l-argument is saturated first. As usual, next to merging the VP-argument to the resulting DP-representation, the plural variant allows 'optional' distribution via an additional duplex condition also. .[7] Besides this, the entries should be rather self-explanatory. It goes without saying that, in all referential cases, the (saturated) DP- or NP-argument instantiates the description of a α_{def}-condition.

We conclude this section with some sample sentences and corresponding disambiguated representations that illustrate the range of the chosen quantifier and determiner modeling.

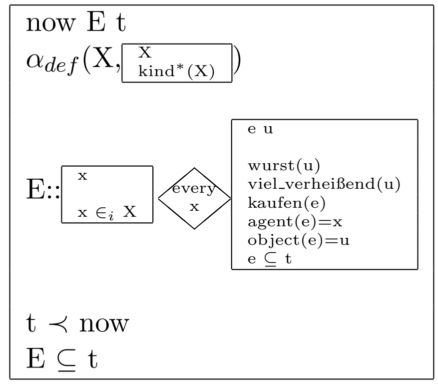
[7] In representations that are disambiguated towards the collective reading, we can (and do often) leave out the universal quantification condition, since, in these cases, it is the empty condition.

(49) *Die Kinder kauften eine viel verheißende Wurst.*
The children bought a promising sausage

$(49_{rep.a})$

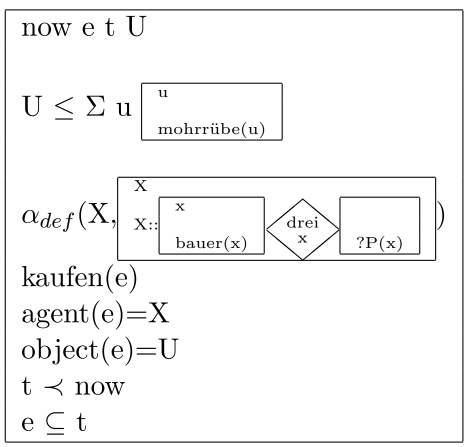


$(49_{rep.b})$



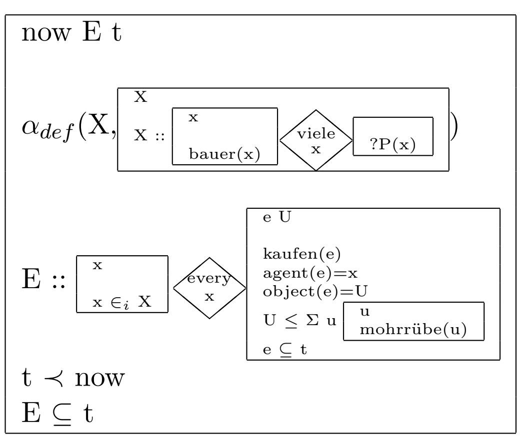
(50) *Die drei Bauern kauften Mohrrüben.*
The three farmers bought carrots.

(50_{rep})



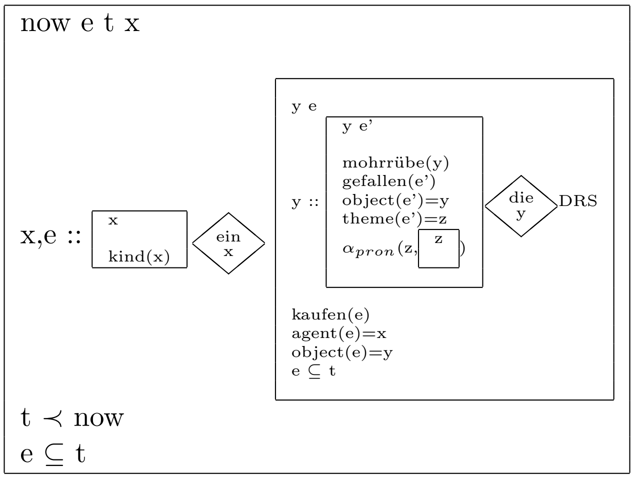
(51) *Die vielen Bauern kauften Mohrrüben.*
The many farmers bought carrots.

(51_{rep})



(52) *Ein Kind kaufte die Mohrrübe, die ihm gefiel.*
One child bought the carrot that pleased him.

(52_{rep})



Although we will say something about the impact of the tense information only in §3.11, the representations contain corresponding contributions. We say nothing further about this here. ($49_{rep.a}$) and ($49_{rep.b}$) combine the alternative referential readings of the definite determiner applied to a plural noun with the attributive and existential reading of the indefinite singular determiner respectively. In (50_{rep}) the definite determiner modifies a *qpsem_l*-labelled phrase and is disambiguated to the collective reading. Also, the normal collective reading of a bare plural is represented. In (51_{rep}), the definite determiner also modifies a *qpsem_l*-labelled phrase, but is disambiguated to the distributive reading. In (52_{rep}) the articles obtain true quantifier interpretations, such that the assumption is that there is just one child who bought a carrot such that this carrot is the only one that pleased a contextually available individual (this the reading of the pronoun), probably the child himself.

3.6 Adverbs and adjectives

3.6.1 Overview

Adverbial and adjectival modification does not present a homogeneous picture. Consider the following simple sentences which try to exemplify prototypical kinds of modification:

(53)

a. *Das* GRÜNE *Auto fährt.*
The green car works/moves

b. *Inge kam* HIERHER.
Inge came here.

c. *Hans sah einen* KLEINEN *Elephanten.*
Hans saw a small elephant.
d. *Peter lief* SCHNELL *zum Bahnhof.*
Peter ran to the station quickly.
e. DAMALS *lebte ein kleines Mädchen im Hutzelwald.*
At this time, a little girl lived in the Hutzelwald.
f. *Der* EHEMALIGE *Lehrer kennt ihn.*
The former teacher knows him.
g. VIELLEICHT *scheint die Sonne.*
Maybe the sun is shining.
h. *Der* ANGEBLICHE *Mörder wurde gefasst.*
The alleged murderer was caught.
i. ERFREULICHERWEISE *schien die Sonne.*
Fortunately the sun was shining.
j. *Manfred arbeitete* STUNDENLANG.
Manfred was working for hours.
k. STUNDENLANG *sprang Hansi in's Wasser.*
For hours, Hansi was jumping into the water.
l. ERST *kam Hansi.*
Hansi came first.
m. *Nachdem Inge gekommen war, kam Peter* ERST.
Only after Inge had come, Peter came.
n. *Peter ging* OFT *spazieren.*
Often, Peter went for a walk .
o. *Peter und Inge sprangen* gleichzeitig.
Often, Peter and Inge jumped at the same time.

Remind that we want to classify the linguistic material according to the formal properties of the representations which we assign to them instead of relating to the interpretation of the representations. With respect to adverbial and adjectival modification, this means that we are not interested in subclassifying circumstancial adverbs say into temporal, spatial and manner adverbs but in distinguishing modifiers which confirm the predication of the modificandum about its discourse referent (and refine them) from modifiers which revise this predication (and/or the identity of the discourse referent). The members of the first group are generally called *intersective modifiers*. (53.a)–(53.d) are sentences which make use of intersective adverbial and adjectival modifiers and also (53.j), (53.l), (53.m) and (53.o). We call a word a *modifier*, if, semantically, it is a one-place functor whose argument has the same type as its result. In addition, with adverbs and adjectives, we concentrate on modifiers which are *Xtype*-modifiers, i.e. which show a distinguished discourse referent which is the control variable of the modificandum. Since we assume that, besides V/V-, VP/VP-, N/N- and NP/NP-modification, as in (53.a)–(53.f), in (53.h), in (53.j)–(53.o), adverbs and adjectives respectively effectuate also S/S-modification and DP/DP-modification of the modificandum (see the discussion of the example (53.i) below, section 3.6.4about examples like (53.g) and (53.i) and section 3.6.3), adverbial and adjectival modification exhausts the entire range of*Xtype modification* and, therefore, is correctly identified by this term. *Intersective* Xtype-modification means that the modificandum, which is (/can be seen as) a one-place-Xtype-predicate, is specified by the modifier such that its extension is restricted: The modifier adds a new predication about the distinguished discourse referent of the Xtype to the set of conditions of the Xtype. Schematically this can be represented by the following transition, where M is the argument-characterization and Mod the contribution proper of the modifier:

λ x . M(x) $\longrightarrow\lambda$ x. (M(x) $\wedge$ Mod(x))

(53.a)–(53.d) present typical examples of intersective modifiers and illustrate that there are formally different subtypes of this class of modifiers: Mod may or may not be one-place (*hierher* introduces a new DRF – for the place it describes – *grün* does not). Additional arguments may or may not be discourse referents for objects or individuals: They may be qualities also (generally, it is assumed that *klein, schnell* attribute small size and big velocity with respect to a specific class of objects/individuals only, *small for an elephant* say). We will say more about this in the next section, where we will model the genral format of intersective modifiers.

(53.e)–(53.i) present typical examples of what we call *embedding modifiers*. In contrast to the intersective case, the modifier doesn't add a condition about the Xtype-DRF but changes the Xtype-predicate such that, in the model, the extension of the modificandum is shifted (the extensions of the argument of the modifier and of the result aren't contained in each other). With respect to representation this means that the modifier, instead of introducing an additional DRS-condition, *embeds* the argument representation in a new, complex condition: The representation of the modificandum is subordinated to the representation of the modifier. Schematically, for such non-contracting functions from Xtypes into Xtypes, we assume the following transition:
λ x . M(x) $\longrightarrow\lambda$ y . Mod(λ x. (M(x))(y)
(with M in the domain of Mod such that λ y . Mod(λ x. (M(x))(y) $\not\subseteq$ λ x . M(x)). Intuitively, it should be clear why (53.f)–(53.h) are examples of shifting modifiers: A person characterized by *angeblicher M"order/alleged murderer* is not necessarily a *M"order/murderer*. Similarly, a situation characterized by *vielleicht schien die Sonne* is not necessarily one in which the sun is really shining. For a person characterized by *ehemaliger Lehrer/former teacher*, one can be even quite certain that he or she is not a *Lehrer/teacher* at present.

Maybe that it is not so clear why we assume that (53.e) and (53.i) show embedding modification. In section 3.6.3, which is about what we call *situational shift*, we will argue that modifiers like *damals*not only relate to the event of the sentence (providing some reference time for it), but to the whole situation described, including the characterization of the DRFs figuring in this situation, such that, similar to the modification of of adjectives like *ehemalig/former*, these characterizations may be 'relativized' to some contextally relevant time (such that it cannot be asumed that they hold for the time of evaluation).

In section 3.6.4, which is about *modal modifiers*, we will argue that *erfreulicherweise* is a modal modifier which, though confirming the existence of the event of the argument, just like the other modal modifiers, is not intersective because it does not relate to this event but to the situation which **contains** this event (meaning that the modifier turns an event-predicate into a predicate about situations (or facts or propositions)–in other (more traditional) words: the modifier is a sentence modifier, not a VP-modifier). In this section we will treat also a number of other modal modifiers including those of (53.f)–(53.h). [8]

(53.j) and (53.k) document the existence of Xtype modifiers (adverbs in this case) whose semantic contribution can change, depending on the structural properties of their argument. Adverbs like *stundenlang* require a specific *Aktionsart* of the argument event type in order to be intersective. If the argument has another Aktionsart, as in (53.k), this argument can be *reinterpreted* via applying a suitable type changing operation so that the resulting argument representation conforms to the constraints of the modifier. Thus, *stundenlang* requiring *homogeneous* Aktionsart of its VP-argument (which means something like that parts p of a corresponding event e, better: of a corresponding process or state, are of the same type as e), where *Maria working/being at work* has this Aktionart, in (53.j), the modifier just adds a condition to the argument representation which informs about the duration of the considered process of working. In contrast, in (53.k), the argument event type Hansi jumping into the water is *heterogeneous*, at least with respect to its preferred reading which is Hansi jumping into the water one time.We see how the conflict between this and the expectation of the modifier is solved: The argument is reinterpreted by applying a conventionalized rule of cooperation about the interpretation of event types, which, in this case, is *iteration*. This yields something like *Hansi jumping into the water again and again*, which, easily, can be characterized as lasting for hours. (Of course, in this case, the DRF which is picked up by the modifier is not the distinguished DRF of the original argument representation, but the (sum-)DRF

[8] The explanation of what we call shifting modifier, via the formula λ x . M(x) $\longrightarrow \lambda$ y . Mod(λ x. (M(x))(y), is certainly not very enlightening as it stands, at least not with respect to adverbial modification, because there, in contrast to to adjectival modification, the argument is a more-place functor (the semantic representation of a verb or of a verb projection which is not necessarily maximal), so that, next to the event variable there will be a number of other DRFs bound by lambda operators (for the subcategorizd functions not yet applied). Without going into details with this here, we assume that this is solved by semantic composition making use of functional composition so that adverbial modification may apply to a one-place-predicate about the event variable where the bearers of the verb roles, like traces, are seen as constants from the perspective of this modification and where the corresponding lambda prefixes are passed from the argument to the resulting representation. Hence, a more adequate sketch of what we mean by embedding modification is:
λt1 ... λt1 λ x . M(x) $\longrightarrow$ λt1 ... λt1 λ y . Mod(λ x. (M(x))(y))).

of the representation which develops from this by iteration; this means that *stundenlang* is intersective in the first case, which is the normal case so to speak and which is exemplified by (53.j), but not in the second reinterpretation case which is exemplified by(53.k)). We deal with such phenomena in section 3.6.5, which is about aspect- or Aktionsart-changing operations, frame- and duration-adverbials and other modifiers which can trigger such operations. We call the corresponding modifiers*Aktionsart sensitive modifiers*.

(53.l) and (53.m) show that there are adverbs which are (in another way) ambiguous with respect to the different formal classes of modification: Next to the interpretation as temporal adverb, where, formally, a condition will be introduced which relates the argument event to some contextually available reference time, *erst* can obtain a focus adverb interpretation, where the formal representation cannot do without presuppositions about the expectations of speaker (and hearer). We say something about *erst* in particular and focus adverbs in general in section 3.6.7.

We will consider *frequency adverbs*, as in (53.n),which, as quantificational adverbs, are a specific subclass of embedding modifiers, in section 3.6.8.

Finally, in section 3.6.6, we will treat modifiers like the adverb *gleichzeitig* in (53.o), as a specific case of circumstancial modification which make specific assumptions about the structure of their (sum-)argument and which we call *control modifiers* therefore. (Though they share this property with the modifiers that we have called Aktionsart sensitive modifiers we handle the cases in different sections, separating the introduction of Aktionsart-functions like the sketched *iteration*, which **change** the argument representation, from means which (conservatively) **specify** this representation only).

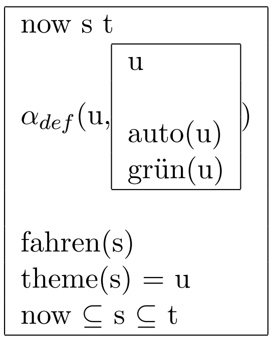
We repeat that, the purpose of this paper being investigating the formal **basis** of a FUDR theory, we do not go into great detail with any of the mentioned modifier types. We are aware of the fact that the mentioned types do not exhaust the possibilities of adjectival or adverbial modification. [9]

[9]We add that, of course, the introduced distinction of embedding from intersective adjectives and the other classifications are not findings of the investigations which led to this report. There is a wide range of literature which treats the mentioned and (the) other (sub-) types of modification, see for instance [Cresswell(1985), Kamp(1975), Abraham(1989)]. Since, instead of presenting critical reflections on the literature and presenting fine-grained alternative analyses of particular modifier types which may develop from such reflections, the aim of this study is to listing the main (DRT-type) representation categories (based on fundamental model-theoretic distinctions) for such analyses, we do not relate to the relevant literature in every place where this is possible, and we use the terminology introduced above because it seems relatively striking with respect to this purpose. Nevertheless, we mention that the used distinction of intersective and embedding modifiers corresponds relatively closely to the dichotomy between *restrictive* and *non-restrictive* modifiers which is often used, where the intersective modifiers are restrictive, and where what we call embedding modifiers are non-restrictive. Also, frequently, the restrictive modifiers are partitioned into referential and non-referential modifiers, where the non-referential modifiers are sometimes called *relative*. The scalar adjective of (53.c) is an example of a relative modifier, because its contribution depends on making reference to some (contextually available?) scale which measures size. To subclassifications of modifiers in this terms and to their representation see also [Pinkal(1985)].

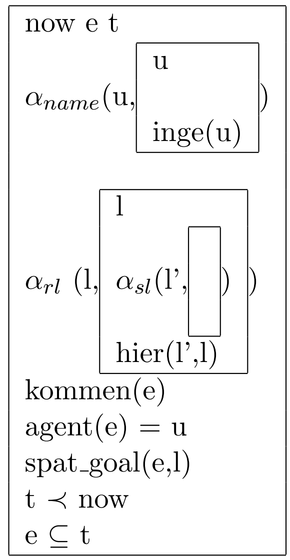
3.6.2 Intersective modifiers

The examples (53.a)–(53.d) of the last section make clear that we must distinguish several subtypes of intersective modifiers. Consider the representations (53.a$_{rep}$))–(53.d$_{rep}$) to this purpose:

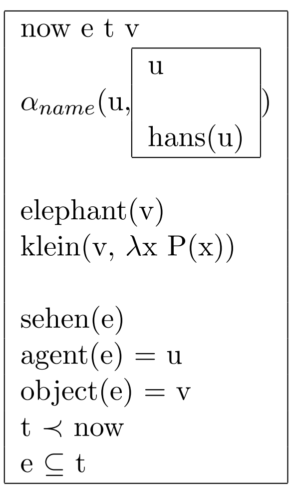
(53.a$_{rep}$)



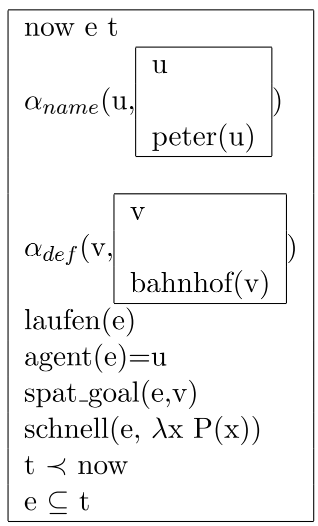
(53.b$_{rep}$)



(53.c$_{rep}$)



(53.d$_{rep}$)



According to (53.a$_{rep}$), *grün* is analysed as a *predicative* NP-modifier. This means that it introduces a one-place predicate that is applied to the distinguished referent of the semantics of the NP-argument (*gr"un(u)*). (53.b$_{rep}$) shows that, in contrast, *hierher* introduces a more-place predicate and provides a referential argument, where the introduced relation is required to hold for this referential DRF and the distinguished DRF of the argument semantics (*spat_goal(e,l)*). Because of this relating the argument DRF to a (newly introduced) DRF for an object or individual, we call such modifiers *object relational*modifiers. According to (53.c$_{rep}$), *klein* is analysed as a modifier which we call an *aspect relational* modifier. In contrast to the object relational modifier, the second argument is a predicate which informs about the aspect which the scalar modfier relates to. With this, the predication the modifier introduces is relativized to this particular aspect. With respect to ($53.c_{rep}$), this means that it is nothing said about whether the elephant v is *klein/small* in some absolute sense (*klein(v)*), the representation only asserts that v is small with respect to *being a P* ($\lambda x.\ P(X)$), which is expressed by the condition *klein(v,* $\lambda x.\ P(X)$*).* In ($53.c_{rep}$), it is nothing said about the nature of this aspect. Of course, mostly, the aspect P will be the argument predicate, which, in the example, is $\lambda x.$ *elephant(x)* (such that the predication means *small for an elephant*in this case). However, P can also be another aspect, *big game* say, in the example, or some other aspect which is contextually relevant at the time of presenting the qualification. The least that can be said is that it must (can) be (presupposed as) a property of the argument DRF. (It doesn't make sense to qualify an elephant as *small for a screw*, i.e. to assume $\lambda x.$ *screw(x)* as an aspect providing a specific scale for size). With respect to ($53.d_{rep}$), which represents a VP-example of an aspect relational modifier, the relevant aspect which the adverb *schnell* relates to might be the event (process) type *Peter running*, yielding the qualification *fast for a running of Peter*, or the type *running of a human being* or *running*) (*of a living being in general*) or the type *moving of Peter/human being/etc.* or the process type in general (and possibly others).

For simplicity, we will suppose that the aspect is commonly the head predicate of the modified phrase including representations of the subcategorized functions which restrict the corresponding DRFs to the respective head predicate or that the aspect is a generalization of this conjunction, in accordance with the available hierarchy of semantic types. [10] As in the representations ($53.c_{rep}$) and ($53.d_{rep}$) above, we will mostly skip retaining such an assumption however. Note that, independent of this restriction to generalizations of mentioned predicates, the informationless characterization ($\lambda x.entity(x)$) is an aspect candidate. Hence, in a way, the absolute meaning of scalar adverbials is a specific case of our modeling of the general meaning.

As it seems aspect relational modifiers do not introduce referential arguments (in contrast to object relational modifiers, the aspect cannot be referenced by referential terms (like personal and other pronouns)).

Summarizing, throughout the rest of this paper, by *aspect* we mean a one place predicate that is used to point to a particular perspective under which an individual or event is considered. Among other things, we use aspects for 'relativizing' scalar modification. [11]

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[10] Using KL-ONE-like notation, for the *schnell*-example, we will assume therefore the following (hierarchies of) types as subset of the set of aspect candidates: RUNNING $\cap$ agent:PETER $<$ RUNNING $\cap$ agent:HUMAN $<$ RUNNING, MOVING $\cap$ agent:PETER $<$ MOVING $\cap$ agent: HUMAN $<$ MOVING, PROCESS.

[11] What we call aspect relational modifier is very similar to what in [Pinkal(1985)] and elsewhere is called *privative* modifier. Privative modifiers are specific modifiers of the λy. Mod(λx. M(x))(y)

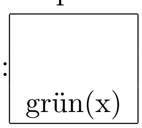
The representation (53.b_{rep}) adds new types of α-conditions to the set introducd in section 1.3, namely α_{sl} and α_{rl}. α_{sl} points to the *speech location*; i.e., the landing site of the corresponding projection must be the main DRS level and must be identified as the place of the speaker (the *hic*). α_{rl} points to some salient spatial *reference location*. (In the specific case of *hier* or *hierher*, it points to a place that overlaps with the speech location (via the condition *hier(l',l)*); a broader account of *hier* and *hierher* probably has to replace the reference to the speech location by the weaker reference to some salient (personal) perspective location that may be introduced via an α_{pl}-condition (*pl* for *perspective location*), see [Roßdeutscher(1996)] for corresponding data.) We skip saying something about the representation of the tense information. See section 3.11 for this.

According to the representations (53.a_{rep}) – (53.d_{rep}), we stipulate the following lexical entries:

grün $\longrightarrow$mod_npsem_t $\begin{bmatrix} \lambda\text{:} & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{grün}}(\text{L}) \end{bmatrix}$

<u>grün</u>(npsem_l) $\Rightarrow$npsem_l

<u>grün</u>(L) := $l1_x$:

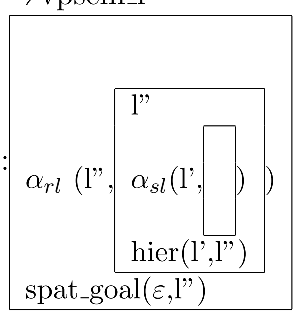


$\{l \leq l1\}$ L_x

hierher $\longrightarrow$mod_vpsem_t $\begin{bmatrix} \lambda\text{:} & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{hierher}}(\text{L}) \end{bmatrix}$

<u>hierher</u>(vpsem_l) $\Rightarrow$vpsem_l

<u>hierher</u>(L) := $l1_\varepsilon$:



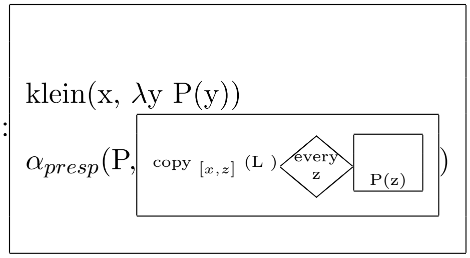
$\{l \leq l1\}$ L_ε

klein $\longrightarrow$mod_npsem_t $\begin{bmatrix} \lambda\text{:} & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{klein}}(\text{L}) \end{bmatrix}$

<u>klein</u>(npsem_l) $\Rightarrow$npsem_l

type in that they assume the modificandum M(x) to be factual (or presuppositional). In our treatment, we have incorporated this property into the representation format directly by treating this type of modifier as a specific intersective modifier, this is by a modifier which doesn't change the argument representation but adds conditions to it.

klein(L) := $l1_x$:

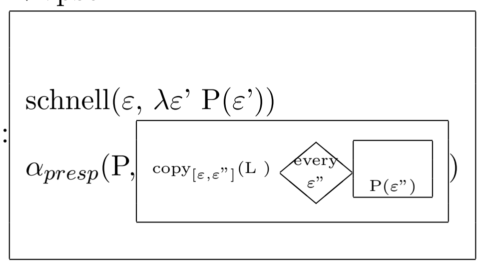


$\{l \leq l1\}$
L_x

schnell ⟶mod_vpsem_t $\begin{bmatrix} \lambda: & \langle L \rangle \\ \text{RES:} & \underline{\text{schnell}}(L) \end{bmatrix}$

schnell(vpsem_l) ⇒vpsem_l

schnell(L) := $l1_\varepsilon$:



$\{l \leq l1\}$
L_ε

The entries show the requirement about the aspect relational modifiers which we have omitted in the representations of the sample sentences: The aspect of the predication is assumed to be conceptually linked to the type of the argument representation. We assume this aspect to be some salient generalization of the argument type (where the α_{presp}-presupposition condition is meant to express salience through that it presupposes P as an accessible discourse referent, which, here, is a quality which the discourse presents as a quality which can be inferred for the argument DRF. *copy* is the DRS *copy*-operator introduced in section 1.4, where the subscript designates constraints about the renaming of the variables).

3.6.3 Situational shift—temporal and spatial modification

Consider the following pair of sentences which varies the position of the temporal/situational modifier *damals*.

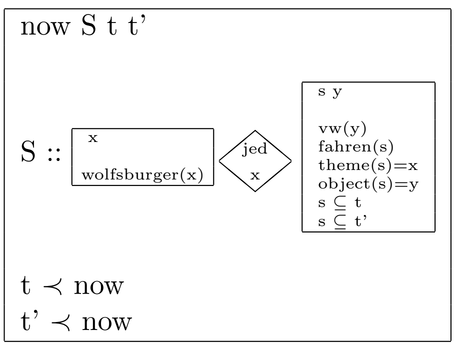
(54)

a. *Jeder Wolfsburger fuhr damals einen VW.*
   Every inhabitant of Wolfsburg drove a Volkswagen at that time.

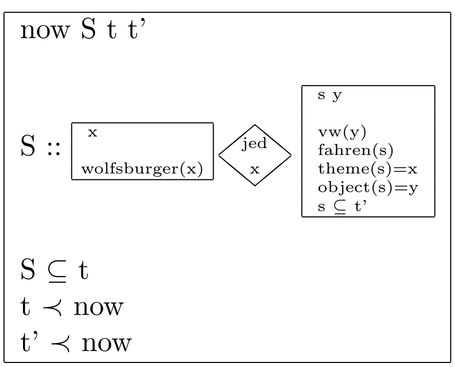
b. *Damals fuhr jeder Wolfsburger einen VW.*
   At that time, every inhabitant of Wolfsburg drove a Volkswagen.

As it seems, the two sentences of (54) suggest different readings which show a subtle difference concerning the respective temporal organisation. What is the nature of this difference? Because of the different position of the adverbial one is rapidly inclined towards saying that the difference consists in that (54.a) prefers the narrow scope reading of the adverbial (with respect to the subject DP), whereas (54.b) prefers the wide scope reading. However, can this explain the difference correctly? What we get from this is that in the first case, the narrow scope case, each driving situation is temporally related to its individual *damals*, whereas in the second wide scope case the different driving situations are jointly located by one single *damals*. Independently of this, i.e. independently of the position of *damals* in the sentence or in its representation, there is the strong impression that *damals*, which is a referential expression, is meant to refer to one unique past perspective time. On this premise (that *damals* is interpreted de re) we obtain the following narrow and wide scope representations (54.$a_{rep'}$) and (54.$b_{rep'}$) (where the presupposition content from *damals*, in both cases, because of the missing context, cannot be resolved, but is accommodated to a wide scope perspective time–outside of this, we assume 'normal' scope order of the verb roles and existential reading of the indefinite):

(54.$a_{rep'}$)



(54.$b_{rep'}$)



We see that (54.$a_{rep'}$) and (54.$b_{rep'}$) differ in that the accommodated perspective time t temporally anchors the states s of the scope of the duplex condition in the first case (narrow scope) or the sum S that is abstracted from this duplex condition in the second case (wide scope). (The relation(s) to t' interpret the meaning of the tense form, we come back to this in section 3.11). Now, we have to be aware of the fact that temporal localizations – and spatial localizations also, which is relevant for the further discussion below – are *distributive predicates* (following the terminology of [Link(1983)]). Distributive predicates P satisfy the following equivalence:

$\forall$ X (P(X) $\leftrightarrow$($\forall$ x $\in_i$ X P(x)))

This means that P is true for a sum X if and only if it is true for all of the atoms, say elements, of X. From this, obviously, we can conclude that (54.$a_{rep'}$) and (54.$b_{rep'}$) are logically equivalent, i.e. that they represent the same situation. So, what does the difference between (54.a) and (54.b) come from and what is it if the different scopal interpretations of the adverbial collapse into one proposition?

The difference concerns the effect the temporal localization has with respect to the quantified verbal role. One may wonder whether it is purely pragmatic, meaning that the situation described is the same but the information structure is different, with different presuppositional consequences and implicatures. It is true that (54.a) and (54.b) can be interpreted differently by assigning different information structures which cause a difference with respect to presupposition of a type which the following pair of sentences, because of its simpler structure, (55) brings out much more clearly:

(55)
a. Gestern schwamm jeder Wolfsburger.
Yesterday, every inhabitant of Wolfsburg swam.
b. Jeder Wolfsburger schwamm gestern.
Every inhabitant of Wolfsburg swam yesterday.

Provided neutral intonation, the pragmatic contribution of (55.a) is to provide information about what happened yesterday. This means that it presents *jeder Wolfsburger schwamm* as new information against the contextual background which is provided by *heute*. This distinction in background and new information, in presuppositional and assertional part of the information, is also easily available for (55.b), provided neutral intonation. However, because of the slightly marked order, one also easily would assign an accent to the postverbal position. In this case, the information could be partitionned conversely: We presuppose the *swimming of every inhabitant of Wolfsburg* and add as new information that this happened yesterday. Depending on the markedness of the (postverbal) accent and of its scope, according to Rooth's explanation and representation of focus, we can obtain for (55.a) the new information that the swimming was done by **all** inhabitants of Wolfsburg and not by a subset of them only or that it was done by the inhabitants of Wolfsburg and not by the inhabitants of some other city, where the new infomation consists of the respective positive statement **and** by presuppositionally excluding the alternatives. For (55.a), in contrast, we obtain that the swimming happened today and not at some other day. We take from this that the different surface order of (55.a) and (55.b) may suggest intonation patterns which cause different structuring of the information so that the described situation is the same in both cases but not the information which can be concluded by presupposition or implicature. The same is true with respect to our example (54), the only difference being that, because of the additional verbal role, things are more complicated here. [12] However, we think that, in contrast to the case presented by (55), with respect to (54), the (positively) described situations are different also, so that the sketched partitioning of the information doesn't provide a solution to the interpretational difference. We think that the situations differ in that the wide scope reading of (54.b) not only presents a location time for the (sum of) events that the sentence introduces, it also strongly suggests a perspective from which the whole scenario is described, and this, essentially, means that it restricts the attention onto those individuals only that, seen from the *damals* perspective, are inhabitants of Wolfsburg, i.e. onto those individuals that satisfy the property $\lambda x.\ wolfsburger(x)$ in the *damals*-situation (independently of whether those individuals are (still) inhabitants of Wolfsburg with respect to the main level *hic et nunc* perspective). In contrast, the narrow scope reading doesn't suggest a similar restriction about the quantified constituent in the same way.

Two questions arises if this truly describes the relevant difference between (54.a) and (54.b) . Firstly, what is the cause for restricting the range of quantification onto those individuals which live in Wolfsburg at the time of the event? Is it really the wide scope reading of the temporal adverbial that triggers this restriction ? Secondly,

---

[12] Here and throughout the rest of the study we base our understanding of focus and the corresponding structuring of the information on Rooth's interpretation of focus structure, and especially on his interpretation about the implicatures that are made about the alternatives of the focussed element ([Rooth(1985), Rooth(1992)]). One must be aware of the fact however, that, at least with respect to examples like (54) or the following, similar (56), things are not thus simple as described above.

(56)

a. *Heute fuhren die meisten Autos über die Brücke.*
Today, most of the cars crossed the bridge.
b. *Die meisten Autos fuhren heute über die Brücke.*
Most of the cars crossed the bridge today.

With respect to such sentences with richer modification structure, we seem to accept relatively easily interpretations with double focus instead of one focussed consitutent. One of the first to note and model this is [Büring(1996)]. For (57) this means that, next to the verb and the consituents (or substructures of them), pairs of consituents may be focussed (*die meisten Autos :: über die Brücke* in the first case, *heute :: über die Brücke* in the second). Of course, the number of different presuppositions and implicatures that arise from these possibilities of structuring is enormous. In order to assess the relevance of the different interpretations, in addition one must account for the influence which is exerted by the nature of the constituent. In particular, the different types of quantifiers make things complicated: Replace *die meisten* by *einige* in the example and, as it seems, the preferred scenarios are slightly different. This has to do with different behaviors of the quantifiers with respect to optional collectivity (distributivity) and with diverging referential impact. We cannot consider this further here.

how should this restriction be represented?

We could introduce an additional temporal argument for nominal predicates like *wolfsburger* which restricts the validity of the predication for some x to its 'lifetime' which is expressed by this second argument. This yields predicates like $\lambda x,\ t.\ wolfsburger(x,t)$. In contrast, we can make use of the DRT-condition type for states which 'relativizes' the predication to the extension of the described state. For instance, s: [ill(x)] means that there is a state *s* for which it holds that the interpretation of *x* is in the extension of the predicate *ill* (such that for all substates s' of *s* the same is true, i.e. it holds: s': [ill(x)]). We will make use of this second representation type, generalizing it so that the description of the state (to the right of the colon) isn't necessarily a box with just one relational condition, but an entire DRS. This requires extending convential DRT model theory accordingly, in particular partitioning DRT-worlds into situations, in this respect similarly to Barwise and Perry's conception of *situation theory* ([Barwise/Perry(1983)]). See section 5.3 for this. Compare also Shoham's theory ([Shoham(1987), Shoham(1988)]), where it is shown and used that temporal arguments can be avoided and equivalently replaced by the use of 'relativizing' times of evaluation. We choose this type of representation mainly for three reasons: It is notationally simpler (it 'relativizes' conditions to states only if needed, in particular it avoids the use of more complex predicate symbols and it avoids 'relativizing' the (homogeneous) conditions of a DRS to the *hic et nunc* of this DRS), it is more general (a situation may show its own universe and may be described by more than one condition) and it is much simpler with respect to compositional semantics and corresponding construction, as will be exemplified by constructing the representation of our example (54).

When trying to find an answer to the first question we must be aware of the fact that relating the description of a thematic role to some time that is different from the speech time–i.e., relativizing the validity of the role description to some contextually given reference or perspective time which is not the *now* of the utterance–is a procedure which does not presuppose an explicit (wide scope) modification that comes from a temporal adjunct and which, even in this case, is not as rare as one might think. Compare the following examples for this:

(57)
- a. *Der Bittsteller wurde positiv beschieden.*
  The petitioner got a positive response.
- b. *Jeder Bittsteller wurde positiv beschieden.*
  Every petitioner got a positive response.

Normally, a person is a petitioner only as long as his petition is not accepted or rejected. This means that the individual(s) of (57) aren't correctly characterized by *Bittsteller* when considering the main level DRS. The sentences exemplify that all cases where the characterization of a thematic role conflicts with the conclusions which can be drawn from the event about the properties of this role before or after the occurrence of the event are instances of the representation problem where particular periods of validity are required for particular characteriziations of roles. Other examples are presented by sentences where the characterization is known to be temporally relatively restricted so that, given some sufficiently extended time span between event and speech time, world knowledge tells that the description cannot hold at the main DRS's *now*. Among others, [Shoham(1987), Shoham(1988), Hinrichs(1987)] treat such phenomena (from different standpoints–from an AI-position and from a more linguistically motivated position) and present approaches to it (so that the characterization of the bearer of a thematic role can be related to a time different from the speech time). Using the representation means as suggested above, a (sketchy) representation of (57) might look as follows:

(57.a_{rep})

now e t

α_{def}(x, [x s t | b; s: [bittsteller(x,b)]; s $\circ^t$ t])

positiv_beschieden_werden(e)
object(e)=b
rec(e)=x
e $\subseteq$ t
t $\prec$ now

(57.b_{rep})

now E t

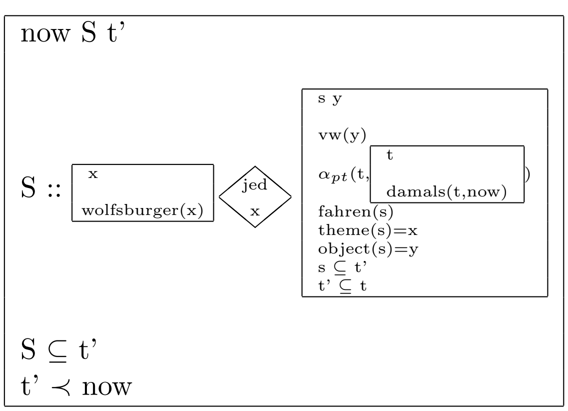
E:: [x s | b; s: [bittsteller(x,b)]; s $\circ^t$ t] ⟨jed x⟩ [e; positiv_beschieden_werden(e); object(e)=b; rec(e)=x; e $\subseteq$ t]

t $\prec$ now

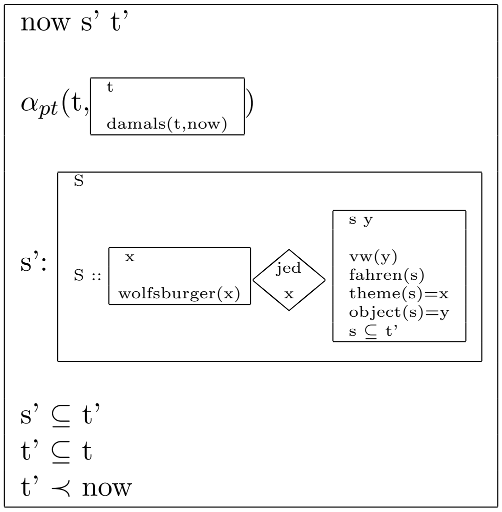
In these representations, the property of being a *Bittsteller* is relativized to a situation s, where it is assumed that s overlaps the focus time of the verb contribution. If we want this temporal statement to be a result of general semantic composition (including pragmatic resolution of referential terms) we must assume that all roles (with top level predication which is normally temporally restricted) are always subject to temporal resolution, so that the 'normal' case where the validity of the characterization of the role coincides with the evaluation time of the main DRS is interpreted as the (default) case of temporal resolution where the relativizing state is resolved to the *hic et nunc* of this main DRS. The question therefore is whether, generally, we assume that all roles introduce temporal α-conditions so that temporal resolution can determine the anchoring of the evaluation states of the thematic roles or whether there is no such temporal relativization connected to the roles, but a particular 'relativizing' power to some specific temporal adverbials which effectuates such 'relativization' for the characterizations of the individuals in their scope, as in (54.b). Examples like (57) argue for the first alternative. Also, with respect to quantified roles, like *jeder Wolfsburger* in (54), this representational option fits with the observation that, generally, in order to correctly determine the range of quantification, there must be taken into account restrictions from the context or from world knowledge which aren't explicitly mentioned. With respect to (54) a restriction of this type (another restriction of this type) is that certainly one implicitly considers inhabitants of Wolfsburg only that have a driver's license. (Compare the corresponding discussion of *context sets* in section 3.4.3). The fact that each and every predicate whose validity can be assumed to be temporally restricted (like *Junge/boy, Mädchen/girl, Schüler/pupil*) must be 'indexed' by a situation parameter then which must undergo temporal resolution is an argument against this alternative. Though only 'practical' in nature, we take this argument seriously, because, as said in the beginning of this study, efficiency is a very relevant property with regard to designing an interpreting system with broad coverage that works. From a theoretical point of view, we are not sympathetic with this alternative (at least not if it isn't complemented by the second), because it doesn't explain the difference between the considered readings of (54): Under this alternative, in both cases, the quantified DP introduces a situational parameter which, independent of the scope order, can be resolved to the time of *damals*, provided *damals* is interpreted *de re* as motivated further above. In particular, there is no reason why this solution should be preferred in the one case (where *damals* has wide scope) and not in the other, if not the one which assumes that α-conditions must be resolved according to nestedness and which says that, in case *damals* has narrow scope, the situation parameter of the quantifier must be resolved first and must be accommodated therefore, whereas, in the other case, it can be resolved to the time of *damals* which, in this case, has been accommodated or resolved before. We think that this reasoning is not very convincing because there are a number of cases where resolution of an α-condition presupposes resolution of an embedded α-condition; think of examples like *Peter's wife was there and Alfred's. He started talking to Peter's wife*, etc. Note that, the information provided by world knowledge which says that the characterization of the role is more likely to hold at a past time than at the speech time supports the 'relativizing' solution for the narrow scope case in right the same way as for the wide scope case. Exactly for this, it must be explained why, nevertheless, this solution is significantly more prominent in the wide scope case. To our opinion this cannot be explained other than by an influence of *damals* on its scope, which can be exerted with respect to the quantified DP in the wide scope case, but not in the narrow scope case. Under this explanation, 'relativizing' comes rather systematically with respect to the scope of adverbials like *damals* (and mustn't refer to world knowledge, it can be modelled as being a purely 'semantic' feature of a lexical item so to speak), whereas in the first case 'relativizing' the characterization to a specific reference time (which is set by the sentence event or by some accompanying location time) heavily draws on world knowledge, it is widely 'pragmatic' so to speak. Because of this, we assume that temporal location modifiers, like *damals, three years ago, next month, in 1999* etc. generally is assigned an (additional) reading that not only anchors the event of the modificandum, but that also takes the entire modificandum in its scope and relativizes it to some situation which is different from the actual perspective time (speech time); i.e., with respect to such modifiers, we suggest an (additional) treatment in the spirit of classical tense logic (compare [Prior(1967)]). In order to correctly cope with phenomena as illustrated in (57), we relate to the assumption that such examples doesn't designate the default case and need pragmatic inferences in order to be correctly resolved and assume therefore that the corresponding representations result from pragmatic reinterpretation which is postponed to compositional semantics and which is triggered by general Gricean cooperation maxims and information from worldknowledge which says that, without reinterpretation the constructed information is contradictory or highly unlikely. Note by the way that on the basis of a similar argumentation we assume similar reinterpretation in order to cope with the mentioned phenomena in connection with determining correct context sets, i.e. in connection with determining the most plausible completion of the description of (the range of) a quantifier.

Thus, we finally come up with the following pair of representations of (54):

($54.a_{rep}$)



(54.b_{rep})



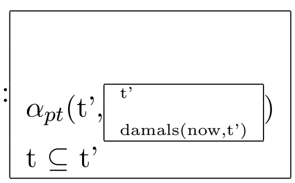
In (54.a) the people designated by *Wolfsburger* are the individuals that are *wolfsburger* in the utterance situation, in (54.b) they are the individuals that were *wolfsburger* at a particular, rather distant time in the past.

We can obtain these representations using the following lexical entry for *damals*:

$$\text{damals} \longrightarrow \text{mod\_vpsem\_t} \begin{bmatrix} \lambda: & \langle L \rangle \\ \text{RES:} & \underline{\text{damals}}(L) \end{bmatrix}$$

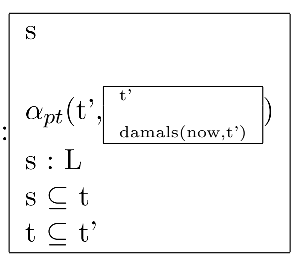
$\underline{\text{damals}}(\text{vpsem\_l}) \Rightarrow \text{vpsem\_l}$

$\underline{\text{damals}}({}^{vpsem\_l}\text{L}) := \text{l1}_{\varepsilon_t}$:



$\{l \leq l1\}$
L_{ε_t}

$:= \text{l1}_{s_t}$:



$\{l < l1\}$
L_{ε_t}

According to this, *damals* is ambiguous between a reading which adds a temporal condition to its argument and a reading which 'relativizes' its argument to a state *s*. Making use of the second alternative, we can also adequately represent the example (53.e) of the introductory list of examples of modification, which is:
Damals lebte ein kleines Mädchen im Hutzelwald / at this time, a little girl lived in the Hutzelwald:

(53.e_{rep})

now t s v

α_{pt}(t, [t | damals(t,now)])

s: [s' | α_{def}(u, [u | hutzelwald(u)]) mädchen(v) klein(v, λx P(x)) leben(s') theme(s')=v loc_in(s',u) s' $\subseteq$ t]

s $\subseteq$ t

(For simplicity, here, we have identified focus time and the presupposed perspective time of *damals*). Since *damals* has been assigned two interpretations, (53.e_{rep}), where the characterization *kleines Mädchen* is correctly related to an evaluation time in the past, competes with a representation where this characterization is assumed to hold **now**, though the *living in the Hutzelwald* of the corresponding individual is longtime ago. Using world knowledge, (53.e_{rep}) can be pragmatically determined to be the preferred one.

Similarly to *damals*, we can represent other adverbs which show a similarly decisive focussing on a particular time. As an additional example, we represent *morgen/tomorrow*:

morgen $\longrightarrow$mod_vpsem_t $\begin{bmatrix} \lambda: & \langle L \rangle \\ \text{RES:} & \underline{\text{heute}}(L) \end{bmatrix}$

morgen(vpsem_l) $\Rightarrow$vpsem_l

morgen(^{vpsem_l}L) := $l1_{\varepsilon_t}$: [α_{tloc}(t', [t' | α_{st}(t", [ ]) morgen(t",t')]) t $\subseteq$ t'] $\{l \leq l1\}$ L_{ε_t}

:= $l1_{s_t}$: [s | α_{tloc} (t', [t' | α_{st}(t", [ ]) morgen2(t",t')]) s : L s $\subseteq$ t t $\subseteq$ t'] $\{l \leq l1\}$ L_{ε_t}

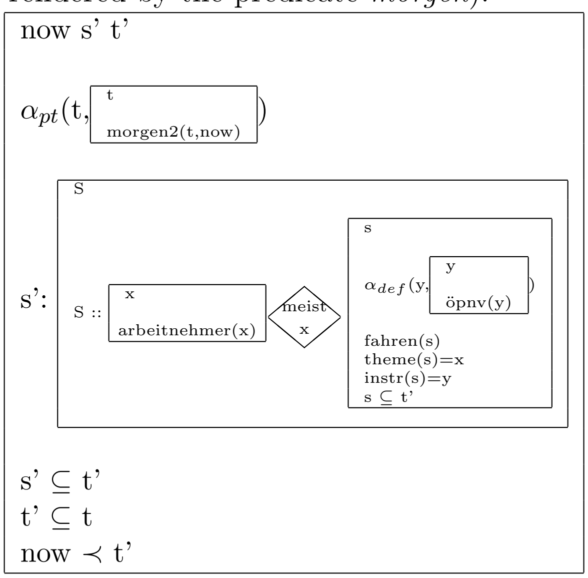
Using the 'relativizing' second evaluation of morgen, we can represent interpretations of examples like the following (58), where the perspective is shifted to a situation which is relatively far away from the situation of the textual *hic et nunc*:

(58)

Morgen werden die meisten Arbeitnehmer mit dem ÖPNV fahren.
Tomorrow, most employees will use local public transport.

The following representation (58_{rep}) relativizes the range of the considered employees to those who will be *employee* at the time denoted by *morgen2*. (We assume that the 'relativizing' understanding of *morgen/tomorrow* presupposes a figurative interpretation of the adverb in the sense of *at some time in the future*–whereas the 'normal' interpretation basis on the literal meaning, which, here, in the representation, is rendered by the predicate *morgen*).

(58_{rep})



Some of these (temporally) 'relativizing' adverbs have counterparts with respect to nominal modification. We mention *damalig, ehemalig, zukünftig / at that time, former, future*. We can represent these adjectives in close parallel to the corresponding adverbial case. Note however that, here, 'relativizing' is not an option, but is the only meaning, because the adjective clearly modifies the characterization of the NP (and cannot assumed to modify something else, like the adverb can do with respect to the rich VP-representation; even it cannot modify the NP-DRF only, because this one, normally, is no event or state). A consequence of this is that the conclusions (implicatures?) that can be drawn with respect to the validity of the modified predication seem to be more strict than in the adverbial case. We try to model this by adding in the case of *ehemalig* und *zukünftig* a condition to the semantic representation of the lexical item which says that the predication of the argument doesn't hold with respect to the current perspective time (mostly the speech time):

damalig $\longrightarrow$mod_npsem_t $\begin{bmatrix} \lambda: & \langle L \rangle \\ \text{RES:} & \underline{\text{damalig}}(L) \end{bmatrix}$

$\underline{\text{damalig}}$(npsem_l) $\Rightarrow$npsem_l

$$\underline{\text{damalig}}(L) := l1_y: \boxed{\begin{array}{l} \text{y s} \\ \\ \alpha_{pt}(\text{t}, \boxed{\begin{array}{l} \text{t} \\ \text{damals(now,t)} \end{array}}) \\ \text{s:}(L \cup \boxed{\text{x=y}}) \\ \text{s} \subseteq \text{t} \end{array}} \begin{array}{l} \{l < l1\} \\ L_x \end{array}$$

ehemalig $\longrightarrow$mod_npsem_t $\begin{bmatrix} \lambda: & \langle L \rangle \\ \text{RES:} & \underline{\text{ehemalig}}(L) \end{bmatrix}$

$\underline{\text{ehemalig}}$(npsem_l) $\Rightarrow$npsem_l

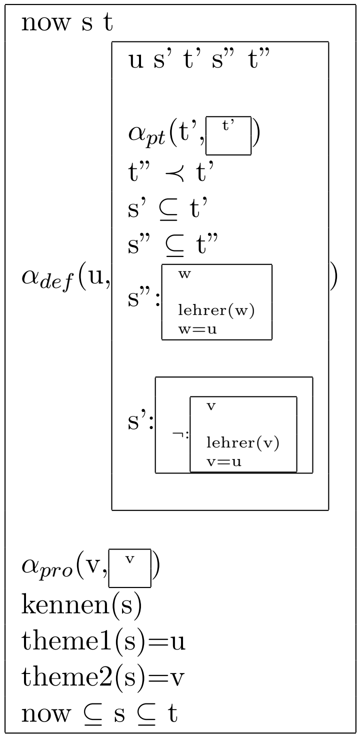
$$\underline{\text{ehemalig}}(L) := l1_y: \boxed{\begin{array}{l} \text{y s s' t'} \\ \\ \alpha_{pt}(\text{t}, \boxed{\text{t}}) \\ \text{t'} \prec \text{t} \\ \text{s':}(L \cup \boxed{\text{x=y}}) \\ \text{s'} \subseteq \text{t'} \\ \text{s:} \boxed{\neg(L \cup \boxed{\text{x=z}})} \\ \text{s} \subseteq \text{t} \end{array}} \begin{array}{l} \{l < l1\} \\ L_x \end{array}$$

$\underline{\text{zukünftig}}$(npsem_l) $\Rightarrow$npsem_l

$$\underline{\text{zukünftig}}(L) := l1_y: \boxed{\begin{array}{l} \text{y s s' t'} \\ \\ \alpha_{pt}(\text{t}, \boxed{\text{t}}) \\ \text{t} \prec \text{t'} \\ \text{s':}(L \cup \boxed{\text{x=y}}) \\ \text{s'} \subseteq \text{t'} \\ \text{s:} \boxed{\neg(L \cup \boxed{\text{x=z}})} \\ \text{s} \subseteq \text{t} \end{array}} \begin{array}{l} \{l < l1\} \\ L_x \end{array}$$

On the basis of the given representation of *ehemalig*, we can represent the sixth of our introductory examples, (53.f), *der ehemalige Lehrer kennt ihn / the former teacher knows him*, as follows:

(53.f$_{rep}$)



We still must occupy with spatial modification. The question is whether this type of modification shows a similar power which forces its argument to be modeltheoretically evaluated with respect to some situation introduced by the modifier. We've called this procedure which, of course, is very similar to the impact of modal modification, situational shift and described it by *'relativizing' a description to a situation*. We think that the answer is twofold. Examples like the following (59) seem to suggest that there is indeed a similar influence exerted by (some of) the spatial modifiers. However, here, 'relativizing to a situation *s*' seems to be restricted to considering the individuals only which are physically present in the situation *s*. The contrast which is made up by these modifiers between the 'normal'evaluating situation and the introduced one seems to be exclusively spatial in nature such that, in contrast to the temporal case, it cannot be that the characterization of a particular individual changes under 'spatial relativization' or 'spatial shift', the only difference being that the individual may be present in the one situation and absent in the other. Under this perspective, (purely) spatial relativization might be looked at as summarizing a number of conditions which assert that the members of the universe of the situation are those members of the 'normal' situation which are physically present in the space of the modifier situation at the time of this situation.

We will motivate this in the following and then conclude this section with some exemplary lexical entries. Consider the following pair of sentences:

(59)

a. *Jeder Jüngling lebt hier von Rotwein.*

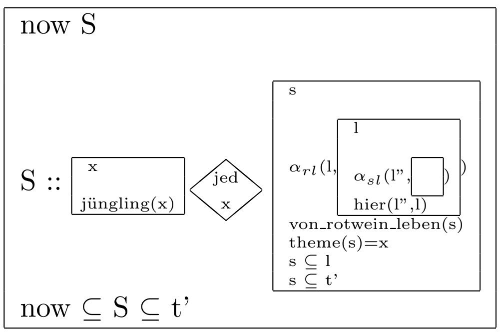
Every young man lives on red wine here.

b. *Hier lebt jeder Jüngling von Rotwein.*

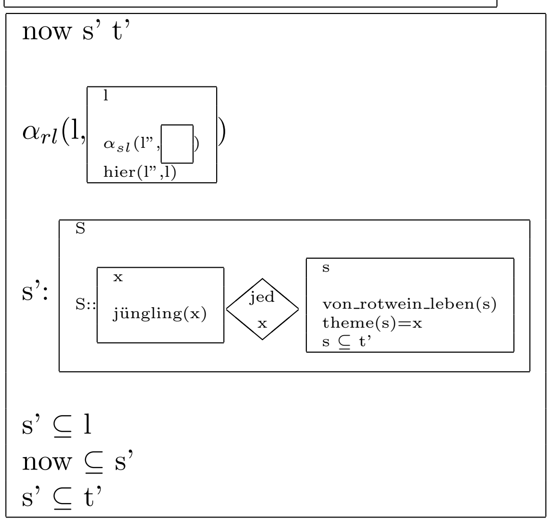
Here, every young man lives on red wine.

Similarly to (54), we think that also here there is a wide scope reading (which is more preferred in the (59.b) case than in the (59.a) case) that effects a situational shift such that the perspective changes to the standpoint of the situation introduced by the modifier. In close parallel to (54) , we suggest the following representations:

($59.a_{rep}$)



($59.b_{rep}$)



The model theory of section §5.3 is such that, with respect to ($59.b_{rep}$), the domain of quantification is restricted to those objects that are available in the considered situation s’ and which, in s’, satisfy the predication of the restrictor. In contrast, the a-reading restricts this domain to those objects that are available in the utterance situation and that, in this situation, satisfy the restrictor predication. This is quite similar to the representations of the corresponding temporal example (59). However, in contrast to there, here, the temporal parameters of the utterance situation and the modifier situation aren’t different, as there, but are required to be the same. In order for this to be meaningful (i.e. distinctive), the model of the representation must subdivide the (actual) world into situations such that, for the same time, different situations are available with different spatial coverage. Then we can assume that different situations of the same time slice show different individuals, but provide the same properties for those individuals which they have in common, except for those properties which are spatial. For those individuals however which are present in all of these situations The model theory of section 5.3 will account for this. We repeat that this modeling (which doesn't subdivide the world into times only, but into situations, which have temporal and spatial projections) flavors our DRT approach with situation theoretic ingredients (compare [Barwise/Perry(1983)]). [13]

A further comment seems to be appropriate in the presence of the additional spatial relativization: The transition (59.a) – (59.b) will restrict the set of those individuals that are young men in the (spatially unrestricted) utterance situation to the set of those young men that are present in the particular, spatially restricted situation. In this connection, we cannot avoid to notice that (59.a) has another reading which is more prominent than the depicted one. The depicted one says that for every young man it holds that there is at least one situation in which he lives on red wine here. The more prominent reading certainly is the one saying that for each young man it holds that whenever he is here, he lives on red wine.

We think that what is specific to this reading is not triggered by the the quantifying expression, but is a general feature of the impact of information structure on the meaning of sentences. Often, if the sentence is clearly structured into background and focus and in case the background is an event predication, one obtains a habitual reading by generic quantification over the domain of the background predicate where the scope consists of the sentence predication. For instance, *Peter raucht 'Gauloises* can be paraphrased by whenever Peter smokes, he smokes a Gauloise. This can interfer with (supplementary) event quantification as in *Peter raucht manchmal Gauloises* which can be paraphrased by *sometimes, if Peter smokes, the cigarette is a Gauloise*. In this paper, as mentioned, we cannot really deal with information structure and its contribution to semantics and pragmatics, but, for some further indications, see [Büring(1996)] and also sections 3.6.8 and 3.6.7. This means that we must omit dealing with readings which result from such specific pragmatic structuring.

We are now in a position to state the lexical entry of the considered representative of spatial modifiers *hier* and, for illustration, of the similar and contrastive modifier *dort*). Because these modifiers can be used as nominal modifiers also (*der Mann*

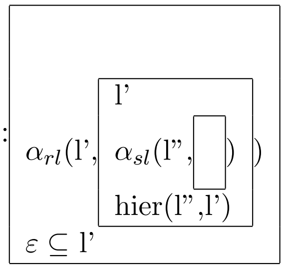
[13] However, this modeling is rather DRT-conservative. In a way it repeats the unfolding of an interpreting world into actual world and set of possible worlds known from modal logic with respect to the actual world, obtaining by this, quite similarly, an additional formal means of more fine-grained interpretation allowing for a distinction of the type extension/intension within the actual world. This is very conservative however, because *transworld identity* is kept (with respect to both types of unfolding) and situations just 'relativize' physical presence and duration of predications and their impact can be more or less completely characterized by transition to their spatial and temporal projections. The spatial relativization will play a rather restricted role (see also the lexical entries of the considered spatial modifiers below; these representations should be enlightening in this respect).

hier/dort ist schuldig–The man over there is gilty, we must account for this use also:

hier $\longrightarrow$mod_xtype_t $\begin{bmatrix} \lambda\text{:} & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{hier}}(\text{L}) \end{bmatrix}$

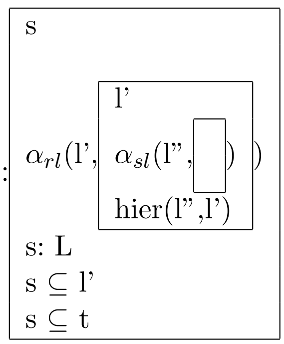
$\underline{\text{hier}}$(xtype_l) $\Rightarrow$xtype_l

$\underline{\text{hier}}(^{vpsem\_l}\text{L}) := {}^{vpsem\_l}\text{l1}_{\varepsilon}$:



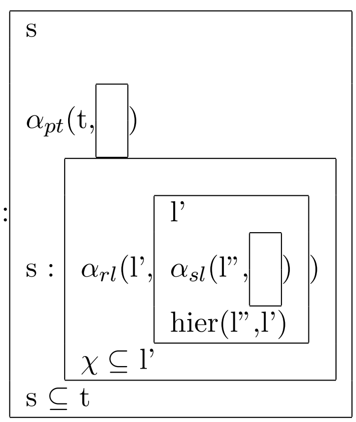
$\{\text{l} \leq \text{l1}\}$
L_{ε}

$:= {}^{vpsem\_l}\text{l1}_{s_t}$:



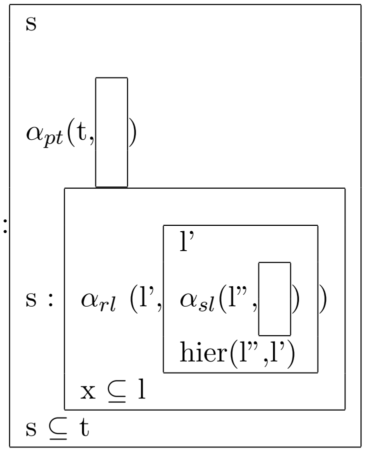
$\{\text{l} < \text{l1}\}$
L_{ε_t}

$\underline{\text{hier}}(^{dpsem\_l}\text{L}) := {}^{dpsem\_l}\text{l1}_{\varepsilon,\chi,\psi}$:



$\{\text{l} \leq \text{l1}\}$
$\text{L}_{\varepsilon,\chi,\psi}$

$\underline{\text{hier}}({}^{npsem\_l}\text{L}) := {}^{npsem\_l}\text{l1}_x$:

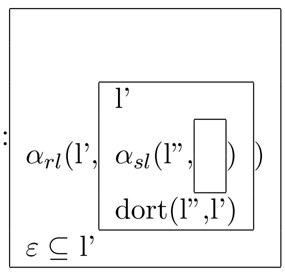


$\{l \leq l1\}$ L_x

dort $\longrightarrow$mod_xtype_t $\begin{bmatrix} \lambda\text{:} & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{dort}}(\text{L}) \end{bmatrix}$

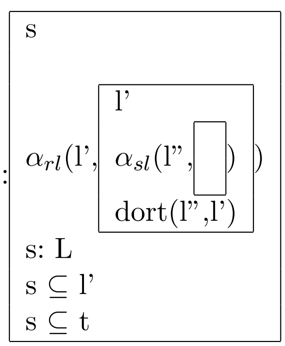
$\underline{\text{dort}}$(xtype_l) $\Rightarrow$xtype_l

$\underline{\text{dort}}({}^{vpsem\_l}\text{L}) := {}^{vpsem\_l}\text{l1}_\varepsilon$:



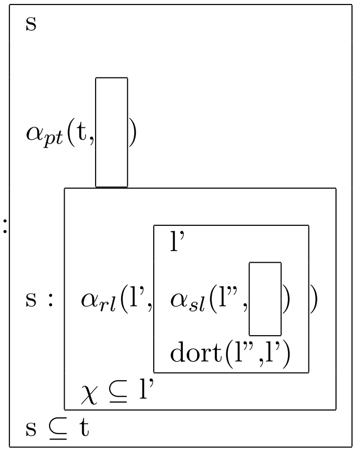
$\{l \leq l1\}$ L_ε

$:= {}^{vpsem\_l}\text{l1}_{s_t}$:



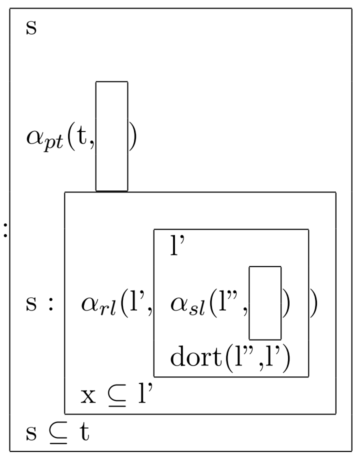
$\{l < l1\}$ L_{ε_t}

$\underline{\text{dort}}(^{dpsem\_l}\text{L}) := {}^{dpsem\_l}\text{l1}_{\varepsilon,\chi,\psi}$:



$\{\text{l} \leq \text{l1}\}$
$\text{L}_{\varepsilon,\chi,\psi}$

$\underline{\text{dort}}(^{npsem\_l}\text{L}) := {}^{npsem\_l}\text{l1}_{x}$:



$\{\text{l} \leq \text{l1}\}$
L_{x}

With the entry for *hier*, we can obtain the representations (59.a$_{rep}$) and (59.b$_{rep}$).

Note that, besides the NP-variant, the DP-variant is necessary with respect to *hier* and *dort*: In *viele Männer und noch mehr Frauen hier*, *hier* clearly modifies the coordination (which is a DP) and not only the NP *Frauen*. The assumption of these nominal cases is that the referential DRF x of the modificandum is assigned a situation s so that, in this situation it is located within a space which is a *hier*-space (and a *dort*-space respectively) of the actual 'hic' (speech location). Temporally the situation s is located within a salient perspective time (which, probably, is the speech time).

We emphasize (again) that, in contrast to the adjectival use of *hier* and *dort*, as modeled here, the representations of the adjectives *damalig* and *ehemalig* as presented above, instead of intersectively adding a situational restriction of the referential index of their argument, relativize the entire NP-predication to a specific (past) situation. *Ehemalig* and *zukünftig* even exclude the NP-predication of the NP-referent for the actual perspective time. We stress that we don't think that spatial modifiers should be assigned a similarly strong interpretation, because, as it seems, they never can assign a characterization to an individual that, for the same time, at some other place is false. To our opinion, spatial relativization to some place l just restrains the set of available individuals to those that, spatially, are contained in l (at the relevant evaluation time). Thus, spatial relativization is of another type than temporal relativization. The first one, at least as far as we have considered it in this section, restricts the universe of the given world, whereas the second one restricts the validity of (particular) predications about the individuals, without restricting the considered universe.

Summarizing, we think that *jeder Jüngling dort* denotes just these young men that are *dort* at the actual perspective time. Similarly, in the adverbial, situation shifting case the relevant individuals are those that are part of the (actual) *dort*-province. The difference is that this relativization goes through for all thematic roles in the scope of the relativizing modifier.

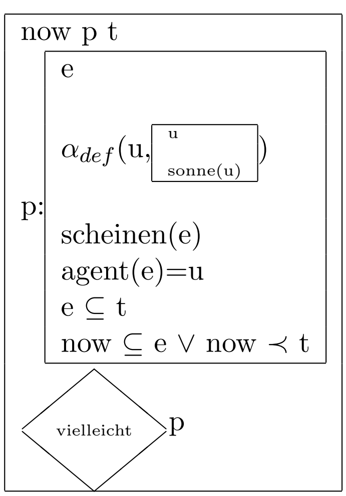
In case that the adverb and the corresponding adjective do obtain similar, situation shifting interpretations, sentences that replace such an adverb by a corresponding adjectival modification of a thematic role obtain equivalent interpretations, provided there is just this thematic role in the adverbial's scope, and provided the introduced situations are related to the same perspective time: compare *damals fuhr jeder Wolfsburger einen VW* and *jeder damalige Wolfsburger* (better: *jeder Wolfsburger damals*) *fuhr einen VW* to this end.

We repeat also that relativizing a statement to some situation, as has been dealt with in this section, is a specific variant of modal embedding. In the next section, we will present the treatment of the classical modal operators and we will say a bit more about the problems that are connected to the introduction of situation variables.

3.6.4 Modal modifiers

(53.g), *vielleicht scheint die Sonne / maybe the sun is shining*, is an example of modal modification. We represent this sentence as follows:

($53.g_{rep}$)



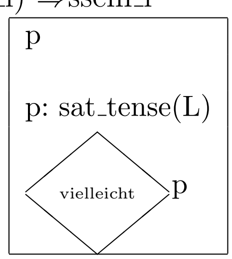
According to this representation, we model modal adverbs as sentence modifiers that prefix the proposition the sentence describes by a modal operator. Since normally, in the approach here, the tense information of a sentence is resolved only when incorporating the sentence representation into the representation of the preceding text, the modal modifier triggers temporal resolution in order to make its argument a proposition. Thus, technically, our interpretation means that the modal adverb will take a (maximal, i.e., saturated) V projection (with unresolved tense information) as argument. It will interpret this argument as a sentence radical (see [Löbner(1988)] for the term), i.e., as an event predicate. It does this through interpreting the result index as lambda operator binding the corresponding event variable. Then this event predicate will be turned into a tensed proposition via introducing temporal conditions that interpret the tense information stored in the result index and that bind the event variable to a specific time. The resulting representation is designated by a (new) proposition DRF. Then, this new proposition referent is made the argument of the introduced modal operator. In section 5.3, it will be stipulated for a condition p:DRSp to be true in a model M iff the value of p in M, which will be a DRS-object, is such that the information state it describes entails the information state described by DRSp (under the constraints that the free variables of DRSp (which are bound by the DRS that contains p:DRSp as a condition (of a sub-DRS)) put onto the interpretation, see [Asher(1986)] for an early conception of this modeling via representations as denotations). The reason for introducing DRFs for propositions is to allow for referring to propositions, as in *Peter believes that .... John believes* *__that__* *too*, via the common DRT treatment of anaphora resolution.

The following entry for *vielleicht* exemplifies these general assumptions about modals:

vielleicht $\longrightarrow$mod_ssem_t $\begin{bmatrix} \lambda: & \langle \mathrm{L} \rangle \\ \mathrm{RES:} & \underline{\mathrm{vielleicht}}(\mathrm{L}) \end{bmatrix}$

__vielleicht__(satvpsem_l) $\Rightarrow$ssem_l

__vielleicht__(L) := l1$_{\emptyset}$:



{l < l1}
L

Of course, other modals like *möglicherweise, notwendigerweise ...* are treated according to this. We will say something to the functionality of the operation *sat_tense* in section 3.11. The new type of labelled structure *satvpsem_l* is sorted as follows:

vpsem_l = satvpsem_l | nsatvpsem_l.
vsem_l < nsatvpsem_l.

We subsume a group of modifiers under the class of modal modifiers also, that, in

[Eberle(1995)], we have called *Sachverhaltsbewertung/ comment on fact*. The items of this group also take a saturated V projection and turn it into a tensed proposition. What is specific to the items of this group is that they report a (more or less emotional) attitude that the speaker connects to this proposition, where he assumes the proposition to be true (and signals this—via presupposition or implicature or solely via inferable assertion—to the hearer). That is, these modifiers assume the factuality of the argument proposition and give a qualification of the corresponding fact, i.e., of the situation which is assumed to hold. We don't investigate the presuppositional force that relies on such statements and simply put the entire representation onto the assertional level, leaving the task of partitioning the representation into presupposition and assertion proper to the component that analyses the impact of information structure (this, we repeat, is outside the scope of this paper).

The example which we represent is *erfreulicherweise / fortunately*

$$\text{erfreulicherweise} \longrightarrow \text{mod\_ssem\_t} \begin{bmatrix} \lambda\text{:} & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{erfreulicherweise}}(\text{L}) \end{bmatrix}$$

$$\underline{\text{erfreulicherweise}}(\text{satvpsem\_l}) \Rightarrow \text{ssem\_l}$$

$$\underline{\text{erfreulicherweise}}(\text{L}) := \text{l1}_{\emptyset}\text{:} \begin{array}{|l|} \hline \text{now s} \\ \\ \text{s: sat\_tense(L)} \\ \text{now} \subseteq \text{s} \\ \text{erfreulich(s)} \\ \hline \end{array} \begin{array}{l} \{\text{l} < \text{l1}\} \\ \text{L} \end{array}$$

From this, we obtain the representation (53.i_{rep}) for (53.i), *erfreulicherweise schien die Sonne / fortunately, the sun was shining.*

(53.i_{rep})

$$\begin{array}{|l|} \hline \text{now s} \\ \text{s:} \begin{array}{|l|} \cdots\cdots\cdots\cdots\cdots\cdots \\ \text{e t} \\ \\ \alpha_{def}(\text{u}, \begin{array}{|l|} \hline \text{u} \\ \text{sonne(u)} \\ \hline \end{array}) \\ \\ \text{scheinen(e)} \\ \text{agent(e)=u} \\ \text{t} \prec \text{now} \\ \text{e} \subseteq \text{t} \\ \cdots\cdots\cdots\cdots\cdots\cdots \end{array} \\ \\ \text{erfreulich(s)} \\ \hline \end{array}$$

In this representation, the dotted lines of the description of s indicate that the corresponding DRS is accessible from the main level of the sentence representation, i.e., that it does not function as an embedded structure, but as part of the main

DRS. What is specific to this part is that it is annotated by a designator which is an element of the universe of the main DRS. The expressive power of this additional feature relies on the possibility of making statements within the DRS about parts of the text representation. This representational extension is akin to Asher's suggestion of segmented DRSs (see [Asher(1993)]). Note that with this extension one has to be aware of the fact that sentences of the type liar's paradox can be represented, in case one additionally allows that a representation makes use of the DRF that designates the representation. As with the abstraction of sums from duplex conditions in §2.5.2 we remain on the safe side with respect to this point of self reference throughout the rest of this paper. (However, natural language nevertheless allows for such ugly sentences that complicate matters with respect to model theory.) Notice that, in order to truly reflect the accessibility conditions, the s-described representations of the last section should be revised in this respect by exchanging the box-format for the dotted line box-format. We will be more precise with such representations of situational relativizations in the following. (For the subject compare also the section about discourse relations 3.7).

We terminate this section by the representation of a prototypical NP-modifying modal. We represent *angeblicher / alleged* as follows:

$$\text{angeblicher} \longrightarrow \text{mod\_npsem\_t} \begin{bmatrix} \lambda: & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{angeblicher}}(\text{L}) \end{bmatrix}$$

$$\underline{\text{angeblicher}}(\text{npsem\_l}) \Rightarrow \text{npsem\_l}$$

$$\underline{\text{angeblicher}}(\text{L}) := \text{l1}_y\text{:} \begin{array}{|l|} \hline \text{y p} \\ \\ \text{angeblich(p)} \\ \text{p: (L } \cup \begin{array}{|c|}\hline \text{x=y}\\ \hline\end{array}) \\ \hline \end{array} \quad \begin{array}{l} \{\text{l} < \text{l1}\} \\ \text{L}_x \end{array}$$

From this, we obtain (53.h$_{rep}$) for the example (53.h), *der angebliche Mörder wurde gefasst / the alleged murderer was caught*:

$$(53.\text{h}_{rep}) \quad \begin{array}{|l|} \hline \text{now e t} \\ \alpha_{def}(\text{u}, \begin{array}{|l|} \hline \text{u p} \\ \\ \text{angeblich(p)} \\ \text{p: (} \begin{array}{|l|} \hline \text{v} \\ \\ \text{mörder(v)} \\ \text{u=v} \\ \hline \end{array} \text{)} \\ \hline \end{array}) \\ \text{fassen(e)} \\ \text{object(e)=u} \\ \text{t} \prec \text{now} \\ \text{e} \subseteq \text{t} \\ \hline \end{array}$$

These representations illustrate that, for representing a qualifier of a proposition, we use the predicate notation as a variant of the rhombus notation also, provided there is no additional information to annotate to the qualifier—as, for instance, its specific subtype etc. These representations also illustrate that embedding NP-modifiers introduce a new DRF for the referent of the head noun (compare also the treatment of the relativizer *ehemalig* in the last section). They do this for reasons of security. Remember that we assume DRFs that are assigned a specific (semantic) sortal information. Depending on the granularity of the sortal characterization, it might be that the considered embedding modifiers require a different sortal description of the result index. In such cases, the DRF of the noun could not be percolated upwards without contradiction.

3.6.5 Aktionsart sensitive modifiers

In the literature, there are different suggestions for classifying sentences or sentence radicals or the events or situations described by the sentence into Aktionsarten, see [Vendler(1967), Bennett/Partee(1972), Verkuyl(1972)], among others, for some early fundamental studies; see also [Mourelatos(1981), Moens/Steedman(1988), Krifka(1989)], and there is a large number of more recent studies that we cannot refer to here. Without going into detail with the Aktionsarten, we just mention that we assume that Aktionsarten are not properties of events, but properties of event predicates (take *event* in the wide sense here—of *situation*, say). Further, we assume that there are *event* descriptions (narrow sense)—that roughly correspond to Vendler's *achievements* and *accomplishments*, that there are *process* descriptions—that correspond to Vendler's *activities*, and *state* descriptions—corresponding to Vendler's *states*. (Often, there is the distinction of *telic* and *atelic* events that, roughly corresponds to achievements and accomplishments on the one hand, and to processes and states on the other). We call *event* descriptions also *heterogeneous* and *process* and *state* descriptions *homogeneous*. The underlying (compositional) Aktionsart theory, that strongly relates to Krifka's approach, is spelled out in [Eberle(1991a)] and [Eberle(1998)].

There are adverbs that select for event types of a specific Aktionsart category. For instance, the *hierher* of (53.b), *Inge kam hierher / Inge came here*, is applicable to event types only that describe processes. (Since the modifier introduces a spatial goal, we know that the process is a moving and that the describing argument event type accepts a corresponding thematic role (call it *spat_goal* as in the representations further above) and, of course, that this event type does not come with a specification of this role already). A number of these adverbs provide rather regular semantic-pragmatic reinterpretations of the argument event type, in case this event type does not come with the expected Aktionsart. Such reinterpretations are also called *type coercion* (see [Moens/Steedman(1988)]). So, for instance, the normal semantic contribution of the adverbial use of *schnell* requires the argument event type to introduce an event or process, as in (53.d), *Peter lief schnell zum Bahnhof / Peter ran to the station quickly*. It then scales the reoccurrence rate of the underlying periodic 'motion' (in the wide sense) as high, or, with regard to telic events, it rates the time for the realization of the result as short. Now, in the presence of states, this type of valuation is not possible:

(60) *Peter war schnell betrunken.*
Peter got drunk quickly.

The *betrunken sein/be drunk* of (60) is a state. The state as such cannot be valuated in terms of rapidity. However, there is a common reinterpretation of states that allows for such valuations: the inchoative reading that focusses on the event that introduces the state as its result. The English translation of (60) anticipates this type coercion. Making use of one of the Aktionsart operators as introduced in [Eberle(1991a)], *ingr* (which outputs the *ingressive* counterpart of the argument event type), we can represent (60) as follows:

(60_{rep})

now e t
α_{name}(u, [u | peter(u)])
e ∈ ingr s [s | s: [betrunken(u)]]
schnell(e, λe' P(e'))
t $\prec$ now
e $\subseteq$ t

We omit refining our *schnell*-entry in this respect (by adding a rule for homogeneous argument descriptions which applies the considered Aktionsart operator first). We see that *ingr* is an operator that applies to a predicative DRS, an event predicate (where *s* the event variable in the example) and that returns an event predicate.

In this paper, without going into model theoretic and deep explanatory details (see [Eberle(1991a)] for this), we use the following Aktionsart operators:

- *ingr*
  returns the inchoative aspect of an event type;
  with regard to states and processes the extension of the result type just subsumes events that introduce instances of the argument event type as their result state.
  With (telic) events the denotation of the result type is harder to obtain, because the existence of an instance of the ingressive type does not necessarily entail the existence of a subsequent instance of the argument type (compare *er begann ein Buch zu schreiben / he started writing a book* for this). This is similar to the case of the *prog*-operator.

- *prog* returns the progressive aspect of an event type.

- *perf* returns the perfective aspect of an event type.
  Its extension consists of perfective or result states of events of the argument type.

- *iter* returns the iterative aspect of an event type.
  Its extension consists of suitably constructed sums of instances of the argument event type.

- *max* returns the event type whose extension consists of the maximal phases of the underlying homogeneous event type.
  Applied to *Peter being drunk*, for instance, the extension of the result subsumes these instances of *Peter being drunk* that are not temporally included within more extended instances of the same type, in other words: those that are local maxima of the *Peter being drunk*-type.

Span or duration adverbials like *stundenlang* require argument event types that are homogeneous. In case this default is violated, the adverb can trigger the iterative or the progressive reinterpretation of the argument type. Of course, world knowledge about the average duration of the instances and the like will have to evaluate the different options and to decide whether they are possible at all respectively.

Consider the representations of (53.j) and (53.k), *stundenland arbeitete er (he worked for hours) / stundenlang sprang Hansi ins Wasser (for hours, Hansi jumped into the water)*:

(53.j_{rep})

now e t
α_{pro}(u, [u])
arbeiten(e)
agent(e)=u
stundenlang(e)
e ∈ max e' [e' ; arbeiten(e') ; agent(e')=u]
t ≺ now
e ⊆ t

(53.k_{rep})

```
┌──────────────────────────────────────────────────────────┐
│ now t E                                                  │
│ α_name(u, [ u | hansi(u) ])                              │
│                                                          │
│ E ∈ iter e [ e                                           │
│              α_def(v, [ v | wasser(v) ])                 │
│              springen(e)                                 │
│              agent(e)=u                                  │
│              spat_goal(e,v) ]                            │
│                                                          │
│ E ∈ max E' [ E'                                          │
│              E' ∈ iter e [ e                             │
│                            α_def(v, [ v | wasser(v) ])   │
│                            springen(e)                   │
│                            agent(e)=u                    │
│                            spat_goal(e,v) ] ]            │
│ t ≺ now                                                  │
│ E ⊆ t                                                    │
└──────────────────────────────────────────────────────────┘
```

We see that in the normal case, the argument is a homogeneous event description. What the adverb adds is the assumption that the argument e is a maximal representative of the argument description. Of course, it also provides a measure statement about this e. With respect to the coercion case, the corresponding contributions are preceded by an additional type changing operation. In both cases, the result will be heterogeneous (loosely speaking, because subevents of events of the result type do not satisfy the result type characterizations). According to these representations (and including the *prog*-variant) we provide the following *stundenlang*-entry. This entry also exemplifies the representation schema which the other duration adverbials satisfy:

stundenlang $\longrightarrow$mod_vpsem_t $\begin{bmatrix} \lambda: & \langle L \rangle \\ \text{RES:} & \underline{\text{stundenlang}}(L) \end{bmatrix}$

$\underline{\text{stundenlang}}$(vpsem_l) $\Rightarrow$vpsem_l

$\underline{\text{stundenlang}}(L_{\varepsilon_{akt(hom)}}) := l1_{\varepsilon_{akt(het)}}$: [stundenlang($\varepsilon$) | $\varepsilon \in$ max ε' $co_{[\varepsilon\ ,\varepsilon\ ']}$(L)] {l $\leq$ l1 } L

$\underline{\text{stundenlang}}(L_{\varepsilon_{akt(het)}}) := l1_{E_{akt(het)}}$: [stundenlang(E) | E $\in$ iter ε L | E $\in$ max E' $co_{[E,E']}$([E' | E' $\in$ iter ε L])] {l < l1 } L

$$\underline{\text{stundenlang}}(L_{\varepsilon_{akt(het)}}) := l1_{e_{akt(het)}} : \boxed{\begin{array}{l} \text{stundenlang(e)} \\ e \in \text{prog}\ \varepsilon\ L \\ e \in \max\ e'\ \text{co}_{[e,e']}(\boxed{\begin{array}{l} e' \\ e' \in \text{prog}\ \varepsilon\ L \end{array}}) \end{array}} \quad \begin{array}{l} \{l < l1\} \\ L \end{array}$$

The rules for *stundenlang* illustrate how the Aktionsart calculus is incorporated into the compositional semantics: operations that are applied to the VP semantics report on their effect by means of the Aktionsart feature of the result index.

Often, in discussions about Aktionsart, frame adverbials are mentioned as counterpart of duration adverbials. Such adverbials (for instance *innerhalb von drei Tagen / within three days*) require heterogeneous event types as argument. In case the argument is homogeneous, the type coercion via *ingr* is prominent (or mostly the only possibility, if any). In both cases of arguments, the result type will be heterogeneous. We omit a corresponding representation.

We conclude this hasty tour d'horizon through the realm of Aktionsart sensitive modifiers, by the representation of the sentence negation (which outputs homogeneous descriptions).

(61) *Peter kam nicht.*
Peter did not come.

We allude here to what has been said about the negative quantifier in section 3.4.4, especially to its temporal restrictedness, and represent (61) in accordance to this.

$$(61_{rep}) \quad \boxed{\begin{array}{l} \text{now t} \\ \neg : \boxed{\begin{array}{l} \alpha_{name}(u, \boxed{\begin{array}{l} u \\ \text{peter(u)} \end{array}}) \\ e \\ \\ \text{kommen(e)} \\ \text{agent(e)} = u \\ e \subseteq t \end{array}} \\ t \prec \text{now} \end{array}}$$

The corresponding entry for *nicht* is as follows:

$$\text{nicht} \longrightarrow \text{mod\_vpsem\_t} \begin{bmatrix} \lambda: & \langle L \rangle \\ \text{RES:} & \underline{\text{nicht}}(L) \end{bmatrix}$$

$$\underline{\text{nicht}}(\text{vpsem\_l}) \Rightarrow \text{vpsem\_l}$$

$$\underline{\text{nicht}}(\mathrm{L}_{\varepsilon_t}) := \mathrm{l1}_{t_{akt(hom)}}: \boxed{\begin{array}{c} \\ \neg: \mathrm{L} \end{array}} \begin{array}{l} \{\mathrm{l} < \mathrm{l1}\ \} \\ \mathrm{L} \end{array}$$

3.6.6 Control modifiers

Adverbs like *einzeln, nacheinander, gleichzeitig / separately, successively, simultaneously* are akin to so called *floating* or *floated quantifiers*, like (postponed, i.e., *floated*) *je, jeder / each, jeweils / each time*: they force a distributive reading of the sentence. Floated quantifiers effectuate this by the distributive reading of some plural thematic role, the *source of the distribution* (to the left of the quantifier—see [Link(1987), Krifka(1989)] for an analysis of the prototypical *je*). With respect to floated quantifiers, the first question is about the syntactic analysis that should be assigned to them. Often they have been treated as an example of pure syntactic transformations. There are a number of objections that can be made to this (see [Dowty/Brodie(1984)] among others), and [Krifka(1989)] gives an attractive model that analyzes these quantifiers as specific instances of adverbial quantification: what is specific with these quantifiers is that they bind the referent x of one of the subcategorized functions of the verb by making it the quantified variable of the introduced quantification. Percolating the lambda prefix of the argument Etype-representation to the result with the referent x replaced by the sum variable X that is introduced as domain of the floated quantifier correctly assigns the same semantic type to argument and result representation and does the correct linking. The problem with this modeling is that the source of distribution does not necessarily come with the representation of a subcategorized function, as illustrated by the following example (62):

(62) *In den Zellen beteten jeweils fünf Mönche.*
In each of the cells, five monks said their prayers

Here, the domain of quantification is provided by the spatial adjunct. So, what should one do, knowing that the lambda abstract of the argument predicate does not always provide the variable that should be bound by the quantification? Note that the case is quite similar with respect to adverbs like *nacheinander, gleichzeitig / successively, simultaneously*: They also require the distributive reading of the sentence via the distributive reading of a thematic role, and this thematic role need not stem from a subcategorized function. In contrast to the considered floated quantifier case however, they additionally require a specific temporal outcome of the resulting sum of events. What type should be assigned to the floated quantifiers, so, and to the adverbs that show the same quantificational modification of a thematic role as part of their meaning? Since we assume that this modification can apply to subcategorized functions as well as to adjuncts, the option of treating it syntactically in terms of a pure transformation assigns it a type ambiguity. We also would obtain a type ambiguity when modeling these quantifiers and adverbs as functors from VPs and DPs or VP-modifiers into (accordingly reduced) VPs. Whereas the first option might be better motivated with respect to pure floated quantifiers, the second option seems to take it over the first because of the twofold modifying effect of such adverbs that, on the one hand, relates to the reading of a role and, on the other, to the characterization of the (resulting) VP event. Note that, on the basis of the approach suggested in this paper, the argument in favor of the second option, technically, is not really weighty, because the temporal structuring that the considered adverbs provide for the VP event can be easily rendered also under the first option by using the result index of the argument DP or the argument VP-modifier which makes available exactly this event. Next to the type ambiguity, a further flaw of both these solutions is that, type theoretically, they fall outside the common treatment of adverbials.[14] Without going further into detail, we choose the modeling which, probably, is the simplest with regard to syntax. We interpret the considered adverbs as VP-modifiers, and, in accordance with this, the simpler floated quantifiers also. Note that this is legitimated only by the fact that the scope assignment of the disambiguations of our underspecified representations need not homomorphically reflect the syntactic hierarchy, in particular the floated quantifier or adverb syntactically might be (or even must be) in the scope of the source of distribution (through the movement to the right), whereas, semantically, it can take scope (and must take scope) over this source of distribution. Under this assumption, what is the impact of the floating quantifier *je*? It requires for the argument VP representation that there is a duplex condition from which an event sum E is abstracted that is the DRF of the resulting index, and from which a sum X is abstracted which is the domain of the quantified variable x. Does this sufficiently constrain the verbal projection? It does. There must be a plural noun phrase (like *viele / fünf / die Männer (many / five / the men)*) that obtains a distributive reading, because of the duplex condition and the constraint about the resulting index. This plural noun phrase obviously has wide scope with respect to the remaining description of the VP-argument, since E is the referent of the resulting index. Also this plural noun phrase indeed characterizes a thematic role of the event (instead of characterizing some other DRF, of a relative clause, for instance), because E is abstracted from the duplex condition that quantifies over the x.[15]

The representation of *nacheinander / successively* will introduce the same constraint. In addition, it will temporally structure the event sum, and similarly for the mentioned *gleichzeitig / simultaneously*. We obtain the following:

[14]There is a quite similar ongoing discussion about the correct typing of focus adverbs. We say something about this in the next section, when dealing with focus adverbs. Some of the arguments (pro and con) seem to be equally relevant for the case at hand.

[15]The x must be the bearers of some thematic role with respect to the components of E, because, in the approach here, the DRF of the resulting index, if abstracted from a duplex condition, always is abstracted from a duplex condition introduced by a subcategorized function or by a VP-modification, i.e., by a phrase that provides a thematic role.

je $\longrightarrow$mod_vpsem_t $\begin{bmatrix} \lambda\text{:} & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{je}}(\text{L}) \end{bmatrix}$

$\underline{\text{je}}$(vpsem_l) $\Rightarrow$vpsem_l.

$$\underline{\text{je}}(\text{l}_{E_{akt(A)}}\text{:} \boxed{\begin{array}{l} \ldots \text{E} \ldots \\ \vdots \\ \text{X,E :: LR} \ \Diamond^{\text{QU}}_{\text{x}} \ \text{LS}_{\mathcal{E}} \\ \vdots \end{array}}) := \text{l1}_{E_{akt(A)}}\text{:}\boxed{}\ {}^{\{\text{l} \leq \text{l1}\}}_{\text{L}}$$

nacheinander $\longrightarrow$mod_vpsem_t $\begin{bmatrix} \lambda\text{:} & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{nacheinander}}(\text{L}) \end{bmatrix}$

$\underline{\text{nacheinander}}$(vpsem_l) $\Rightarrow$vpsem_l.

$$\underline{\text{nacheinander}}(\text{l}_{E}\text{:} \boxed{\begin{array}{l} \ldots \text{E} \ldots \\ \vdots \\ \text{X,E :: LR} \ \Diamond^{\text{QU}}_{\text{x}} \ \text{LS}_{\mathcal{E}} \\ \vdots \end{array}}) := \text{l1}_{E_{akt(a\_eval(X,L))}}\text{:}\boxed{\underline{\text{nacheinander0}}(\text{E})}\ {}^{\{\text{l} \leq \text{l1}\}}_{\text{L}}$$

gleichzeitig $\longrightarrow$mod_vpsem_t $\begin{bmatrix} \lambda\text{:} & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{gleichzeitig}}(\text{L}) \end{bmatrix}$

$\underline{\text{gleichzeitig}}$(vpsem_l) $\Rightarrow$vpsem_l.

$$\underline{\text{gleichzeitig}}(\text{l}_{E}\text{:} \boxed{\begin{array}{l} \ldots \text{E} \ldots \\ \vdots \\ \text{X,E :: LR} \ \Diamond^{\text{QU}}_{\text{x}} \ \text{LS}_{\mathcal{E}\ akt(A)} \\ \vdots \end{array}}) := \text{l1}_{E_{akt(A)}}\text{:}\boxed{\underline{\text{gleichzeitig0}}(\text{E})}\ {}^{\{\text{l} \leq \text{l1}\}}_{\text{L}}$$

We see that each of the representations indeed requires that its argument shows a wide scope distributive reading of a plural thematic role.[16] Whereas the pure floated quantifier *je* does not introduce any further constraint, *nacheinander* introduces the condition nacheinander0(E), where nacheinander0 will be defined in such a way that it effectuates the successive ordering of the events of E. Similarly, *gleichzeitig* introduces the condition gleichzeitig0(E) which will guarantee the simultaneity of the parts of E.

The representations come with Aktionsart assignments that follow the Aktionsart theory of [Eberle(1998)]: obviously, *je* does not change the Aktionsart of the

[16]Note that it would not be sufficient for these distributive modifiers to only stipulate the argument to be a characterization of an event sum. It has to be made explicit that the sum is not created via some type coercion or the like but by the impact of a thematic role.

(distributed) argument event predication. However, under certain circumstances A might be an unevaluated term because there cannot be assigned a clear Aktionsart to the representation $\lambda E.\ L$: One reason is that one does not know the internal temporal structure of E, with regard to the events associated to the partaking x (in the mentioned [Eberle(1998)] we have tried to present details about this type of Aktionsart-ambiguity). The other reason, of course, is that the (underspecified) representation LS might present scope ambiguities such that the LS-Aktionsart cannot be precisely determined. In the case of *nacheinander*, however, the Aktionsart of the resulting event predicate will be *hom*, if X stems from a *bare plural* constituent, and *het*, in all other cases. The function *a_eval* models this alternative. Note that the corresponding quality of the X-role (being the representation of a bare plural constituent or not) can be detected from the form of the X-contribution in L. *Gleichzeitig* will preserve the Aktionsart of the LS-description.

Whereas adverbs like *nacheinander* and *gleichzeitig*, and also adverbials like the *in rascher Aufeinanderfolge / in quick succession* of the example (25) in section 2.5.3, propose a temporal order of the events of the sum, other distributive adverbs do not. We consider *einzeln / separately* to be an instance of this (and also the other modifiers that we have introduced as pure floated quantifiers). All these adverbs control the referential setting of their argument and, in particular, the reading of a thematic role of the argument VP. For this reason, we call such adverbs *controlling adverbs*. The control (or part of the control) does not necessarily consist of requiring the distributive reading of the thematic role that is in focus. In contrast, it might consist of requiring the collective reading. We consider *zusammen / together* to be an example of this case. We represent this adverb as follows:

$$\text{zusammen} \longrightarrow \text{mod\_vpsem\_t} \begin{bmatrix} \lambda\text{:} & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{zusammen}}(\text{L}) \end{bmatrix}$$

$$\underline{\text{zusammen}}(\text{vpsem\_l}) \Rightarrow \text{vpsem\_l}$$

$$\underline{\text{zusammen}}(\text{l}_{\varepsilon_{akt(A)}}\text{:} \boxed{\begin{array}{l} \ldots \varepsilon \ldots \\ \vdots \\ \text{X}, \emptyset :: \text{LR} \ \Diamond_{\text{QU}\,\text{x}}\ \text{LS} \\ \vdots \end{array}}\ ) :=_{L \models tr(\varepsilon\ ,X)} \text{l1}_{\varepsilon_{akt(A)}})\text{:}\Box \ \begin{array}{l}\{\text{l} \leq \text{l1}\} \\ \text{L}\end{array} \ .$$

Like the representations of the other control adverbs further above, the representation of *zusammen* assumes a VP argument with a (wide scope) thematic role that introduces a sum X. In contrast to these representations, however, *zusammen* requires that this thematic role obtains a collective reading. This is effectuated by identifying the event sum that is abstracted from the corresponding duplex condition to the empty set (i.e., following the quantifier modeling of section 2.7.2, the quantifier statement is *saturated* without using the verb contribution). The restriction $L \models tr(\varepsilon\ ,X)$ guarantees that X indeed is a thematic role of the VP-event. Here, tr(ε ,X) will hold iff X is related to ε or to the atomic parts of ε (if any) through a thematic role relation (where the second case reflects the case where X is the distinguished referent of a subcategorized function and there is distribution over some other thematic role). Of course, there was no similar restriction needed for the *nacheinander*-case and the other distributive cases, because, there, the fact that the DRF E of the result index stems from the duplex condition that introduces the distribution of X guarantees this relation.

Obviously, *zusammen* does not change the Aktionsart of the event predication, because there is no modification outside the controlling of the reading of the considered thematic role. This is similar to the case of *je*.

It is an open question whether the representation of adverbs like *zusammen*, *gemeinsam* etc., besides this requirement of a plural thematic role with collective reading, should introduce further conditions describing additional assumptions about the particular partaking of the elements of the introduced sum with respect to the resulting event (sum) ε . Thus, for instance, *gemeinsam* will probably presuppose that the considered event type shows an agent and that the adverb will relate to this agent. Probably there is also the assumption that the elements of the collective agent can be assigned some intention (of collaborating in order to bring about the result of the event in question). We omit such refinements here.

3.6.7 Focus adverbs

Although, as for the adverbs of the last section, there might be reasons to treat focus adverbs, i.e., adverbs like *schon (already) / noch (still) / erst (only / nothing but ...) / nur (only)*, as modifiers of DPs or of VP-modifiers or as functions from VPs and DPs or VP-modifiers into VPs, we treat them as VP-modifiers also, like the control adverbs of the last sections and all the others further above.[17]

The assumption is that the semantic VP-argument comes with a focus-background structuring that directs the effect of the adverb. That is, the assumption is that the information structure that is available for the VP representation distinguishes focussed from background conditions and that the set of focussed conditions

[17]It is the fact that the focus is not necessarily one constituent, like in *Er gab nur Peter ein Brot / He gave only a roll to Peter* with focussed *Peter* or *Peter* × *a roll*, that is taken as an argument against the DP/DP and the VP/(VP,DP)-modifier assumption (and the corresponding (VP/VP)/(VP/VP) and the VP/(VP,VP/VP)-modifier assumption respectively—see [Jacobs(1989), Jacobs(1984)] for this). However, there are commonly accepted assumptions about the German vorfeld that contradict the remaining VP/VP-modifier classification for focus adverbs (compare the argument of [Bayer(1985), Bayer(1988)], also the summarizing discussion of [König(1991)]). We have nothing specific to say about this, at least with respect to the syntactic behavior, and, therefore, without going further into detail, we proceed with the classification which, probably, might also be the simplest with regard to obtaining a suitable underspecified representation of the focus structure that is put on top of the semantic representation.

delimit the goal constituent of the adverb.[18] We use *erst* as the representative of focus adverbs. We first list the representations of its readings and then comment on them—the introductory example (53.l) (*erst kam Hansi / first Hansi came*) shows the reading as temporal adverb, examples like *erst Hansi kam / only (so far) Hansi came*) suggest two readings as focus adverb[19] :

$$\text{erst} \longrightarrow \text{mod\_vpsem\_t} \begin{bmatrix} \lambda\text{:} & \langle^{\text{vpsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{erst}}(\text{L}) \end{bmatrix}$$

$$\underline{\text{erst}}(\text{vpsem\_l}) \Rightarrow \text{vpsem\_l}$$

$$\underline{\text{erst}}(\text{L}_\varepsilon\ ) := {}^{vpsem\_l}\text{l1}_\varepsilon : \boxed{\begin{array}{l} \alpha_{re}(\bar{e}, \boxed{\bar{e}}) \\ \varepsilon \ \ \text{starts } \bar{e} \end{array}} \begin{array}{l} \{\text{l} \leq \text{l1}\} \\ \text{L} \end{array}$$

$$\underline{\text{erst}}(\text{L}_\varepsilon\ ) :=$$

[18]On the level of semantics (or pragmatics) this is identical to saying that the adverb structures its argument into focus and background (since the decision criteria are syntactic in nature (and prosodic respectively), not semantic), and then applies further modification to the thus enriched semantic representation.

[19]The description follows the suggestion of [Eberle(1996b)].

^{vpsem_l}l1$_{\varepsilon}$:

E'

α_{presp}(s, [s | s: ATT(χ, { < MODE, [$\bar{e}$ E | E = $\Sigma_{i=1}^{i=k}$ e$_k$; $\bigwedge_{i=1}^{i=k-1}$ (e$_i$ $\prec$ e$_{i+1}$); $\bigwedge_{i=1}^{i=k}$ (e$_i$ $\subseteq$ $\bar{e}$); $\bigwedge_{i=1}^{i=k}$ P$_i$(e$_i$); $\forall$ P$_i$ (P$_i$ $\in$ {λe.L$_{[FOC(\text{L})|Q]}$ | $Q \in ALT(FOC(\text{L}))$}; $\bigwedge_{i=1}^{i=k-1}$ P$_i$ $\prec_{order(ALT(FOC(\text{L})))}$ P$_{i+1}$] > })])

realization_of(ε ,e$_l$)

P$_l$ = λ e . L

E' = $\Sigma_{i=1}^{l-1}$ e'$_i$

$\bigwedge_{i=1}^{i=l-1}$ realization_of(e'$_i$,e$_i$)

s meets e'$_1$

- - - - - - - - - - - - - - - optional - - - - - - - - - - - - - - - - - - -

α_{impl}(s', [s' | s': ATT(ξ, { < BEL, [E" | realization_of_beginning(E",E); |E"| $\geq$ l; E" $\prec$ temp_loc(ε)] > }); s' $\prec$ temp_loc(ε); s {$\prec$ $\vee\oslash$} s'])

{l $\leq$ l1}

L

$\underline{\text{erst}}(L_{\varepsilon}) :=\ ^{vpsem\_l}l1_{\varepsilon}$:

α_{presp}(E, [$\bar{e}$ E | $E = \Sigma_{i=1}^{i=k} e_k$; $\bigwedge_{i=1}^{i=k-1} (e_i \prec e_{i+1})$; $\bigwedge_{i=1}^{i=k} (e_i \subseteq \bar{e})$; $\bigwedge_{i=1}^{i=k} R(e_i, P_i)$; $\forall P_i\ (P_i \in \{\lambda e.L_{[FOC(L)|Q]} \mid Q \in ALT(FOC(L))\}$; $\bigwedge_{i=1}^{i=k-1} P_i \prec_{order(ALT(FOC(L)))} P_{i+1}$])

$\bigwedge_{i=1}^{i=k-1} (\neg$: [e_i' | $P_i(e_i')$; $e_i' \subseteq e_i$])

$\varepsilon \subseteq e_k$

$P_k = \lambda$ e . L

- - - - - - - optional - - - - - - -

α_{impl}(s, [s | s: ATT(ξ, < EXP, [e' | P_j(e'); n $\prec$ e'; e' $\subseteq e_j$; $e_j \prec e_k$] >); s $\prec$ temp_loc(ε)])

$\{l2 \leq l1\}$
L

The rules, in turn, present the three uses of *erst*. *Erst* can be used as temporal adverb, meaning *zuerst / first*. This use is reflected by the first rule. Here, we presuppose an actual reference event of the preceding text that is elaborated by the event that is introduced in the new sentence. We have omitted here to explicitly represent the information about the discourse relation, i.e. *elaboration* (for extensions of DRT in this respect see [Asher(1993), Eberle(1992), Lascarides/Asher(1991)]). There are specific syntactic constellations that can decide between this use and the two others. We assume that such syntactic information is available and can be used. [20] The two other uses are specifications of the focus adverb use.

The second rule reflects the case of a scenario like the following:

(63) *Gestern wollte Peter schnell nach Hamburg fahren. Um 12 war er erst in KÖLN.*
Yesterday Peter wanted to travel to Hamburg quickly. At noon, he only was at Cologne.

Here, *erst* means that a *plan* or a *desire* of someone is presupposed (where, in the representation, the variable MODE subsumes these alternatives) saying that a particular event $\bar{e}$ be realized, where this event encompasses a number of relevant

[20] Again, compare the discussion of [König(1991)] about syntactic analysis and its consequences. For an approach to focus adverbs in general, also compare [König(1991)], the earlier [König(1979)], also [Löbner(1989)]).

successively ordered subevents which are described by (contextually relevant) alternatives of the argument event predicate of *erst*. We assume that these alternative event predicates develop from the argument event predicate through replacing the focussed condition(s) by (contextually licensed) alternatives to the/these focussed condition(s). The order of the event types is assumed to be available from the order of the alternatives of the focus element.[21] The assertion then is that the plan or desire $\bar{e}$ is realized to a certain extent with respect to the considered reference time; i.e., the reported event is realized at this reference time and this event is the last realized one of a series of subevents that makes up the plan or desire. A conventional implicature of this scenario is that a contextually available observer (the hearer, the speaker, probably both) would have expected a more complete realization of $\bar{e}$ for the evaluation time. In the entry, we have made use of the suggestion for the representation of attitudinal states that is developed in [Kamp(1995b)] and that we have used in §2.6 already.

The third rule reflects the case of a scenario as in (64).

(64) *Peter probierte eine Reihe von Schuhen an. Erst die Birkenstock-Schuhe paßten.*
Peter tried a number of shoes. Only (nothing before) the Birkenstock shoes fitted.

Here, we assume that a presupposition is involved—that of a temporally ordered series of test cases for the realizations of alternatives to the argument event type (such that, with respect to the example, R(e_i,P_i) is interpreted as 'e_i is a testing of the ith type of shoes). The assertional impact is assumed to be the realization of the argument event type within the corresponding test environment together with the exclusion of realizations of the event types that correspond to the previous test occasions. In a way, this is a mirror image of the other focus adverb reading. Whereas that reading entails the realization of previous alternatives, here, the realization of the previous possible instantiations is excluded. According to this back-to-front outcome, we assume the corresponding back-to-front implicature. As was observed frequently, the meanings of a number of German focus adverbs are closely related to each other (see [Löbner(1989)] for a corresponding relational outline). Therefore, the representation suggested for *erst* might serve as a schema for the representation of a whole bunch of German focus adverbs. We emphasize once again that here we cannot deeply investigate focus adverbs as such, or merely comment in greater detail about the formal means of the given representations and about motivations; instead, take the complexity of these examples of exhaustive deep semantics as a further argument for the necessity of an architecture that provides flat semantics that gradually can be worked out.

[21] The order of the event types will result from an interplay between the natural order of the focus alternatives and the presupposed scenario that is elaborated. With regard to (63) the focus as such, Cologne, and the alternative cities do not entail an order. Here, the relevant order comes from the knowledge that the cities function as places of a path.

3.6.8 Frequency adverbs

Frequency adverbs effect quantification:

(65)

a. *Inge fuhr oft nach Hamburg.*
   Inge often went to Hamburg.

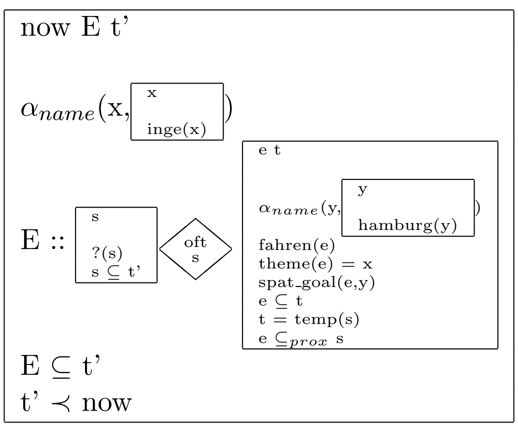
b. *Helmut war dreimal in Paris.*
   Helmut was in Paris three times.

c. *Dreimal traf Peter nicht.*
   Peter missed (the mark) three times.

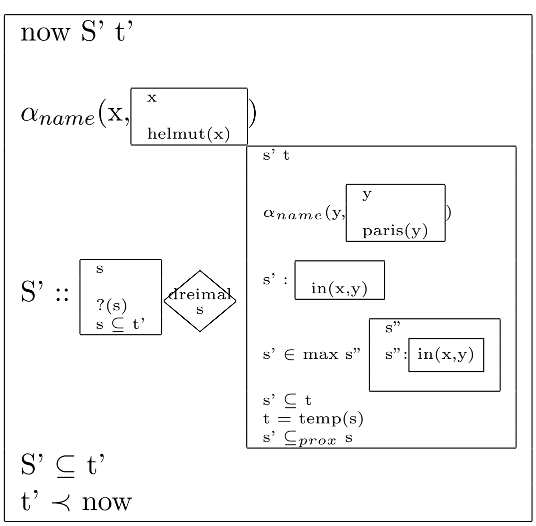
d. *Peter fährt immer mit dem AUTO nach Frankreich.*
   Peter always travels to France by car.

We represent (65.a) – (65.d) as follows:

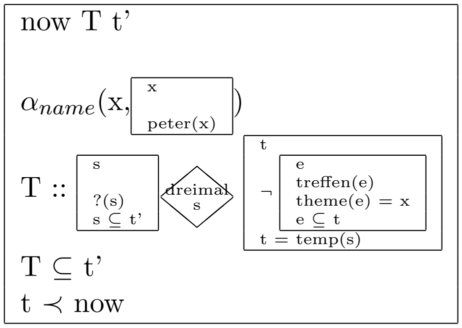
(65.a$_{rep}$)



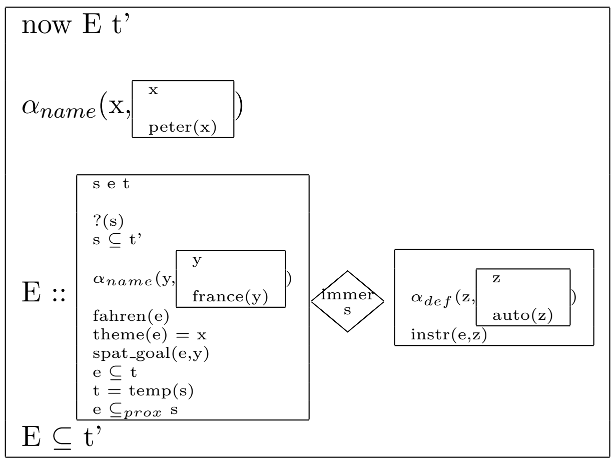
(65.b$_{rep}$)



($65.c_{rep}$)



($65.d_{rep}$)



The representations restrict the quantification to *relevant situations*, s, which, of course, have to be characterized by contextual information, therefore the condition '?(s)'. The example and its representations should illustrate that the descriptions of what is relevant may differ widely. Whereas the only interest of (a) and (b) is to inform about the number of travels to Hamburg and of sojourns in Paris respectively as included in the contextually given reference time; that is, whereas , here, regardles of some further restricting criterion, each subsituation of the focused reference time is potentially relevant, (c) and (d) take into account some pretty restricted subsituations only. We will come back to this latter case of (c) and (d) in an instant.

($65.a_{rep}$) represents the standard case: the adverb introduces a generalized quantifier that relates the set of the (not further specified) contextually relevant situations to the subset of those relevant situations which are specified by containing an instance of the argument event type. Because in the (65.a) scenario, the temporal focus of the embedded event type obviously must be restricted to the considered situation, the scope representation of the frequency duplex condition binds the corresponding focus time to the time of this considered situation, and, thus, guarantees that the scopal event indeed is included within the time of the situation. Of course, there is introduced a new focus time for the restrictor situations that is percolated upwards.

Note that this procedure of binding the focus time of the event to the situation is not sufficient to rule out the case where a considered situation contains more than one event of the argument type. Since this case would contradict the intuitions about the counting that is effectuated by the frequency adverbials, we refine the relation between the relevance situation s and the scopal event e by saying that e spatio-temporally approximates s, to the effect that s cannot contain more than one event of the considered argument event type. Here, we cannot spell out a logically suitable definition of the corresponding $\subset_{prox}$ -relation.[22] It is clear that the corresponding further constraint is meant to have the effect that there is a one-to-one-correspondence between the events which satify the scope requirements and their relevance situations, such that (65.a_{rep}) means that against the background of the relevant situations, what, here, means: against the background of the totality of the possible location times as presented by the reference time, the situations which correspond to instantiations of the event type in question are *oft*-many. Obviously, *oft*, just like the NP-quantifiers *viele* and *wenige*, will be defined by comparison. That is, what is *oft* will depend on some presupposed comparison value which says something about the expected 'normal' frequency of instantiations of the considered event type with respect to a stretch of time of equal length as the considered one.

Because, through the quantification, the focus time of the event is bound to the intermediate reference situation, the impact of the tense information, which is to control the correct choice of a contextual available reference time is pending, so to speak. Of course, its function must be to trigger the anchoring of the restrictor reference situations to a suitable contextual reference time which identifies the considered background of the quantification. That is, we will introduce a new focus time t' which temporally includes the restrictor situations, and which, according to the tense information will be resolved to a contextual reference time, when the sentence representation is incorporated into the context representation. Thus, in other terms, part of the contextual setting of *relevance* will consist of focusing on some relevant time, on t'. In the examples before, we accommodated the focus times at the main level of the DRS, instead of introducing them via (unresolved) presuppositional α-conditions. We continue to do so for the new focus time also. Therefore, in (65.a_{rep}), as in the following examples, the new focus time t' is introduced into the outermost universe.

(65.b_{rep}) emphasizes that quantification presupposes the notion of countability. Mass terms do not provide a counting criterion, the same is true for homogeneous event types (that, in a way, can be considered as a subclass of mass terms). What is counted in the case of homogenous event types are local maxima: (65.b_{rep}) means that, against the background of the relevant situations, there are three maximal states in which Helmut was in Paris; we are not counting sub-states of these states.

[22]For the introduction and use of such a relation in order to designate proximity to a time point see [Herweg(1990)], for a corresponding spatial use [Bierwisch(1983)].

For the case at hand, note that a precise analysis would have to take into account some contextual criterion (the event predicate?) as a third argument.

Therefore (so our conclusion), in case the frequency adverb is applied to a homogeneous argument event type, type coercion via *max*-operation must be triggered, as in (65.b_{rep}).

(65.c_{rep}) exemplifies the need for a specific treatment of the subclass of homogeneous argument event types that describe the exclusion of events of a particular type. Think of a scenario where Peter shoots several times at the fairground booth and in which he misses several times in sequence. Then the maximal phase of missing the mark would consist of several failures, but would be counted once according to our existing representation schema for homogeneous argument descriptions. Thus, in this specific case, we omit the maximality condition which restricts the argument event type. And, since, in this specific case, the argument type, as seen, doesn't come with a natural intrinsic prescription of the shape of its instantiations it is not astonishing that this task of seizing and presenting a form is taken over by the surrounding structure; that is, that (65.c_{rep}) exemplifies the case were the description of the relevant situations is indeed relevant. Of course, against the described scenario, the relevant situations are a series of test cases (in the sense of the preceding section about focus adverbs) for successful shootings at the booth; such that the quantification contrasts the failing tests with the totality of tests (and not maximal absences of instantiations of the considered type with the reference stretch of time).

(65.d_{rep}) treats an often observed phenomenon: in case the argument event type is structured into background and focus, the background tends to be part of the restrictor of the adverb duplex condition; i.e., it tends to be understood as further describing the relevant domain of quantification. (65.d_{rep}) indirectly points to the question whether the relevant restricting situations should be construed as pure times or whether they should be assigned finer individuation criteria. Note that the first case allows for relevant situations (i.e.e times) that potentially realize different instantiations of the considered event type such that quantifying over these relevance situations (which are times in this case) could be misleading. Examples like the following (66), which illustrate (variants of) this argument, seem to suggest the second alternative therefore.

(66)

a. Es schneite vielerorts.
It snowed at many places.

b. Es schneite vielfach.
It snowed in many cases.

c. Immer wenn eine Katze eine Maus sieht, fängt sie sie.
Always, when a cat sees a mouse, it catches it.

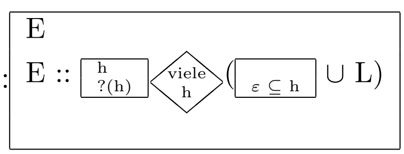
(66.a) illustrates that some frequency adverbs (better: quantifying adverbs) explicitly relate to things that are different from times, to places in this case. What does (66.b) relate to? As it seems, to a mixture of times and places to spatio-temporal situations then?

We leave the question about the precise ontological granulation of the domain of quantifying adverbs open here. However, note that (66.c) very strongly suggests that the relevance situations introduced by quantifying adverbs satisfy the fine-grainedness of events, since, here, it seems to be justified (and the simplest solution) to saying that *immer* identifies its quantified variable to the distinguished referent of the subclause (or effectuates a one-to-one correspondence to this referent respectively). At least, it is true that the subset relation which *immer* claims to hold between the situations where a cat sees a mouse and the situations where a cat sees a mouse and catches it cannot be truly interpreted as a relation between sets of times, Because then, it would be allowed that there are (relevant) t's at which cats see mice without catching them, provided that for the same t's there are cats and mice satisfying the described behavior pattern. (Also, the purely temporal interpretation of the relevance situation seemingly is not fine-grained enough in order to allow for a sufficiently precise constraining effect of the $\subseteq_{prox}$-condition in the general quantification case.[23])

We list entries for the discussed examples (where, for simplicity, we assume that the presuppositional '?(s)' additionally introduces the new focus time, and the proximity-relation statement additionally signifies the temporal identification of the relevance situation to the embedded focus time):

vielerorts $\longrightarrow$mod_vpsem_t $\begin{bmatrix} \lambda: & \langle L \rangle \\ \text{RES:} & \underline{\text{vielerorts}}(L) \end{bmatrix}$

$\underline{\text{vielerorts}}$(vpsem_l) $\Rightarrow$vpsem_l

$\underline{\text{vielerorts}}(L_{\varepsilon \ akt(A)}) \ := \ l1_{E_{akt(\underline{res}(\ <\ het_{A=het}, \emptyset_{A=hom}\ >\ ))}}$: 

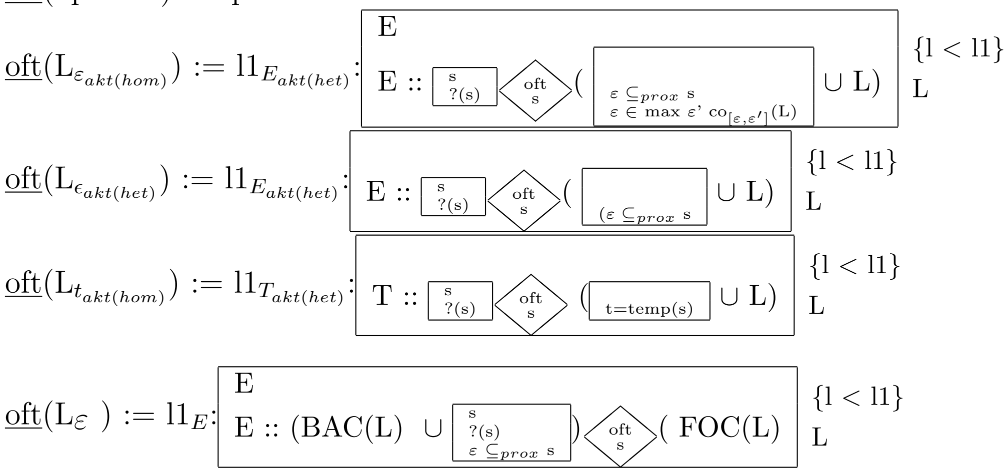
{l < l1}
L

A short reflection makes clear that in the case of explicit quantifying over places there is no need for introducing a new focus time or to distinguish finer cases, i.e. relevance situations, than the quantified places. The individuation problem for events or situations does not arise in this case. We postpone commenting on the Aktionsart information of this entry (which leaves open the decision about the new Aktionsart in the case of homogeneous argument types) and of the following until the section 3.11.

oft $\longrightarrow$vpsem_modifier_t $\begin{bmatrix} \lambda: & L \\ \text{RES:} & \underline{\text{oft}}(L) \end{bmatrix}$

[23]On the basis of similar considerations, [Lewis(1975)] indicates that such quantifying adverbials can be seen as *unselective* quantifiers, where a tuple of parameters corresponds to a *case*. One could say that the relevance situations of the approach here identify (reify) Lewis' cases.

oft(vpsem_l) ⇒vpsem_l

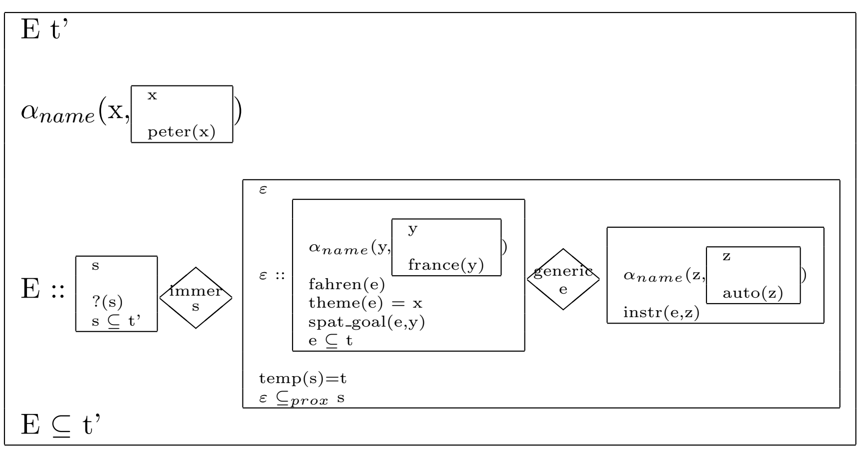


The last rule is only a sketchy illustration of the (66.d.) scenario that has to be worked out. As with the representations of the last section, it remains to exactly define the projections BAC, which picks up the background of a representation, and FOC, which picks up the focused part.[24]

[24]There is also a probably more analytic account of the phenomenon connected to (66.d.).

Taking into consideration that, provided a suitable information structure, the sentence without adverb can be understood as a habitual with generic quantification over the items of the background type and with the focus information in the scope, we can take this representation as argument of the adverb semantics and obtain a representation that says that, for 'adverb-many' (i.e. all, many, few etc.) relevant situations, the generic law holds. Now, taking into account that the generic quantification is a kind of default universal quantification (compare [Asher/Morreau(1990)]), this alternative representation is logically very similar to the one that we have suggested. For (66.d.) the alternative has the following shape:

(65.d$_{rep}$)



We think that this type of alternative is very attractive, because of its more direct compositionality. Also it is more in line with what we have said in section 3.6.3 when discussing example (59) From the theoretical standpoint, we would like to leave the question open, not without mentioning that from this standpoint the discussion about the individuation criteria of relevance situations has to be revised in light of the fact that the argument that we have used in connection with (66.c.)

For *selten, manchmal, zweimal, dreimal, immer, nie* etc. we will obtain similar entries. Of course, when characterizing the introduced quantifiers, we will make use of the typology presented in section 3.4.5 for nominal quantifiers.

3.7 Conjunctions

We present a brief overview of coordinating and subordinating conjunctions, mainly with regard to the types of the introduced relations and the sortal restrictions of the arguments.

3.7.1 Subordinating conjunctions—temporal relations and discourse relations

Consider the following examples of the subordinating conjunctions *nachdem* and *seitdem* (combining different types of sentences):

(67)

a. Nachdem Peter das Auto gewaschen hatte, fuhr er in die Stadt.
After Peter had washed the car, he went into town.

b. Nachdem Peter das Auto gewaschen hatte, regnete es.
After Peter had washed the car, it began to rain.

c. Nachdem Peter das Auto gewaschen hatte, fuhr er nicht in die Stadt.
After Peter had washed the car, he did not go into town.

d. Nachdem Peter das Auto nicht gewaschen hatte, konnte er nicht der Mörder sein.
Because Peter had not washed the car, he could not be the murderer.

*e. *Seitdem Irene nicht da war, fühlte er sich schlecht.*
(*) Since Irene was not there, he felt ill.

f. Seitdem Irene nicht mehr da ist, arbeitet er nicht.
Since the time Irene had left, he did not work.

g. Die Touristen gingen auf ihre Zimmer nachdem sie eingecheckt hatten.
The tourist went to their rooms after they had checked in.

Temporal subjunctions relate events, processes, states or times. There is no uniform distribution however and different cases may have to be considered, with different treatments—introducing different relations, or, even triggering reinterpretation of the event type of main clause or subclause. *Nachdem* and *seitdem* exemplify this to a certain degree. For a more exhaustive discussion and listing of the meaning of the temporal subjunctions compare [Herweg(1990)], also [Eberle(1991a)] (which,

does no longer hold (because under the new perspective the sentence would say that at each situation (time) the mise-catching law holds). From a practical standpoint however, throughout the rest of this paper, we stick to the alternative that has been introduced first.

as seen at various places above, in a way, prepares parts of our suggestions of this study). Here, as in the other sections, we content ourselves to represent uses which, to our opinion, are typical. Thus, the standard case of *nachdem*, which is illustrated by (67.a), obviously localizes the event of the main clause after the reference event which is provided by the subclause. We model this by including the main clause event in the reference time that is introduced by the subclause event and that temporally follows it (corresponding to a/the resultive state of this event). Of course, this is identical to saying that the focus time that comes with the main clause event will be identified as a time that immediately follows the subclause event.

(67.b) shows that this is not sufficient when considering main clause states (or processes). Since representatives of state or process descriptions are not necessarily temporally maximal representatives of their descriptions, the a)-modeling would not exclude that there might be a main clause instance that overlaps the subclause event, which, clearly, is contrary to intuitions. Therefore, the case with homogeneous main clause descriptions first will apply the Aktionsart operator *max* to the main clause description before relating the corresponding distinguished referent (and its focus time) to the subclause event along the lines of the a)-case. (Note that in order to get the relevant information correctly represented—that the state/process of the main clause does not start before the end of the subclause event—an equally suitable alternative is to apply the operator *ing* (for ingression, see section 3.6.5) to the main clause description—it seems that the English translation prefers this alternative).

In the presence of homogeneous descriptions that develop from negating event descriptions, as in (67.c), the corresponding application of an Aktionsart operator not only would be inadequate, it would be false. The argument here is quite similar to what has been said in the last section about frequency adverbs and negated event types.

Summarizing, we aspire to the following representations of (67.a)-(67.c):[25]

[25] In the representations, the information below the dotted lines is information that should come from the resolution component (of the nominal resolution component in this case).

(67.a_{rep})

e_1 t_2 e2
α_{name}(u, [u | peter(u)])
α_{def}(v, [v | auto(v)])
α_{rt}(t_1, [t_1 | $t_1 \prec$ n])
waschen(e_1)
agent(e_1) = u
object(e_1) = v
$e_1 \subseteq t_1$
$e_1 \prec t_2$
α_{pro}(x, [x | .... x=u])
α_{def}(w, [w | stadt(w)])
fahren(e_2)
agent(e_2) = x
spat_goal(e_2,w)
$e_2 \subseteq t_2$

(67.b_{rep})

e_1 t_2 e_2
α_{name}(u, [u | peter(u)])
α_{def}(v, [v | auto(v)])
α_{rt}(t_1, [t_1 | $t_1 \prec$ n])
waschen(e_1)
agent(e_1) = u
object(e_1) = v
$e_1 \subseteq t_1$
$e_1 \prec t_2$
regnen(e_2)
$e_2 \in$ max e co $_{[e_2/e]}$ [e_2 | regnen(e_2)]
$e_2 \subseteq t_2$

(67.c_{rep})

e_1 t_2
α_{name}(u, [u | peter(u)])
α_{def}(v, [v | auto(v)])
α_{rt}(t_1, [t_1 | $t_1 \prec$ n])
waschen(e_1)
agent(e_1) = u
object(e_1) = v
$e_1 \subseteq t_1$
$e_1 \prec t_2$
$\neg$ [
e_2
α_{pro}(x, [x | .... x=u])
α_{def}(w, [w | stadt(w)])
fahren(e_2)
agent(e_2) = x
object(e_2) = w
$e_2 \subseteq t_2$
]

(67.d) illustrates the assumption, which is strongly confirmed by the data, that *nachdem*, as temporal relation, doesn't accept negated statements as internal argument. *Seitdem* is very similar in this respect, see (67.e). However, the difference is that *nachdem* shows an additional reading as a non-temporal (causal) discourse relation. We assume that, for the temporal conjunctions considered and with respect to similar ones, this restriction (partly) is explained by the function that the subclause (commonly) plays with respect to the main clause event: it provides a reference event—and, with this, a subsequent reference time for the main clause event. Following our analysis of the exclusion of events (here and above in sections 3.4.4, 3.6.5, 3.6.8), the only reference time that could be provided by negative statements would be the existing reference time of the preceding text (there would be no reasonable maximality criterion that could provide a maximal time for which the negated statement is claimed to be true—and, with this, a succeeding 'result' time that could be in focus). Therefore, in this case, the subclause would be completely uninformative (and should be ruled out, at least pragmatically, for Gricean reasons). [26]

However, it can be observed that, very regularly, the *nicht mehr* form is accepted where the pure negation is unacceptable (in the subclause of temporal *nachdem* and *seitdem*, for instance). In [Bäuerle(1988)] and [Eberle(1991a)] this is explained by the assumption that *nicht mehr*, in contrast to *nicht*, that excludes the existence of events of the argument type for the reference time, introduces a (positive) resultive state of the argument event type:

$$\text{nicht mehr} \longrightarrow \text{vpsem\_modifier\_t} \begin{bmatrix} \lambda: & \langle \text{L} \rangle \\ \text{RES:} & \underline{\text{nicht\_mehr}}(\text{L}) \end{bmatrix}$$

$$\underline{\text{nicht\_mehr}}(\text{vpsem\_l}) \Rightarrow \text{vpsem\_l}$$

$$\underline{\text{nicht\_mehr}}(\text{L}_{\varepsilon_{akt(hom)}}) := \text{l1}_{s_{akt(hom)}} : \boxed{\begin{array}{l} \text{s} \\ \hline \text{s} \in \text{perf } \varepsilon \text{ (L)} \end{array}} \begin{array}{l} \{\text{l} < \text{l1}\} \\ \text{L} \end{array}$$

We have omitted here to spell out rules that treat the case of heterogeneous argument event types and the corresponding necessary type coercion and its admissible realizations.

It is not only such homogeneous *nicht mehr* descriptions that are accepted as subclause of *nachdem* (and *seitdem*), but also others. According to the above explanation of the subclause function, we expect heterogeneous reinterpretation in this case, however. Thus, we model (temporal) *nachdem* as follows:

[26] Of course, there may be other parameters that influence the setting. Some conjunctions less than others show a clear division of labour, saying that the subclause should anchor the new information of the main clause. The more the information of the conjunction consists of establishing a non-temporal (adversative, contrastive) discourse relation (*während / during* for instance), the more the two situations introduced are equilibrated with respect to the information structural distinction into anchor and new information, and the less excluding negated statements from the subclause is a hard requirement. Also, information structure as such can influence the setting. For instance, some conjunctions accept that, for subclause and main clause, the roles of anchor and anchored information may be exchanged for each other, given suited (syntactic, prosodic, or inferred pragmatic) information.

$$\text{nachdem} \longrightarrow \text{subord\_conj\_t} \begin{bmatrix} \lambda\text{:} & \langle \text{L1,L2} \rangle \\ \text{RES:} & \underline{\text{nachdem}}(\text{L1,L2}) \end{bmatrix}$$

$\underline{\text{nachdem}}(\text{satvpsem\_l,vpsem\_l}) \Rightarrow \text{vpsem\_l}.$

$$\underline{\text{nachdem}}(\text{L1}_{\varepsilon\ 1_{akt(A)\&tf(TL,perf+,\_)}},\ \text{L2}_{\varepsilon\ 2_{akt(B)\&tf(TL,perf+-,\_),t}})$$

$$:= \text{L3}_{\varepsilon\ 2_{akt(het),t}}\text{:}\ \left(\boxed{\begin{array}{l} \text{t} \\ \\ \varepsilon\ 1 \text{ meets t} \\ \underline{\text{res}}(\langle \varepsilon\ 1 \in \max\ \varepsilon \text{ co}_{[\varepsilon\ 1/\varepsilon\ ]}\ (\text{L1})_{A=hom},\ \emptyset_{A=het}\rangle) \\ \underline{\text{res}}(\langle \varepsilon\ 2 \in \max\ \varepsilon \text{ co}_{[\varepsilon\ 2/\varepsilon\ ]}\ (\text{L2})_{B=hom},\ \emptyset_{B=het}\rangle) \end{array}} \cup \text{L1} \right) \quad \begin{array}{l} \{\text{l2} \leq \text{l3}\} \\ \text{L2} \end{array}$$

$$\underline{\text{nachdem}}(\text{L1}_{\varepsilon\ 1_{akt(hom)\&tf(TL,perf-,\_)}},\ \text{L2}_{\varepsilon\ 2_{akt(B)\&tf(TL,perf-,\_),t}})$$

$$:= \text{L3}_{\varepsilon\ 2_{akt(het),t}}\text{:}\ \boxed{\begin{array}{l} \text{t}\ \varepsilon\ 1' \\ \\ \varepsilon\ 1' \text{ meets t} \\ \varepsilon\ 1' \in \text{ingr}\ \varepsilon \text{ co}_{[\varepsilon\ 1/\varepsilon\ ]}\ (\text{L1}) \\ \underline{\text{res}}(\langle \varepsilon\ 2 \in \max\ \varepsilon \text{ co}_{[\varepsilon\ 2/\varepsilon\ ]}\ (\text{L2})_{B=hom},\ \emptyset_{B=het}\rangle) \end{array}} \quad \begin{array}{l} \{\text{l2} \leq \text{l3}\} \\ \text{L2} \end{array}$$

$$\underline{\text{nachdem}}(\text{L1}_{\varepsilon\ 1_{akt(A)\&tf(TL,perf+,\_)}},\ \text{L2}_{t_{akt(hom)\&tf(TL,perf+-,\_),t}})$$

$$:= \text{L3}_{t_{akt(het)},t}\text{:}\ \left(\boxed{\begin{array}{l} \text{t} \\ \\ \varepsilon\ 1 \text{ meets t} \\ \underline{\text{res}}(\langle \varepsilon\ 1 \in \max\ \varepsilon \text{ co}_{[\varepsilon\ 1/\varepsilon\ ]}\ (\text{L1})_{A=hom},\ \emptyset_{A=het}\rangle) \end{array}} \cup \text{L1} \right) \quad \begin{array}{l} \{\text{l2} \leq \text{l3}\} \\ \text{L2} \end{array}$$

The specification of the nachdem function reflects the discussed uses of *nachdem* as temporal relation. The (causal) discourse relation use is omitted. In all cases, the assumption is that subclause and main clause show the same *tense level* (TL); i.e., they share the TL-value (which may be *past, pres*ent and *fut*ure). The representations illustrate that we annotate the tense information to the corresponding event, or, more precisely, to the index of the corresponding event. We make use of the three-dimensional analysis of the tenses, as suggested in [Kamp/Rohrer(1985)]. The tf-feature renders the values with respect to these three dimensions (see also section 3.11 for this). The second slot describes *perfectivity* (yes or no, i.e., '+' or '-'), the third *progressivity* (also by '+' or '-').

Now, the first rule encompasses the use of *nachdem* in (67.a) and (67.b): provided the subclause uses a perfect tense form (i.e., when considering the subclause : main clause relations: past perfect :: simple past/past perfect, present perfect :: present (perfect), future perfect :: future (perfect)...), this rule is applicable. In order to always come up with a heterogeneous description, it is assumed that the *max*-operation is applied to the subclause description in case this description is homogeneous. The treatment of the main clause is as described further above. [27] With this (and without applying type coercion onto the internal argument), we can obtain (67.a_{rep}) and (67.b_{rep}).

The second rule treats the case of non-perfective tense forms, as in: *nachdem er im Zimmer war, öffnete er den Mantel / after he was (*or *arrived) in the room, he opened the coat*: we think that, in this case, the homogeneous subclause description obtains an inchoative reinterpretation, as illustrated by the corresponding lexical representation. Thus, the introduced state or process is seen as the resultive state

[27] Application of *max* to the subclause description and obtaining a heterogeneous reference event by this is the easier the more the resulting maximal state or process can be expected to be relatively short, in order to play the role of a precise anchor.

of its starting event, and, by this, the picture is quite homomorphic to the case of the first rule. We have omitted a represention of the subcase of heterogeneous subclause descriptions (which, as it seems, is rather marginal). The corresponding representation would provide the subsequent application of the coercion-operators *prog* and *ingr*.

The third rule treats cases like (67.c) with negated main clause statements according to what has been said above. There is no rule dealing with the corresponding subcase of non-perfective subclauses. We have the feeling that this subcase does not represent a common or readily used information schema, probably because of the necessity for applying several information changing operations—negation (to the main clause) **and** Aktionsart coercion(s) (to the subclause). A corresponding fourth rule would be defined in the spirit of the second rule (if, for the sake of completeness, one is interested in such a rule).

(67.f) shows that the basic use of *seitdem*, in contrast to the case of temporal *nachdem*, not only includes the main clause event in the reference time that is provided by the subclause, but that it exhausts this time and that it stipulates this time to overlap another contextually given reference (or perspective time); using the above *nicht mehr* representation, we can represent (67.f) as follows:[28]

[28] Here, as in the preceding and following representations, the temporal relations are as in [Allen(1983)], though there are notational differences. t { s, si, id } t' is a more 'Allen'-like notation which says that *t starts t', or is started by t' or is temporally identical to t'*. The relations that we have used so far are abbreviations of Allen's interval relations. Thus $\prec$ stands for { m, b }, with m for *meets* and b for *before*, $\circ^t$ for { f, fi, d, di, s, si, id }, with f for *finishes*, d for *during*, etc., and the corresponding inverse relations. All this should be rather self-explanatory. For details of the notation, see [Eberle(1991a)].

(67.f_{rep})

s_1 t t_2
α_{rt}(t_1, [t_1 | $t_1 \circ^t$ n])

$s_1 \in$ perf s [s | α_{name}(u, [u | irene(u)]) | s : [α_{rl}(h, [h | da(h)]) | u $\subseteq$ h]]

$s_1 \in$ max s" perf s' [s' | α_{name}(u, [u | irene(u)]) | s': [α_{rl}(h, [h | da(h)]) | u $\subseteq$ h]]

$s_1 \subseteq t_1$

s_1 { s, is, id } t_2
n finishes t_2

¬: [e_2
α_{pro}(x, [x])
arbeiten(e_2)
agent(e_2) = x
$e_2 \subseteq t_2$]

Here, this second reference time, which, in addition, has to be a perspective time, must be the contextual *now* (n), because of the specific tense information. In the presence of homogeneous subclause descriptions, as in the case at hand, *seitdem* will pick out a maximal representative of the description and stipulate that the distinguished referent of the main clause temporally starts at the same time as this representative, where both, the representative of the subclause and the referent of the main clause, are required to overlap the perspective time (the 'n' with respect to the example). We note that (67.f_{rep}) satisfies to these assumptions, through the mediation of the corresponding focus times.

In the presence of heterogeneous subclause descriptions, the event of the subclause, similar to the *nachdem*-cases, will be taken as left boundary of the relevant reference time that the subclause provides for the main clause. Of course, the use of perfective tense in the subclause fits best with this relation case. The corresponding entries of the considered cases are the following:

seitdem $\longrightarrow$subord_conj_t $\begin{bmatrix} \lambda\text{:} & \langle \text{L1,L2} \rangle \\ \text{RES:} & \underline{\text{seitdem}}(\text{L1,L2}) \end{bmatrix}$

<u>seitdem</u>(satvpsem_l,vpsem_l) $\Rightarrow$vpsem_l.
<u>seitdem</u>($\text{L1}_{\varepsilon\ 1_{akt(A)\&tf(TL,perf+,\_)}}$, $\text{L2}_{\varepsilon\ 2_{akt(hom)\&tf(TL,perf+-,\_)}}$)

$$:= L3_{\varepsilon\ 2_{akt(het)}} : \left(\begin{array}{|l|} \hline t \\ \hline \varepsilon\ 1 \text{ meets } t \\ \alpha_{pt}(t', \begin{array}{|c|} \hline t' \\ \hline \\ \hline \end{array}) \\ t' \text{ finishes } t \\ t\ \{s, id\} \varepsilon\ 2 \\ \underline{res}(\langle \varepsilon\ 1 \in \max \varepsilon \text{ co}_{[\varepsilon\ 1/\epsilon]}\ (L1)_{A=hom},\ \emptyset_{A=het} \rangle) \\ \varepsilon\ 2 \in \max \varepsilon \text{ co}_{[\varepsilon\ 2/\epsilon]}\ (L2) \\ \hline \end{array} \cup L1 \right) \quad \begin{array}{l} \{l2 \leq l3\} \\ L2 \end{array}$$

$$\underline{\text{seitdem}}(L1_{\varepsilon\ 1_{akt(hom)\&tf(TL,perf-,\_)}}, L2_{\varepsilon\ 2_{akt(hom)\&tf(TL,perf-,\_)}})$$

$$:= L3_{\varepsilon\ 2_{akt(het)}} : \left(\begin{array}{|l|} \hline t \\ \hline t\ \{\ s, id\ \}\ \varepsilon\ 1 \\ \alpha_{pt}(t', \begin{array}{|c|} \hline t' \\ \hline \\ \hline \end{array}) \\ t' \text{ finishes } t \\ t\ \{s, id\} \varepsilon\ 2 \\ \varepsilon\ 1 \in \max \varepsilon \text{ co}_{[\varepsilon\ 1/\varepsilon\ ]}\ (L1) \\ \varepsilon\ 2 \in \max \varepsilon \text{ co}_{[\varepsilon\ 2/\varepsilon\ ]}\ (L2) \\ \hline \end{array} \cup L1 \right) \quad \begin{array}{l} \{l2 \leq l3\} \\ L2 \end{array}$$

Here, α_{pt} triggers the resolution of t' to a contextual perspective time. We have omitted the case of a negated main clause statement. The corresponding representation, mainly the relevant suppressing of the *max*-operation, follows closely the third *nachdem*-rule. Also, we have omitted the (remaining) cases of admissible type coercion. As (67.e) makes clear, there will be no rule that would accept an interval as distinguished referent of the subclause. Note that the listed entries indeed guarantee that the representatives of the main clause share the starting point with the reference time from the subclause, and that they overlap the perspective time also. Note that in case of homogeneous non-perfective subclause descriptions (second rule), the subclause reference situation correctly overlaps this perspective time also.

Seitdem can be used as adverb also. We obtain the corresponding semantics from the existing *seitdem* entry (modulo canonical type revisions) by exchanging the subclause semantics for a further α-condition that points to a further context time.

(67.g) shows that the result of applying a temporal subordinating conjunction to a sentence indeed should result in a VP modifier and not in a sentence modifier: besides the reading of (67.g) that the set of checking-in events precedes the set of going-to-the-rooms events, there is the (weaker and probably more prominent) reading that each of the tourists went onto his room after having checked in, i.e., the reading where the subject DP has scope over the *nachdem*-clause.

Other subordinating conjunctions—causal, consecutive, telic, hypothetical, i.e., *modal* conjunctions (in the wide sense)—show other behavior with regard to the ontological properties of their arguments (and, certain of them, also, with regard to the 'factuality' of the related arguments). In this paper, we only consider the causal conjunction *weil* in a bit more detail. We will try to motivate that the arguments of the corresponding semantic relation are not events (in the wide sense), times or other objects of a canonical 'naive physics' ontology, but statements. That is, at the representation level, the arguments of the corresponding relation symbol are not the common event, or time-DRFs of the DRS-universe, but DRSs as such, or, markers that point to DRSs. The treatment of *weil*, so, is meant as a sample modeling of those subordinating conjunctions that, loosely speaking, instead of relating referents the discourse is about (only), (also) relate parts of the discourse as such. Following common terminology, we will say that such conjunctions introduce *discourse relations* (or *rhetorical relations* as they are called also, see [Hobbs(1985b), Asher(1993), Mann/Thompson(1987)]). Of course, the temporal conjunctions, as considered above, must be interpreted as discourse relations also. We come back to this at the end of this section.

(68)

a. *Weil Petra gekommen war, aß Jan die Spaghetti nicht.*
   Jan did not eat the spaghetti, because Petra had come.
b. *Weil Petra nicht gekommen war, aß Jan die Spaghetti alleine.*
   Jan ate the spaghetti alone, because Petra had not come.

(68) testifies that *weil* connects clauses whose distinguished referent is allowed to be a time. Now, if we claim that the representation of causal subordinating conjunctions (*weil, da, ...*) relate the distinguished DRFs of main clause and subordinate clause, we obtain rather unintuitive representations where a time can be said to be the cause or the effect of an event or another time. But do such conjunction really postulate causal links? It seems not. Natural language *weil* is not used as a narrow causal relation (that could relate only events), but as a relation that provides reasons, arguments that motivate, legitimate, explain the considered situation, and that, of course, may also cause them to a certain extent. Note, however, that, following the Aristotelian picture, normally there is a whole bunch of causes—the material, intensional, triggering, effectuating cause(s) ([Aristoteles(1970)])—from which the causal subclause just picks out a (contextually relevant) subset. Nevertheless, even under this weakened perspective, pure times neither can serve as a reason (as presented by the subclause) nor can they serve as situation that is to be explained by the given arguments (as presented by the main clause). We take this as an argument for that the representation of *weil* doesn't connect the distinguished referents of subclause and main clause to each other, but the corresponding entire descriptions. We extrapolate this and say that discourse relations relate parts of the discourse to each other—therefore the name—and not referents standing for objects the discourse is about. On the basis of this assumption, it is natural to interpret the discourse as partitioned into parts that are connected by discourse relations, this is the suggestion of the so called *segmented Discourse Representation Theory* ([Asher(1993)]). We will develop a variant of this representation issue in the following.

Obviously, in discourse, propositional anaphors are used—in particular in the context of belief reports, but also in general texts, and, what is important, also as a common procedure, such anaphors may relate to antecedants which are parts (not elements) of the preceding discourse ([Bäuerle(1988)] presents nice examples, see also the DRT-treatment of beliefs of [Asher(1986)]). Therefore, we make use of the particular class of propositional DRFs that point to DRSs and that can be picked up in DRS-conditions, in particular, in conditions that identify them with other propositional DRFs via anaphoric links. In section 3.6.4, without further commenting, we have already introduced and used this formal means. Here, partly anticipating the setting of section 5.3, we assume that a proposition-DRF p is interpreted as a DRS describing an *information state*, where a condition p: K is said to hold with respect to a model m and an interpreting function f iff there is a disambiguation of K, such that the information state described by f(p) is at least as informative than the information state described by (the disambiguation of) the DRS K.

Now, should we represent sentences of the structure 'S_{main}, weil S_{sub}' by

weil'(rep(S_{sub}),rep(S_{main}))

,

or by

(WK=)

p_1 p_2
weil'(p_1:rep(S_{sub}),p_2:rep(S_{main}))

respectively (i.e., by a condition type which eases the representation of anaphoric links), or by something else?

First, this representation schema does not entail the factuality of the subclause and main clause statement in the WK interpreting world as it is part of the meaning of *weil*.[29] For basics of the representation of discourse relations, the schema seems suited, but, occasionally, as with respect to *weil*, it does not offer a sufficiently transparent analytic picture. Depending on the type of relation represented, the connection between the actual world of the considered interpretation and the propositions involved will be more direct. Thus, as said, *weil* will stipulate that both propositions involved hold in the actual world, i.e., that both statements are factual, the telic *damit / in order that* will stipulate the factuality of the main clause only, and conditional *wenn (... dann) / if (... then), whenever* may be assigned different meanings, where the classical (non-intentional) DRT-interpretation restricts the evaluation of the propositions to the thus characterized cases of the considered actual world, whereas the 'purely hypothetical' variant explicitly excludes the factuality of the subclause proposition (probably of the main clause proposition also) and, thereby, must be understood as relating the evaluation to the set of possible worlds, since, otherwise, the conditional would be without information. Thus, we will complete the representation by the specific additional factuality information that *weil* provides for its arguments. According to this, we could represent the sentence schema 'S_{main}, weil S_{sub}' by something like

[29]Further above, we have said that, in this paper, we cannot really deal with information structure and the corresponding partitioning of the information into presuppositional and assertional information. Since the meaning and use of *weil* is not further specific in this respect, we continue omitting the respective general partitioning on the information, which, depending of the presentation, would assign presuppositional status to the *weil*-subclause, or to the main clause.

(WK'=)

p1 p2
weil'(p1:rep(S_{sub}),p2:rep(S_{main}))
wahr(p1)
wahr(p2)

,

or, using the relativization means that we have introduced in §3.6.3, we could render it by something like:

(WK"=)

p1 p2
weil'(p1:rep(S_{sub}),p2:rep(S_{main}))
s:p1
s:p2
n ⊆ s

From the above observation about the (possible) factuality of the propositional arguments, we also take that discourse relations may differ in what type of interpretation they suggest for their (propositional) argument representations. Therefore, the second question that arises when modeling *weil* is whether this conjunction introduces its arguments under the extensional or the intensional perspective, and whether it connects its argument on the extensional or intensional level respectively. Now, relating propositions is the job of *laws*. For instance, in connection with the example (68.a), there might be a 'causal' law that says that each world (circumstance) where there is an event of Petra's coming within a considered relevant time period (and where, probably, some other, minor premises hold), is also a world (circumstance) in which Jan does not eat spaghetti with respect to some other relevant time period following the first one.[30] If this is so, then the use of the discourse relation *weil* in sentences like (68.a) and (68.b) rather refers to a specific application of a law than to the stating of a law. According to this, the function of (68.a) is to present the exclusion of a *eating Spaghetti of Jan* for a focused *t* as a fact, and also the *coming of Petra* and to explicate the first fact by the second, through presenting the first fact as a (weak) consequence of the second under the perspective of some law which the utterance insinuates.

In short, we suggest, that *weil* and akin discourse relations connect *situations*, where situations in this sense are parts of the considered actual world (again, compare the use of the corresponding referents in sections 3.6.3 and 3.6.4 and the model theoretic formalization of section 5.3). Therefore, we could represent the *weil*-condition as follows:

(WK"'=)

s1 s2
weil'(s1:rep(S_{sub}),s2:rep(S_{main}))
n ⊆ s

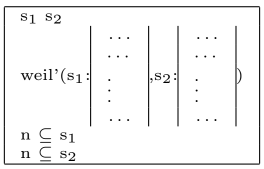
[31]

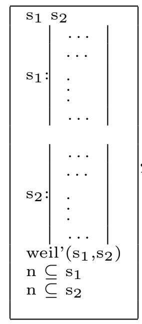
There is still a problem connected to WK"'. Because of the factuality of the argument representations the DRFs of their universes are accessible from the main level DRS, in contrast to DRSs that are embedded by modal operators, by quantification or the like. That is, the *support*-embedding, as we will call the condition type 's:K' also, at least when referring to the utterance situation (temporally, the 'n' of the

[30]This law might be a specialization of a more general 'politeness' law that excludes having meal in the presence of visitors (in the case the visitors (cannot be / are not) invited to join the meal).

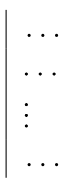
[31]The more general proposition-DRFs (p) may be added subsequently, if required.

DRS), is not a true embedding, it is just a means for annotating parts of the (main) DRS by a DRF such that they can be referred to by anaphors from other parts of the DRS. As stipulated in section 3.6.3, we repeat this here, we mark this, so to speak, improper embedding by the use of boxes with dotted lines that should make allusion to the 'permeability' with respect to the accessibility relation. Thus, we obtain:

(WK*=) 

or the equivalent: 

,

where  stands for rep(S_{sub}) and for rep(S_{main}) respectively.

With this, we render the representations of (68.a) and (68.b) as follows:

(68.a_{rep})

n s1 s2

s1:
. . . .
e1
α_{name}(u, [u | petra(u)])
α_{rt}(t1, [t1 | t1 $\prec$ n])
kommen(e1)
agent(e1)=petra
e1 $\subseteq$ t1
. . . .

s2:
. . . .
α_{rt}(t2, [t2 | t2 $\prec$ n])
e1 $\prec$ t2
¬: [e2
α_{name}(v, [v | jan(v)])
α_{def}(X, [X | spaghetti(X)])
essen(e2)
agent(e2)=v
object(e2) = X
e2 $\subseteq$ t2]
. . . .

weil(s1,s2)
n $\subseteq$ s1
n $\subseteq$ s2

(68.b_{rep})

n s1 s2

s1:
. . . .
α_{rt}(t1, [t1 | t1 $\prec$ n])
¬: [e1
α_{name}(u, [u | petra(u)])
kommen(e1)
agent(e1)=petra
e1 $\subseteq$ t1]
. . . .

s2:
. . . .
e2
α_{rt}(t2, [t2 | t2 $\prec$ n])
t1 $\prec$ t2
α_{name}(v, [v | jan(v)])
α_{def}(X, [X | spaghetti(X)])
essen(e2)
agent(e2)=v
object(e2) = X
e2 $\subseteq$ t2
. . . .

weil(s1,s2)
n $\subseteq$ s1
n $\subseteq$ s2

Adopting the model of *weil* to the underspecification framework, we obtain the following:

weil $\longrightarrow$subord_conj_t $\begin{bmatrix} \lambda: & \langle \text{L1,L2} \rangle \\ \text{RES:} & \underline{\text{weil}}(\text{L1,L2}) \end{bmatrix}$

$\underline{\text{weil}}$(satvpsem_l,vpsem_l) $\Rightarrow$vpsem_l
$\underline{\text{weil}}$($\text{L1}_{\varepsilon\ 1}$,$\text{L2}_{\varepsilon\ 2_{akt(B),t2}}$)

$$:= l3_{\varepsilon\ 2_{akt(B)}}: \begin{array}{|l|}\hline \text{s1 s2} \\ \text{s1:} \begin{array}{|l|} \ldots\ldots\ldots \\ \text{sat\_tense(L1)} \\ \ldots\ldots\ldots \end{array} \\ \text{s2:} \begin{array}{|l|} \ldots\ldots\ldots \\ \text{sat\_tense(L2)} \\ \varepsilon\ 1 \prec \text{t2} \\ \ldots\ldots\ldots \end{array} \\ \text{weil(s1,s2)} \\ \hline \end{array} \begin{array}{l} \{l2 < l3\} \\ \text{L2} \end{array}$$

The representations (68.a_{rep}) and (68.b_{rep}) illustrate our assumption that the introduction of the discourse relational link between the subclause and main clause representation is accompanied by a supplementary temporal relation: we assume that the 'cause', the triggering facts, etc. precede the 'effect'. This constraint will control the (further) temporal resolution (the corresponding trigger will be introduced into the L_2 representation by the *sat_tense* closure).

Other discourse relations, like concessive *though* etc. will introduce temporal relations also.[32]

Vice versa, we will assume that the temporal relations introduce discourse relations also. Commonly used discourse relations that reflect the purpose of introduced temporal links are *continuation, elaboration, background* and others (see [Hobbs(1985b), Lascarides/Asher(1991), Asher(1993), Eberle(1991b)] for a corresponding use). We omit corresponding revision of our entries for temporal relations. Instead, we present in the following a DRS-schema that illustrates how a prototypical representation of a narrative will look like in the suggested formalism:

[32] The constraints effected by the different discourse relations are different. Certain relations probably introduce no temporal relation at all, others that reflect reasoning about causal changes may introduce rather precise relations, as the considerations on *weil* illustrate.

n s1 s2 s3 s4

s1:
.....
e1 ...
P(e1)
⋮
.....

s2:
....
e2 ...
P(e2)
⋮
$e1 \prec e2$
....

s3:
....
e3 ...
P(e3)
⋮
$e3 \subseteq e2$
....

s4:
....
e4 ...
P(e4)
⋮
$e4 \prec e3$
....

continuation(s1,s2)
elaboration(s2,s3)
weil(s4,s3)

A corresponding text could be:

> *He went to Madrid by car (s1/e1). Then he travelled to Porto by motorcycle (s2/e2). At the border he had some trouble (s3/e3), because he had left the passeport at the hotel in Madrid (s4/e4).*

3.7.2 Coordinating conjunctions—discourse relations and the connector *und*

We treat coordinating discourse relations similarly to the formalization of the subordinating discourse relations. We have to take into account only the fact that coordinations which syntactically are realized as adverbs will refer to their first argument via anaphoric link. (69.a) – (69.c) exemplify this.

(69)

a. *Petra war nicht gekommen. Deshalb aß Jan die Spaghetti nicht.*
Petra had not come. Therefore, Jan did not eat the spaghetti.

b. *Petra war nicht gekommen. Dann konnte Jan jetzt nicht ins Kino gehen.*
Petra had (not) come. So, Jan could not go to the cinema.

c. *Petra war gekommen. Trotzdem ging Jan ins Kino.*
Petra had come. Nevertheless, Jan went to the cinema.

We omit the representations of (69) and render the entry of *deshalb* only, which, as a representative, should illustrate the behavior of the entire class.

deshalb $\longrightarrow$adv_coord_conj_t $\begin{bmatrix} \lambda: & \langle \text{L2} \rangle \\ \text{RES:} & \underline{\text{deshalb}}(\text{L2}) \end{bmatrix}$

$\underline{\text{deshalb}}$(vpsem_l) $\Rightarrow$vpsem_l

$\underline{\text{deshalb}}(\text{L2}_{\varepsilon\ 2_t})$

$$:= \text{l3}_{\varepsilon\ 2}: \boxed{\begin{array}{l} \text{s2} \\ \alpha_{presp}(\text{s1}, \boxed{\begin{array}{l}\text{s1}\\ \text{s1: L}_{\varepsilon\ 1}\end{array}}) \\ \text{s2:} \left| \begin{array}{l} \ldots\ldots\ldots\ldots\ldots \\ \\ \text{sat\_tense(L2)} \\ \ldots\ldots\ldots\ldots\ldots \end{array} \right| \\ \text{deshalb(s1,s2)} \\ \varepsilon\ _1 \prec \text{t} \end{array}} \begin{array}{l} \{\text{l2} < \text{l3}\} \\ \text{L2} \end{array}$$

This model interprets *deshalb / therefore* like a ‘weil’ with the first argument replaced by an anaphor for a discourse unit. According to this, it remains to stipulate the following type relation:

adv_coord_conj $<$ mod_vpsem_t

3ex We introduce *und / and* as the representative of coordinations proper and we consider the following uses of *und*:

(70)

a. *Alfons kam und Inge siegte.*
Alfons came and Inge won.

b. *Alfons kam und siegte.*
Alfons came and won.

c. *Auf der Straße steht ein Freund und Helfer.*
In the street is a friend and helper.

d. *Die vier Frauen und die drei Männer kauften ein Haus.*
The four women and the three men bought a house.
e. *Fünfzehn (/ viele) Männer und Frauen waren bei der Versammlung.*
Fifteen (/ many) men and women were at the meeting.
f. *Fünfzehn (/ viele) Hunde und Katzen waren in dem Garten.*
Fifteen (/ many) dogs and cats were in the garden.

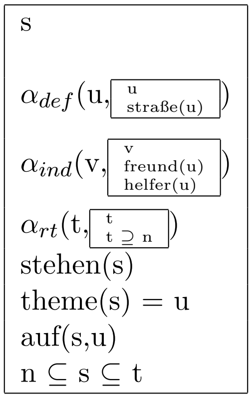
(70.a) is an example of sentence coordination, (70.b) an example of VP coordination. We represent them as follows:

$$(70.a_{rep})\ \boxed{\begin{array}{l} \text{n e1 e2} \\ \\ \alpha_{name}(\text{u},\boxed{\begin{array}{l}\text{u}\\ \text{alfons(u)}\end{array}}) \\ \\ \alpha_{rt}(\text{t1},\boxed{\begin{array}{l}\text{t1}\\ \text{t1} \prec \text{n}\end{array}}) \\ \text{kommen(e1)} \\ \text{agent(e1)} = \text{u} \\ \text{e1} \subseteq \text{t1} \\ \\ \alpha_{name}(\text{v},\boxed{\begin{array}{l}\text{v}\\ \text{inge(v)}\end{array}}) \\ \alpha_{rt}(\text{t2},\boxed{\begin{array}{l}\text{t2}\\ \text{t2} \prec \text{n}\end{array}}) \\ \text{e1} \prec \text{t2} \\ \text{siegen(e2)} \\ \text{agent(e2)} = \text{v} \\ \text{e2} \subseteq \text{t2} \end{array}} \qquad (70.b_{rep})\ \boxed{\begin{array}{l} \text{n e1 e2} \\ \\ \alpha_{name}(\text{u},\boxed{\begin{array}{l}\text{u}\\ \text{alfons(u)}\end{array}}) \\ \\ \alpha_{rt}(\text{t11},\boxed{\begin{array}{l}\text{t1}\\ \text{t1} \prec \text{n}\end{array}}) \\ \text{kommen(e1)} \\ \text{agent(e1)} = \text{u} \\ \text{e1} \subseteq \text{t1} \\ \\ \alpha_{rt}(\text{t2},\boxed{\begin{array}{l}\text{t2}\\ \text{t2} \prec \text{n}\end{array}}) \\ \text{e1} \prec \text{t2} \\ \text{siegen(e2)} \\ \text{agent(e2)} = \text{u} \\ \text{e2} \subseteq \text{t2} \end{array}}$$

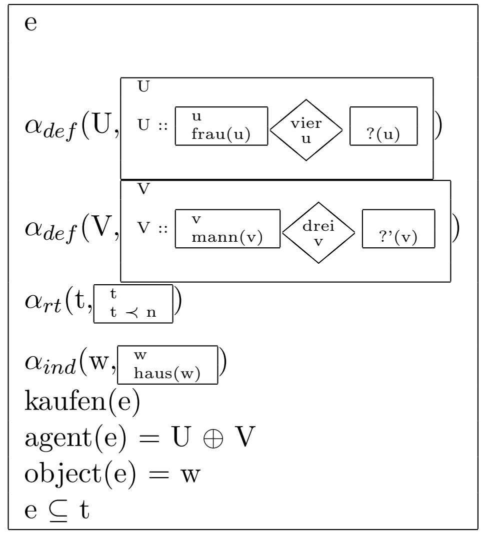
The assumption in both ($70.a_{rep}$) and ($70.b_{rep}$) was that the second event follows the first. This is not necessary. Under the discourse relation *enumeration* (or under the more specific adversative use) that can also come with *und*, there would be no local ordering between e1 and e2. We have omitted here to explicitly represent the corresponding discourse relation, which will be *continuation*. Of course, the syntactic information identifies the agent of e2 to the agent of e1 in the case of ($70.b_{rep}$).

(70.c) is an example of NP coordination, (70.d) an example of DP coordination. We represent these examples as follows:

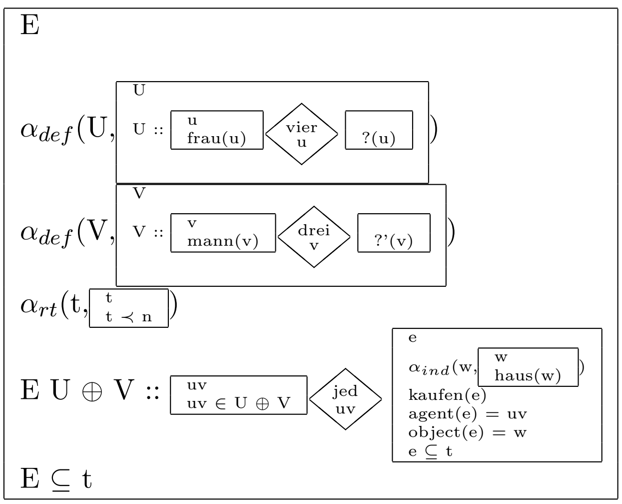
(70.c_{rep})



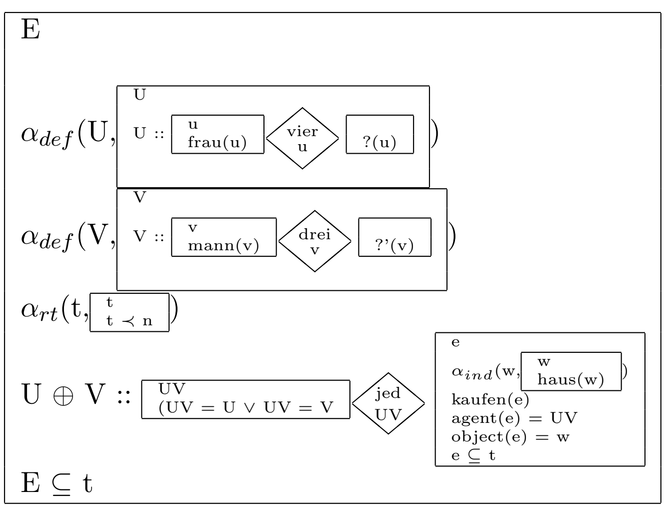
(70.d_{rep}.i)



(70.d_{rep}.ii)



(70.d_{rep}.iii)



The NP coordination example uses *und* as an intersective operator that combines predicative DRSs. The DP coordination example uses *und* as sum formation operator applied to the distinguished DRFs of the arguments. We notice that, with regard to optional distribution, the internal structure of the resulting sum provides different quantification domains: it can be quantified over the atoms of the sum, but also over the (upper referential) referents of the DP conjuncts.

It seems that (70.e) has a reading in which a sum of fifteen human beings is introduced and whose elements are either women or men, whereas (70.f) does not have a corresponding reading (or it seems a bit harder to obtain, at least). We think that, in the case of (70.f), the preferred reading develops from the syntactic distribution of the determiner to the two NPs (*fifteen dogs and fifteen cats*) such that, structurally, the result is similar to the sentence of (70.d) and therefore obtains a corresponding semantics. In our opinion, this is also the preferred interpretation schema in the presence of other quantifiers (see the case in parentheses *many / viele*)— whereas in the (70.e)-case, the other interpretation seems to be preferred, i.e., the disjunctive NP-coordination interpretation. A criterion for its acceptance or preference probably is whether the recipient is aware of a generalizing term, that is, whether a predicate which pretty exactly subsums the noun predicates, like for instance *people* in the case of (70.e) is at his disposal and, what is more, easily comes to his mind at utterance time, or not. We don't know. Probably there are other (cognitive ?) reasons explaining the circumstances of the acceptance of the one-group reading. (Note, however, that the relevant taxonomic notion *domistic* animals is not as precisely subsuming *dogs* and *cats* as *peoble* subsum *men* and *women*). In any case, we have to provide the disjunctive NP-coordination use of (70.e). The supposed quantifier distribution of (70.f), as a matter of syntactic analysis, is not relevant to spelling out the semantics of *und*.

Depending on the material that comes with the two arguments in the e/f-case, there might also exist the reading that assigns the quantifier to one argument and that classifies the second as bare plural, thus producing another variant of DP coordination (compare *fifteen dogs and beautiful, young, black cats*).

In order to obtain a complete solution for the problem that is illustrated by the representations (70.d_{rep}.i)–(70.d_{rep}.iii) of(70.d), it is not sufficient to work out an underspecified representation that just subsumes the three readings depicted: we have to be aware of the fact that there might be embedded coordinations (such that the (70.d_{rep}.iii)-case must be extended to the general case of n conjuncts), and, as it seems, syntactical multiplying out (DP1+VP & DP2 + VP ...) does not always present the correct solution to the different distributive readings (also, in case it is a solution, it is no elegant solution).[33] In this paper, we refrain from going into

[33]In order to get satisfying solutions to the problem of obtaining all admissible subsums of the global sum, it seems promising to further work out the suggestion of [Krifka(1991)], where a new type of discourse objects is proposed that reflects the surface structure in a more fine-grained way than the canonical DRFs do. This formal means can be used to tackle the problem of correctly representing puzzling reciprocal phenomena like *at Waterloo, Blücher and Wellington*

details in this respect and we content ourselves with a rudimentary solution, which allows for the representations that we have sketched above and which is in line with our suggestion for the representation of quantified expressions that underspecifies the collective/distributive distinction. This is the DP-variant of the following set of rules for *und*:

und $\longrightarrow$coord_t $\begin{bmatrix} \lambda: & \langle \text{L1, L2} \rangle) \\ \text{RES:} & \underline{\text{und}}(\text{L1,L2}) \end{bmatrix}$

$\underline{\text{und}}$(xtype_l,xtype_l) $\Rightarrow$xtype_l

$\underline{\text{und}}({}^{vpsem\_l}\text{L1}_{\varepsilon\ 1_{akt(het)}}, {}^{vpsem\_l}\text{L2}_{\varepsilon\ 2_{akt(het),t2}})$

$:= {}^{vpsem\_l}\text{l}_{\varepsilon\ 2}$: $\boxed{\begin{array}{l} \text{sat\_tense(L1)} \\ \varepsilon\ 1 \prec \text{t2} \\ \text{sat\_tense(L2)} \end{array}}$ $\begin{array}{l}\{\text{l1} < \text{l}\} \\ \text{L1}\end{array}$

$\underline{\text{und}}({}^{npsem\_l}\text{L1}_{x}, {}^{npsem\_l}\text{L2}_{x})$

$:= {}^{npsem\_l}\text{l}_{x}$: $\boxed{\text{L1} \ \cup \text{L2}}$ $\begin{array}{l}\{\text{l1} < \text{l}\} \\ \text{L1}\end{array}$

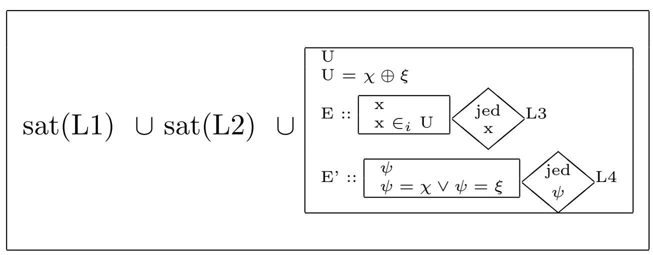
$\underline{\text{und}}({}^{npsem\_l}\text{L1}_{x,pl}, {}^{npsem\_l}\text{L2}_{x,pl})$

$:= {}^{npsem\_l}\text{l}_{x}$: $\boxed{\text{L1} \vee \text{L2}}$ $\begin{array}{l}\{\text{l1} < \text{l}\} \\ \text{L1}\end{array}$

$\underline{\text{und}}({}^{dpsem\_l}\text{L1}_{\_,\chi,\_}, {}^{dpsem\_l}\text{L2}_{\_,\xi,\_})$

:=

${}^{dpsem\_l}\text{l}_{\begin{array}{l}\underline{\text{res}}(\langle \text{E}_{l5 \leq l3}, \text{E'}_{l5 \leq l4}, \varepsilon_{\ l5 \leq_n l} \rangle) \\ \text{U} \\ \underline{\text{res}}(\langle \text{x}_{l5 \leq l3}, \psi_{l5 \leq l4}, \text{U}_{l5 \leq_n l} \rangle)\end{array}}$:



$\{(\text{l5} \leq \text{l3} \vee \text{l5} \leq \text{l4} \vee \text{l5} \leq_n \text{l})\}$

L5_{ε}

There is only one rule that treats VP and S coordination (the examples (70.a) and (70.b)). It accounts for the *continuation* case. As in the representations of the examples, we have omitted the representation of the discourse relation as such. The rules for the other discourse relations (we will certainly assume *contrast* and *enumeration*) are similar (they just require other temporal or non-temporal relations). We leave this out.[34]

---

and Napoleon fought against each other.

[34]It might be that the preferences for a specific discourse relation are different with respect to S and (the different) VP coordinations. However, the module that projects the α_{rt} conditions amongst others; i.e., the temporal resolution, will have access to the relevant syntactic information. Thus, through the syntax-semantics interface, the difference might trigger diverging controlling

It should be clear that the second rule is applicable only if the sort descriptions of the resulting referents of the arguments are compatible, because of the required unification of these DRFs.

The third rule, which treats the disjunctive NP-coordination case, is applicable only if the representations to combine stem from plural NPs.

In order to underspecify between the different distributive and the collective reading, the fourth rule (to a certain extent) generalizes the disjunctive ordering style modeling that we have introduced for quantifiers and plural determiners. On the basis of the given definition of *und*, we get the representations of all uses of *und*, as exemplified by (70).

3.8 Prepositions

In this section we do not consider the function of the prepositional phrase in the sentence, i.e., the use as adjunct or as subcategorized thematic role. For the meaning of the prepositional phrase as such—and for the preposition as such, which is of interest in this section only—this is irrelevant (even if the preposition loses its basic meaning when the prepositional phrase which is built from it is used as a prepositional object where the verbal linking overrides the linking suggested by the preposition).

Certain prepositions can be used as modifiers of other prepositions or of prepositional phrases respectively; compare the use of *bis* in *Peter kam bis zum ersten Biwak*. We ignore such specific uses in the following and treat the basic case only, those in which the preposition is used as a functor from DPs (the internal argument) and verb or noun projections (the external argument) into verb or noun projections, respectively. To our opinion, in the noun projection modifier case, there must be added to the common NP-case the use of the prepositional phrase as DP-modifier also. Thus, we will consider the preposition to be a (VP/VP)/DP-, (NP/NP)/DP-, or (DP/DP)/DP-functor.

The following sentences are examples of these uses:

(71)

a. Boris hat auf allen wichtigen Plätzen gespielt.
Boris has played at all important courts.

b. Von jeder Abteilung ein Angestellter ist anwesend.
There is an employee of each department present.

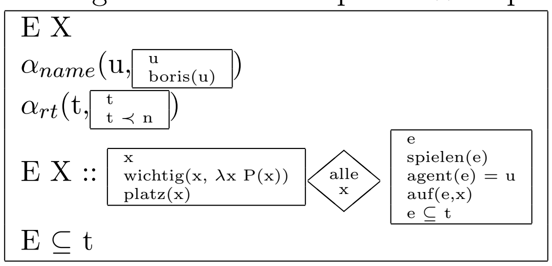
c. Ein Hut mit vielen Federn liegt auf dem Tisch.
There is a hat with many feathers lying on the table.

(71.a) shows that the internal argument can obtain wide scope over the external VP-argument. (71.b) is an example of nested quantification where the internal argument

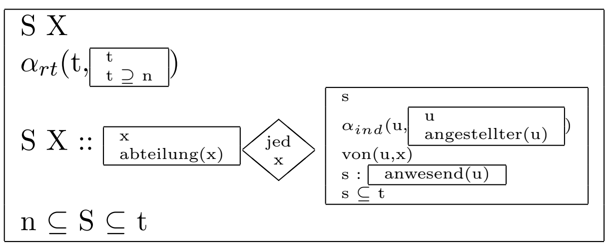
effects onto the temporal resolution (and, through this, onto a supplementary evaluation in terms of discourse structure).

gets wide scope over the external DP-argument which is a subcategorized thematic role of the matrix verb. (71.c) shows that the external argument can be an NP also. In addition, it testifies that, in this case, the internal argument cannot have wide scope over the external argument—with respect to quantification at least, to be precise. This, to our opinion, is explained by the fact that the quantifier/determiner of the DP completely defines and controls the quantificational setting of the DP, such that there can be no other respective assumptions from inside the NP. Therefore the internal argument must obtain a collective reading, and, in case the preposition is *relational* (in the sense of section 3.6.2); i.e., in case it is intersective, as with *mit*, the saturated internal argument and the prepositional relation statement are just added to the argument NP description. We represent (71.a) – (71.c) as follows:

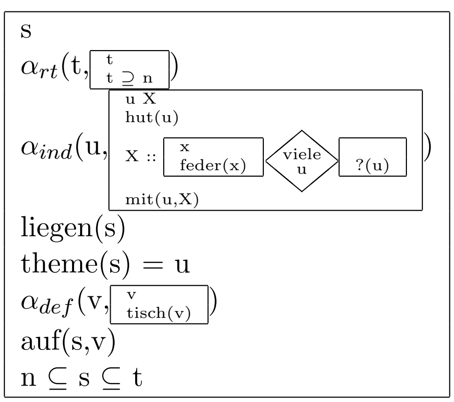
(71.a_{rep})



(71.b_{rep})



(71.c_{rep})



From the observations made we abstract a schema that we exemplify by the entry for *mit*:

$$\text{mit} \longrightarrow \text{prep\_t} \begin{bmatrix} \lambda: & \langle \text{L1, L2} \rangle) \\ \text{RES:} & \underline{\text{mit}}(\text{L1,L2}) \end{bmatrix}$$

$\underline{\text{mit}}(\text{dpsem\_l,xtype\_l}) \Rightarrow \text{xtype\_l}$

$$\underline{\text{mit}}({}^{dpsem\_l}\text{L1}_{\_,\_,\chi'}, {}^{vpsem\_l}\text{L2})$$
$$:= {}^{vpsem\_l}\text{l}: \begin{array}{|c|}\hline \\ \\ \hline\end{array} \begin{array}{l} \{\text{L1}, {}^{vpsem\_l}\text{l3}_{\varepsilon\ '}: \boxed{\text{mit}(\varepsilon\ ', \chi')} \begin{array}{l}\{\text{l4} \leq \text{l3}\}\\ \text{L4}_{\varepsilon\ '}\end{array} \} \\ \{\text{l3} \leq \text{l1}\} \\ \text{L2} \end{array}$$

$$\underline{\text{mit}}({}^{dpsem\_l}\text{L1}_{\_,\_,\chi'}, {}^{dpsem\_l}\text{L2}_{\_,\xi,\_})$$
$$:= {}^{dpsem\_l}\text{l}: \begin{array}{|c|}\hline \\ \\ \hline\end{array} \begin{array}{l} \{\text{L1}, {}^{dpsem\_l}\text{l3}_{\varepsilon\ ,\xi,\xi'}: \boxed{\text{mit}(\xi, \chi')} \begin{array}{l}\{\text{l4} \leq \text{l3}\}\\ \text{L4}_{\varepsilon\ ,\xi,\xi'}\end{array} \} \\ \{\text{l3} \leq \text{l1}\} \\ \text{L2} \end{array}$$

$$\underline{\text{mit}}({}^{dpsem\_l}\text{L1}_{\_,\chi,\chi}, {}^{npsem\_l}\text{L2}_{x})$$
$$:= {}^{npsem\_l}\text{l}_{x}: \boxed{(\text{sat}(\text{L1}) \ \cup \boxed{\text{mit}(\text{x},\chi)})} \begin{array}{l}\{\text{l2} \leq \text{l}\}\\ \text{L2}\end{array}$$

These rules license the scope relations between internal and external argument as discussed above: the first and the second rule introduce two functors on the Fset, the DPsem representation of the internal argument (L1) and a VP or a DP-modifier L3. In both cases, the internal argument representation L1 is stipulated to have scope over the L3 representation. Thus, in a disambiguation, in the first case, the result referent of the argument, ε ', is related to the lower referent of the L1-DP through *mit* first, and then L1 is applied to the result. In the second case the DPsem modifying L3 relates the upper referential index of the argument (the 'sum' referent of the L4-DP) to the lower referential index of L1. Note that this proposal correctly represents examples with plural arguments: for *aus jeder Abteilung viele Mitarbeiter / many employees of each department*, it correctly assigns to each department a set of **many** employees (where the *many employees* might obtain a distributive reading or not, depending on the reading of L2. Note also that in both cases the internal argument L1 is not altered. This means that in case L1 is underspecified between the distributive and collective reading the resulting PP inherits this ambiguity. In contrast, in the NPsem modifier case, by the unification of upper and lower referential index, the L1 is disambiguated to the collective reading, according to the sample representation (71.c_{rep}). We have omitted a full represention of the percolation of the indices, including the Aktionsart assignment (where relevant).

There are different ways in which the basic schema given might have to be modified in order to truly represent the different meanings of prepositions. On the one hand there might be needed more information in order to control disambiguation. We will illustrate this using the preposition *in*, whose disambiguation incorporates further constraints from the syntax semantics interface. On the other hand, the different meanings might differ rather fundamentally in what they do with their arguments, i.e., with respect to the semantic type of the relation that they introduce.

Let us turn to the first case. Consider the following uses of *in*:

(72)

a. *Peter wanderte im Wald.*

Peter walked in the forest.

b. Peter wanderte in den Wald.

Peter walked into the forest.

c. Peter begleitete den Freund in der Nacht.

In the night, Peter accompanied the friend.

d. Peter begleitete den Freund in die Nacht.

Peter accompanied the friend into the night.

The (72) examples reflect the use of *in* as spatially localizing *in* ($\subseteq_l$), goal setting *in* (*spat_goal*), temporally localizing ($\subseteq$) *in*, and, as a kind of metonymy to the temporal domain, *in* as temporal goal (*temp_goal*). We can think of the following representations of (72):

$$(72.\mathrm{a}_{rep})\ \begin{array}{|l|}\hline \mathrm{e} \\ \alpha_{name}(\mathrm{u}, \boxed{\begin{array}{l}\mathrm{u}\\ \mathrm{peter(u)}\end{array}}) \\ \alpha_{def}(\mathrm{v}, \boxed{\begin{array}{l}\mathrm{v}\\ \mathrm{wald(v)}\end{array}}) \\ \alpha_{rt}(\mathrm{t}, \boxed{\begin{array}{l}\mathrm{t}\\ \mathrm{t} \prec \mathrm{n}\end{array}}) \\ \mathrm{wandern(e)} \\ \mathrm{agent(e)=u} \\ \mathrm{e} \subseteq_l \mathrm{v} \\ \mathrm{e} \subseteq \mathrm{t} \\ \hline \end{array} \qquad (72.\mathrm{b}_{rep})\ \begin{array}{|l|}\hline \mathrm{e} \\ \alpha_{name}(\mathrm{u}, \boxed{\begin{array}{l}\mathrm{u}\\ \mathrm{peter(u)}\end{array}}) \\ \alpha_{def}(\mathrm{v}, \boxed{\begin{array}{l}\mathrm{v}\\ \mathrm{wald(v)}\end{array}}) \\ \alpha_{rt}(\mathrm{t}, \boxed{\begin{array}{l}\mathrm{t}\\ \mathrm{t} \prec \mathrm{n}\end{array}}) \\ \mathrm{wandern(e)} \\ \mathrm{agent(e)=u} \\ \mathrm{spat\_goal(e,v)} \\ \mathrm{e} \subseteq \mathrm{t} \\ \hline \end{array}$$

$$(72.\mathrm{c}_{rep})\ \begin{array}{|l|}\hline \mathrm{e} \\ \alpha_{name}(\mathrm{u}, \boxed{\begin{array}{l}\mathrm{u}\\ \mathrm{peter(u)}\end{array}}) \\ \alpha_{def}(\mathrm{t}, \boxed{\begin{array}{l}\mathrm{t}\\ \mathrm{nacht(t)}\end{array}}) \\ \alpha_{ind}(\mathrm{v}, \boxed{\begin{array}{l}\mathrm{v}\\ \mathrm{freund(v)}\end{array}}) \\ \alpha_{rt}(\mathrm{t'}, \boxed{\begin{array}{l}\mathrm{t'}\\ \mathrm{t'} \prec \mathrm{n}\end{array}}) \\ \mathrm{begleiten(e)} \\ \mathrm{agent(e)=u} \\ \mathrm{rec(u)=v} \\ \mathrm{e} \subseteq \mathrm{t} \\ \mathrm{e} \subseteq \mathrm{t'} \\ \hline \end{array} \qquad (72.\mathrm{d}_{rep})\ \begin{array}{|l|}\hline \mathrm{e} \\ \alpha_{name}(\mathrm{u}, \boxed{\begin{array}{l}\mathrm{u}\\ \mathrm{peter(u)}\end{array}}) \\ \alpha_{def}(\mathrm{t}, \boxed{\begin{array}{l}\mathrm{t}\\ \mathrm{nacht(t)}\end{array}}) \\ \alpha_{rt}(\mathrm{t'}, \boxed{\begin{array}{l}\mathrm{t'}\\ \mathrm{t'} \prec \mathrm{n}\end{array}}) \\ \mathrm{begleiten(e)} \\ \mathrm{agent(e)=u} \\ \mathrm{temp\_goal(e,t)} \\ \mathrm{e} \subseteq \mathrm{t'} \\ \hline \end{array}$$

Note that on the purely semantic level the readings cannot be disambiguated. The syntactic case information is relevant. Therefore, we introduce this type of information into the *in* rules that treat the four readings illustrated:

$$\mathrm{in}(\mathrm{L1}_{\_,\_,\chi@\neg\mathrm{TEMP},cat(DatDP)}, {}^{vpsem\_l}\mathrm{L2})$$

$$:= {}^{vpsem\_l}\mathrm{l}\!: \boxed{}\ \begin{array}{l} \{\mathrm{L1}, {}^{vpsem\_l}\mathrm{l3}_{\varepsilon\ akt(A)}\!: \boxed{\varepsilon \subseteq_l \chi}\ \begin{array}{l}\{\mathrm{l4} \leq \mathrm{l3}\} \\ {}^{vpsem\_l}\mathrm{L4}_{\varepsilon\ akt(A)}\end{array} \ \} \\ \{\mathrm{l3} \leq \mathrm{l1}\} \\ \mathrm{L2} \end{array}$$

$$\mathrm{in}(\mathrm{L1}_{\_,\_,\chi@\neg\mathrm{TEMP},cat(AccDP)}, {}^{vpsem\_l}\mathrm{L2})$$

$$:= {}^{vpsem\_l}\mathrm{l}\colon \boxed{} \begin{array}{l} \{\mathrm{L1},\ {}^{vpsem\_l}\mathrm{l3}_{\varepsilon\ akt(\underline{res}(\langle het_{S<\mathrm{MOVE}}, A_{\mathrm{otherwise}}\rangle))} : \boxed{\mathrm{spat\_goal}(\varepsilon\ ,\chi)}\ \overset{\{\mathrm{l4} \leq \mathrm{l3}\}}{{}^{vpsem\_l}\mathrm{L4}_{\varepsilon\ @S,akt(A)}}\ \} \\ \{\mathrm{l3} \leq \mathrm{l1}\} \\ \mathrm{L2} \end{array}$$

$$\mathrm{in}(\mathrm{L1}_{\_,\_,\chi @\mathrm{TEMP},cat(DatDP)}, {}^{vpsem\_l}\mathrm{L2})$$

$$:= {}^{vpsem\_l}\mathrm{l}\colon \boxed{} \begin{array}{l} \{\mathrm{L1},\ {}^{vpsem\_l}\mathrm{l3}_{\varepsilon\ akt(A)} : \boxed{\varepsilon \subseteq \chi}\ \overset{\{\mathrm{l4} \leq \mathrm{l3}\}}{{}^{vpsem\_l}\mathrm{L4}_{\varepsilon\ akt(A)}}\ \} \\ \{\mathrm{l3} \leq \mathrm{l1}\} \\ \mathrm{L2} \end{array}$$

$$\mathrm{in}(\mathrm{L1}_{\_,\_,\chi @\mathrm{TEMP},cat(AccDP)}, {}^{vpsem\_l}\mathrm{L2})$$

$$:= {}^{vpsem\_l}\mathrm{l}\colon \boxed{} \begin{array}{l} \{\mathrm{L1},\ {}^{vpsem\_l}\mathrm{l3}_{\varepsilon\ akt(\underline{res}(\langle het_{S<\mathrm{MOVE}}, A_{\mathrm{otherwise}}\rangle))} : \boxed{\mathrm{temp\_goal}(\varepsilon\ ,\chi)}\ \overset{\{\mathrm{l4} \leq \mathrm{l3}\}}{{}^{vpsem\_l}\mathrm{L4}_{\varepsilon\ @S,akt(A)}}\ \} \\ \{\mathrm{l3} \leq \mathrm{l1}\} \\ \mathrm{L2} \end{array}$$

The first rule analyses *in* into a spatial relation of inclusion. (This is not necessarily $\subseteq_l$, see [Pribbenow(1991)] for an overview of the different versions of spatially locating *in*.) The disambiguating information is sortal information on the one hand, and case information, on the other, that we stipulate to be unified into the index structure of the distinguished DRFs by the syntax semantics interface.

The second rule disambiguates *in* into its meaning of presenting a (the) spatial goal. Note that in this case the resulting event type will be heterogeneous, in case the distinguished referent of the external VP argument is of sort MOVE, if not, the Aktionsart value is percolated upwards. The effect of this assignment is that a modification like *in die Garage / into the garage* changes a homogeneous event type like *pushing the car* into the heterogeneous event type *pushing the car into the garage*, whereas the same modification retains the Aktionsart when changing an event type like *looking* into the type *looking into the garage*.

The third rule reads *in* as the temporal relation $\subseteq$. Here, the Aktionsart is percolated without further case studies, as in the first rule.

The fourth rule reads *in* as temporal goal.[35]

The four rules just reflect the considered examples. Of course, a fully worked out study must comprise investigations concerning the other type suggestions of the basic representation schema. Also, a complete study would treat finer grained distinctions of the localizing relations. We must omit this here.

Likewise, the working out of *für* will focus on some relevant cases only. *Für / for* is an example of a preposition which does not (necessarily) introduce a relation between the distinguished DRFs of internal and external argument, but that (can)

[35] The peculiarity here is that, obviously, the described scenario is a kind of metonymic picture, according to the rather general and conventionalized transitions from the spatial to the temporal domain. Maybe that, instead of introducing *temp_loc*, retaining *spat_goal* and trying a sortal redefinition of the temporal argument would be a better solution in this case, similar to the well known sortal coercion procedures underlying sentences like *the beefsteak did not pay*.

embed the description of the internal or the external argument or of both arguments also (like a modal modifier or a corresponding embedding discourse relation). Consider the following sample uses of *für*:

(73)

a. *Peter arbeitet für die IBM.*
Peter works for IBM.

b. *Peter arbeitet für ein Haus.*
Peter works for a house.

c. *Für Peter ist Jones nicht der Mörder.*
For Peter, Jones is not the murderer.

d. *Für einen Gauner ist er korrekt.*
For a crook, he is correct.

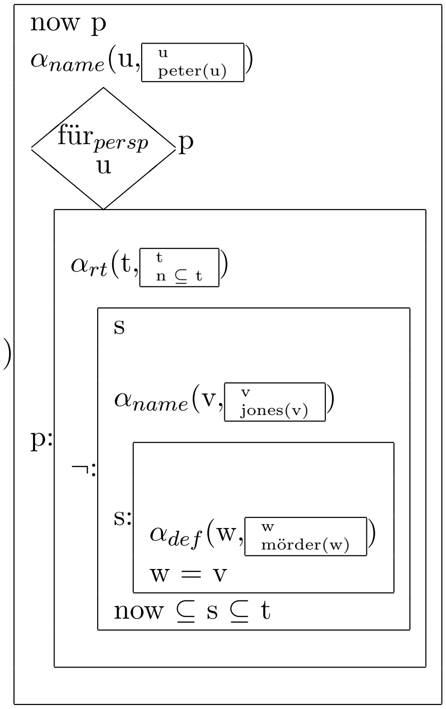
(73.a) illustrates the canonical use of *für* which is to introduce the thematic role of *beneficiary*. (73.b) introduces a purpose, a deontic attitudinal *causa finalis*, as we will say. In contrast to (73.a), the internal argument is not existentially bound at sentence level, but is intentionally subordinated. The *für* of (73.c) relativizes the assumption of the external argument to the perspective of *Peter*. (73.d) is even more complicated. Here the proposition of the external argument is seen not in the perspective of a particular crook, but in light of the crook aspect as such. We represent these examples as follows:

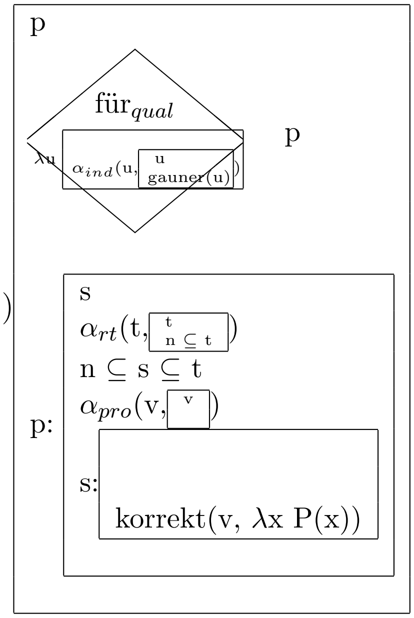
(73.a_{rep})

now e
α_{name}(u, [u | peter(u)])
α_{def}(v, [v | ibm(v)])
α_{rt}(t, [t | n $\subseteq$ t])
arbeiten(e)
agent(e)=u
benef(e)=v
now $\subseteq$ e $\subseteq$ t

(73.b_{rep})

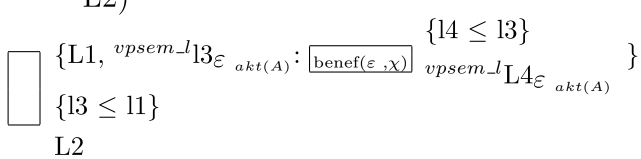
now e p
α_{name}(u, [u | peter(u)])
α_{rt}(t, [t | n $\subseteq$ t])
arbeiten(e)
agent(e)=u
caus_fin(e,p)
p: [α_{ind}(v, [v | haus(v)]) ; ?(v)]
now $\subseteq$ e $\subseteq$ t

(73.c_{rep})


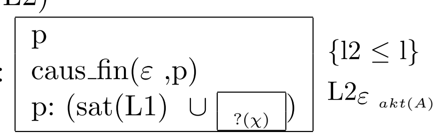
(73.d_{rep})


According to these representations, we stipulate the following rules for *für*.

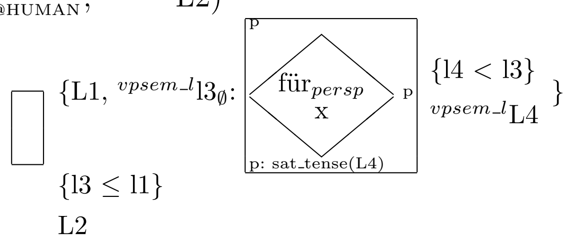
$\text{für}(L1_{\_,\_,\chi}, {}^{vpsem\_l}L2)$

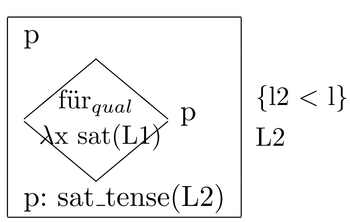
$:= {}^{vpsem\_l}l$:


$\text{für}(L1_{\_,\chi,\_}, {}^{vpsem\_l}L2)$

$:= {}^{vpsem\_l}l_{\varepsilon\ akt(A)}$:


$\text{für}(L1_{\_,\_,x@\text{HUMAN}}, {}^{vpsem\_l}L2)$

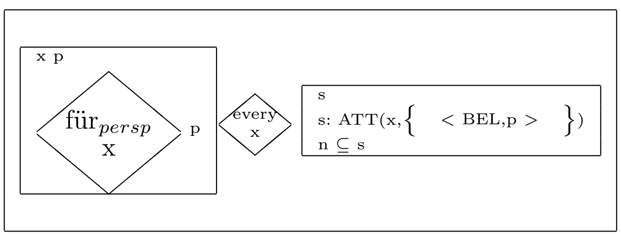
$:= {}^{vpsem\_l}l$:


$\text{für}(L1_{\_,x,x}, {}^{vpsem\_l}L2) := {}^{vpsem\_l}l_{\emptyset}$:


The first rule disambiguates *für* to the thematic role of beneficiary. This role connects the distinguished referential referents of internal and external argument by a 2-place relation. The distributive reading of the internal argument (having scope over the external argument) is accepted.

The second rule reads the internal argument as a *causa finalis* of the external argument. Through making the saturated representation of the internal argument part of the propositional argument of the *causa finalis* (another part will consist of (contextually inferable?) predications of the internal argument referent which the agent wishes to hold) it is assumed that the internal argument obtains a collective reading (not necessarily a de dicto reading, however, because the resolution of the α-conditions may identify its DRF with some wide scope available DRF).[36]

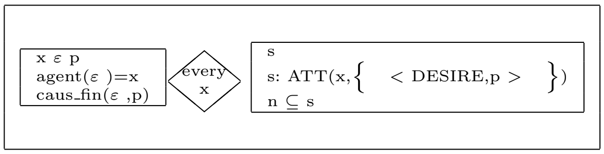
The third rule embeds the external argument semantics into the perspective which is described by the internal argument. The model theoretic consequence of this representation will be that the (tense saturated) external argument holds in the actual personal situation of the person who defines the perspective. Using the notation of [Kamp(1995b), Kamp(1995a)] (compare also sections 2.6 and 3.6.7), we can sketch a meaning postulate that captures this interpretation:

- 

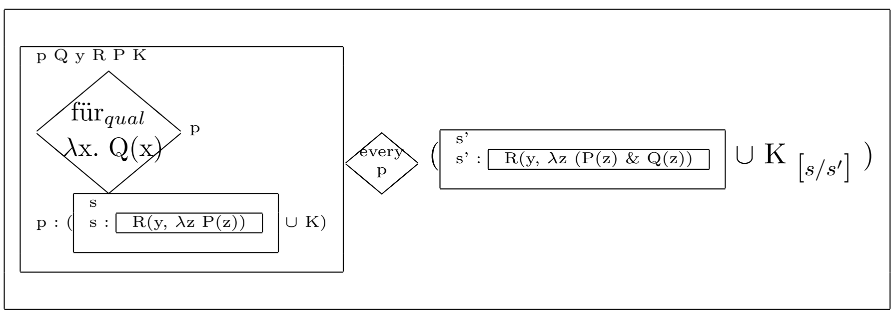
This means that for every x and p, from the relativization of p to x, we can infer an actual attitudinal state of x that contains the belief p. Of course, technically working out this postulate has to pay attention to the correct administration of the DRFs in descriptions of p.

[36]It is interesting to see that a consequence of the distributive reading is the de re interpretation of the internal argument. We omit formulating a corresponding rule. The acceptance of such an interpretation of course strongly depends on whether the (extensionally read) internal argument easily allows for figuring out what the intended goal proper of the agent could be (in case of the de re house this may be nearly as easy as in the case of the de dicto house: whereas there the goal probably is to *have (possess) a house*, here it may be to *realize the house*, where, as a prerequisite of this, *the house* easily is interpreted as *the type, the plan, the concept etc of the house*). Also, the more the quantifier tends to a distributive and partitive meaning where the reference domain presuppositionally refers to a specific *context set*, the more this distributive de re interpretation seems acceptable (or the only possible), provided the just mentioned assumptions about the intended goal proper. Compare examples like *Johann arbeitet für zwei Häuser / für wenigstens zwei Häuser / die meisten (der) Häuser / jedes Haus / jedes der Häuser (John works for two houses / for at least two houses / for most (of the) houses / every house /each of the houses)*, where in turn, as it seems, the collective intensional reading loses acceptance and the distributive de re reading comes into focus (and might be accepted in case one can imagine a reasonable purpose the agent could connect to the houses). Note that the tense setting influences the preferences also. The tenses of the past more easily accept the de re readings of course.

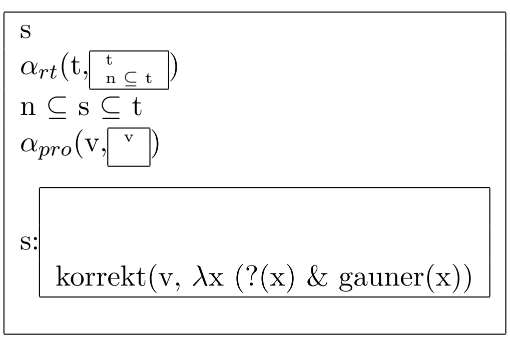
In order to emphasize the attitudinal aspect of the second rule, in close parallel to this, one can formulate a meaning postulate which interprets the compact (and flat) causa finalis relation as description of a part of the agent's actual attitudinal state, more precisely, as a description of one of the agent's desire:

- 

The *für*-meaning of the fourth rule presents the external argument in light of a particular quality, which comes from the internal argument. In the presence of parts of speech which call for a contextual parameter of the same quality type, like the *aspect relational* modifier *klein* of section 3.6.2 (*klein(x, λy.P(y))*) and the similar *korrekt* of example (73.d), it normally will be this quality from the preposition which will identify the aspect of the modifier (or will contribute to it, at least). We can make explicit such interpretational links by corresponding meaning postulates. The following treats the just mentioned case of aspect relational conditions; i.e., it provides a (sketchy) rule which is applicable to (73.d):

- 

Applied to (73.d), this meaning postulate entails the following:



It is clear that for the precise formulation of the meaning postulate, one has to pay attention to the correct (and suited) treatment of α-conditions (and to correct copying). The example illustrates that, obviously, the α_{ind}-condition of the internal argument has to be resolved within the *für*-operator domain. We add that, as it seems, the rule 4-interpretation of *für* is possible only if the internal argument is a singular indefinite DP or a bare plural. This assumption can be incorporated into the rule (into the index of the internal argument for instance) as an additional filtering constraint.

Another contextual interpretation parameter that probably can be resolved to the rule 4-*für* aspect may be the comparison criterion which defines the reference situations that back the interpretation of the quantifiers which, in section 3.4.3, we have called contextually defined quantifiers. For illustration, in the sentence *für einen Gauner kannte er wenig Gefängnisse / For a crook, he knew few prisons* the comparison criterion that is needed for evaluating the truth of the asserted *wenig*-relation, according to the *comp_def_qu* interpretation as exemplified for *viele* in section 3.4.3, as the average of the ratios holding for the persons P of a specific set Q between the restrictor set cardinality (the number of prisons) and the cardinality of the set of prisons that are known by the person P , is the property that defines this specific set Q—and this property, evidently, is the *being a crook* of the *für*-PP.

The reason why we do not represent this use of *für* directly as suggested by the consequence representation(s) of the corresponding meaning postulates (the depicted one and other similar ones for the different modification cases) is that there is hardly to find an approach that could handle all the cases that should be considered in a correct (and preferably generalizing) compositional way.

There are prepositions that deviate from the so far considered formal behavior. An example is *als*:

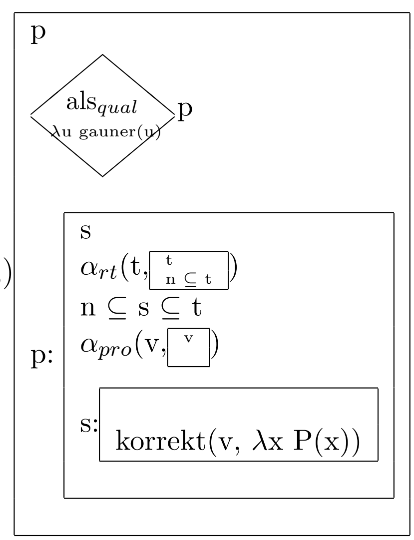
(74)

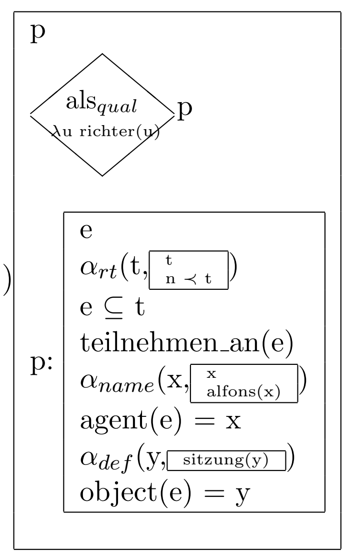
a. Als Gauner ist er korrekt.
As a crook, he is correct.

b. Alfons nimmt als Richter an der Sitzung teil.
Alfons participates in the meeting as judge.

(74) shows, first, that there are prepositions which take nouns (or properties respectively) as internal arguments, not the commonly required DPs. Note, however, that at least (74.b) also accepts the indefinite *ein Richter*. This, to our opinion, further supports the assumption that the type of use that, above, for *für*, we have marked *qual* indeed interprets the internal argument as an aspect, that it is legitimate, thus, to interpret the indefinite DP as a predicate (as in our $für_{qual}$-representation through the lambda abstracted locally resolved (accommodated) α_{ind}-condition, $\lambda x.\alpha_{ind}(x, \boxed{\substack{x \\ P(x)}})$, which, of course, is equivalent to the predicate $\lambda x.\ \boxed{\substack{x \\ P(x)}}$, or $\lambda x.P(x)$ respectively).

Second, (74) also shows, as we think, that there is a whole range of possibilities for presenting situations under different aspects. Both sentences are similar to (73.d) in that they apply some aspectual relativization to the propositional argument. As it seems the factuality of the external argument is relativized to different degrees or in different respects. However it is never as contested as it is under the true modal interpretation of *für*, which we have called $für_{persp}$. Therefore, it seems legitimate to subsume the (73.d)-, (74.a)- and (74.c)-uses of the prepositions under the one *qual* marked aspect operator use. A relevant difference with respect to the effect of applying the operators seems to be connected to whether the external argument provides a presuppositional aspect position (that could be filled by the internal argument semantics) or not. This is the case in (74.a). We think that there is a reading of this sentence that comes very close to the *für*-PP-effect of (73.d). It is the, so to speak, narrow scope reading of the aspect-operator which plugs the aspect into the position of the, as yet unresolved, contextual parameter of the external argument (as suggested by the corresponding meaning postulate, which could be formulated in accordance to the $für_{qual}$ postulate). In the following representation of (74.a) we leave the decision open; i.e., the aspect obtains the operational wide scope position and the operator is of a general type als_{qual} which subsumes types $als1_{qual}$ and $als2_{qual}$ say, where for $als1_{qual}$ (without loss of generality) the mentioned postulate holds, not for $als2_{qual}$. The $als2_{qual}$-meaning seems to consist of relativizing the VP semantics to an *aspect* (in the sense of [Landman(1989)]) of the subject referent. This second reading exists for (74.a) also (saying something like *(whenever he does something) in his capacity as crook, he is correct*) and is different from the first one (where *correctness* is relativized to *correctness to the scale holding for crooks*). Note that this second, so to speak wide scope reading does not exist for *für* (exchange *als Richter* for *für einen Richter* in (74.b)). That is, the interpretation $für_{qual}$ presupposes that the external argument comes with an unresolved contextual parameter that it can identify. This means that $für_{qual}$ is identical to a, so to speak, narrow scope $für1_{qual}$. We represent (74) by (74.a_{rep}) and (74.b_{rep}). We omit the according entry for *als*. Neither will we provide refined representations for such deep analyses of *als* and *für*.

(74.a_{rep}) 

(74.b_{rep}) 

Summarizing, next to the common relational uses of prepositions, we have investigated and represented different non-relational uses. Here, the examples were *für* and *als*. For the non-relational uses—we have distinguished deontic, modal and aspectual embeddings—we have suggested a compositional semantics which closely follows the surface structure. With respect to certain aspectual embeddings, subsequent application of meaning postulates may restructure the representations. It is unclear how the DRT-model theory of relativizations to personal aspects should look like. We will not have to say something specific to this in the corresponding section 5.3.

We leave open the question which of the discussed specific meanings (be it relational or not) is possible when the prepositional phrase modifies not a VP but a DP or a NP, or what the sortal restrictions are in these cases. The causa finalis meaning of *für* certainly is admissible (and the only possible) in cases like *ein Buch für Erwachsene / a book for adults*. Directional *in* is admissible for all kinds of objects that can be assigned a direction. These are nominalizations of events of *moving*, or *looking* or the like, and also objects that can be understood as paths, like *river*, *road* etc. The discussed (personal, functional etc.) aspect meaning of *als* is easily admissible, of course, when the PP-aspect is a generally accepted perspective under which the modificandum can be seen.[37]

We conclude this section by repeating the restriction mentioned in the beginning of this section. The aim was to sketch relevant dimensions of the adjunct use of prepositions. Of course, in the fragment there will be uses that cannot and will not be treated analytically: in cases like *an* in (74.b) we assume that the prepositional phrase is subcategorized by the verb and that the preposition loses its meaning proper thereby.

3.9 Verbs II

In section 3.3, we have considered verbs which introduce relations between classical first order objects, i.e., individuals and Davidsonian events. Type theoretically, these verbs are functions from objects into truth values (or, depending on the perspective chosen, into sentence radicals). In this section, we will consider verbs whose representations take an argument which is different from classical individuals and events. We will consider the copula use of *sein / to be* and representatives of verbs that introduce dispositions, deontic relativization, as well as verbs that report attitudes towards intensional arguments.

3.9.1 Copula

We will base our interpretation of the copula use of *sein / to be* on the occurrences with (predicative) adjectives, nouns and DPs as in (75).

[37]However, there is a rather tricky interplay of different factors going on, like *agentivity of the reported event, yes or no, intention of the partaking agent, yes or no, aspect is in concurrency to other aspects, yes or no*, which controls whether readings as in (74.b) or the $als1_{qual}$-reading of (74.a) are possible.

(75)

a. *Peter ist groß.*
Peter is tall.

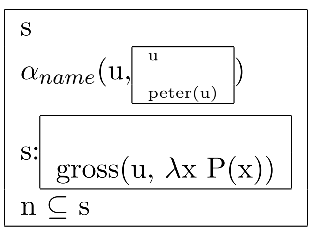
b. *Peter ist Bäcker.*
Peter is a baker.

c. *Peter ist ein Bäcker.*
Peter is a baker.

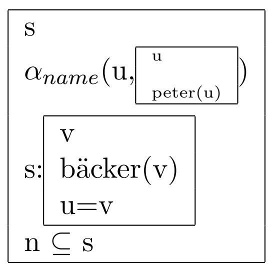
c. *Peter ist der Dieb.*
Peter is the thief.

We assume that the copula introduces what in [Bos et al.(1994)] is called a *support condition*, and that, here, in section 3.6.3 we have introduced as *situational relativization*, represented by s:K (see also 3.7.1). We also call conditions of the type s:K *s-descriptions*, in correspondence to the *p-descriptions*, p:K. We suggest the following representations of (75):

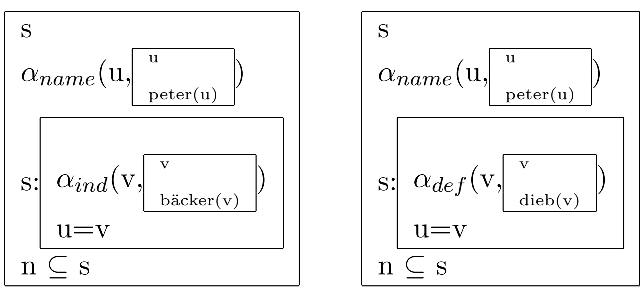
(75.a)



(75.b)



(75.c)



According to these representations, we assume the following representation of the copula use of *sein*:

$$\text{sein} \longrightarrow \text{cop\_t} \begin{bmatrix} \lambda: & \langle \chi, \text{L1} \rangle) \\ \text{RES:} & \underline{\text{sein}}(\chi, \text{L1}) \end{bmatrix}$$

$$\underline{\text{sein}}(\text{ind,itype\_l}) \Rightarrow \text{sat\_vpsem\_l}$$

$$\underline{\text{sein}}(\chi, {}^{\text{npsem\_l}}\text{l1}_\chi\text{:PDRS} \ {}^{\{\text{l2} \ \leq \text{l1}\}}_{\text{labelvar\&npsem\_l}}\text{L2} \ )$$

$:= l_{s_{akt(hom),t}}:$ $\boxed{\begin{array}{l} s \\ s{:}sat(L1) \\ s \subseteq t \end{array}}$

$\underline{sein}(\chi, {}^{nsem_l}L1_{\chi'}$

$:= l_{s_{akt(hom),t}}:$ $\boxed{\begin{array}{l} s \\ s{:}(L1\ \cup \boxed{\chi = \chi'}) \\ s \subseteq t \end{array}}$

$\underline{sein}(\chi, {}^{dpsem_l}L1_{\_,\chi',\_}$

$:= l_{s_{akt(hom),t}}:$ $\boxed{\begin{array}{l} s \\ s{:}(sat(L1)\ \cup \boxed{\chi = \chi'}) \\ s \subseteq t \end{array}}$

The first rule treats the NP-modifier case, i.e., the case of adjectival complements. Underspecified labelled structures of adjectives are typed *npsem_l*, and differ from NPs in that they show a variable bottom element which is also of type *npsem_l*. Since the composition rules of §4 will prevent non-predicative adjectives from being combined with the copula, there is no corresponding filtering needed here. Saturation of the adjective representation means that the variable bottom element is resolved to the empty DRS. This is equivalent to saying that it is cut off.

The second rule treats the noun case. Note that the distinguished referent of the noun representation is identified to the subject referent of the copula, via the '='-link. It is not unified to this referent, because, as mentioned in the beginning of this study, we wanted to allow for sorted DRFs and, under this modality, there could develop unwanted conflicts when DRFs of embedded representations (negation!) are unified to accessible DRFs.

The third case handles the DP-case. We have not provided a distributive reading for the DP-case. If the data suggest this, one easily adds a corresponding rule (along the lines of the treatment of distributive internal arguments in the preposition rules). Saturation of the DP is as described in section 2.7.2.

According to the representations of shifting modifiers as suggested in §3.6.3, from the third rule, we obtain (76_{rep}) for the following illustrating example (76), which is a complicating variant of the older (53.e).

(76) *Das damalige schöne Mädchen ist heute eine alte Frau.*
The beautiful girl of that time is an old woman today.

(76$_{rep}$)

```
[ s t
  α_def(u, [ u s'
             α_pt(t', [ t' | damals(n,t') ])
             s': [ u' | mädchen(u'), schön(u', λx P(x)), u=u' ]
             s' ⊆ t' ])
  s: [ α_ind(v, [ v | frau(v), alt(v, λy Q(y)) ])
       u=v ]
  heute(n,t)
  n ⊆ s ⊆ t ]
```

3.9.2 Other embedding verbs

In this section we will contrast dispositions with deontic relativizations. We will do this using German *können* which is ambiguous in this respect. After this, we will consider representatives of the verbs that report propositional attitudes, or more generally, of the verbs whose representations take a propositional argument.

Consider the following example with *können*:

(77) *Peter kann schwimmen.*
a. Peter can swim.
b. Peter is allowed to swim.

The English translations reflect the ambiguity.

We represent the first, dispositional meaning through a relation between the theme and the ability or faculty that is predicated of the theme:

(77.a$_{rep}$)

```
[ s P t
  α_name(u, [ u | peter(u) ])
  können1(s)
  theme(s)=u
  disp(s)=P
  P= λx [ e | schwimmen(e), agent(e)=u ]
  n ⊆ s ⊆ t ]
```

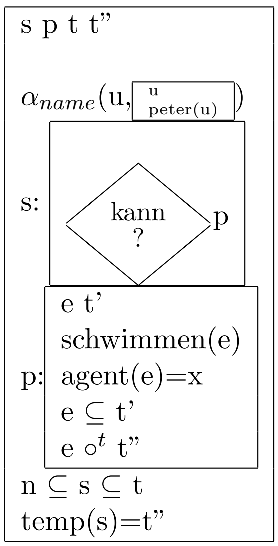
As can be seen the dispositional content is represented as a predicate (a property).[38] Note that this representation, that we suggest as schema for similar disposition

[38] As in similar cases at various places of the study, the status of a DRS K as in the condition of type P= λx.K of (77.a$_{rep}$) can be seen under different perspectives: the distinguished referent, *e* in the case at hand, can be understood as lambda abstracted, or not. In the first case the DRS stands for a sentence radical in the second it is saturated.

statements, is completely compositional, taking the infinitival complement for what it stands.

The representation of the second, deontic meaning will deviate from this in that, here, it is assumed that there is subject control. Therefore, the infinitival complement will come out as sentence radical. In addition, obviously the verb exercises a deontic embedding. Therefore, we obtain the following:

(77.b$_{rep}$)



This is very similar to the introduction of other operators in preceding sections (modal and aspectual operators in this case). Therefore, we can skip commenting on this representation, except probably some remarks about the temporal statements: since the focused range for which the agent is allowed to carry out the action is the occurrence time of the state of permission, the proposition must localize its event as overlapping the time of the state (e $\circ^t$ t”). We accommodate the focus time of *schwimmen* at the p level such that it cannot contradict the relevant temporal setting. Finally, the temporal anchoring of the embedding permission state (and of the corresponding focus time) is treated as usually done with state and process DRFs. From this and the previous representation, we retain the following entry of *können*:

können $\longrightarrow$verb_t $\begin{bmatrix} \lambda\text{:} & \langle\chi,\ \lambda\text{x.L1}\rangle) \\ \text{RES:} & \underline{\text{können}}(\chi,\ \lambda\text{x.L1}) \end{bmatrix}$

<u>können</u>(ind, λind.vpsem_l) ⇒sat_vpsem_l

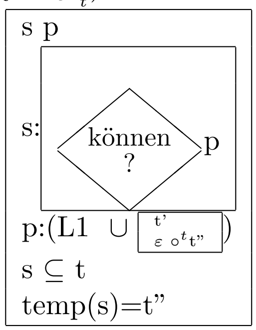
<u>können</u>(χ, λx.L1)

$:= l_{s_{akt(hom),t}}$:

s P
können(s)
theme(s)=χ
disp(s)=P
P= λx.L1
s $\subseteq$ t

<u>können</u>(χ, $\lambda\chi$.L1$_{\varepsilon\ t'}$)

$:= l_{s_{akt(hom),t}}$:



Note how unifying the subject DRF to the lambda variable of the infinitival complement implements the subject control of the deontic reading (second rule). In §4 it will become clear how the lambda terms of the second argument are provided and how it is guaranteed that the lambda variable is correctly identified with respect to the bearers of the roles in the VP representation L1.

The '?' of the deontic operator of the second rule, and of the corresponding operator in (77.b$_{rep}$) is a variable that is to be resolved to the contextual authority which is the source of the permission (or that is to be accommodated respectively).[39]

Now, let us turn to the intensional *suchen / to search for* and the epistemic *glauben / to believe*:

(78)

a. *Peter sucht ein Buch.*
   Peter looks for a book.

b. *Peter glaubt, daß er das Buch gefunden hat.*
   Peter believes that he has found the book.

The problem with (78a) is that *ein Buch* is not (necessarily) existential (with respect to the main level of the DRS—remember the classical *looking for a unicorn*). We can model this classical case of introducing an intensional context (see [Montague(1974)]) by using the p-description:

[39] In a recent study about modal subordination ([Frank(1997)]), Frank argues for an explicit modal base and introduces a corresponding DRS to the left of the operator, just like a restrictor box in the case of quantification, such that the modal assertion is understood as a relation between the base and the subordinated stuff, in close parallel to the quantificational duplex condition and also to the general relation of presupposition and assertion. This is an attractive alternative. (See also [Roberts(1987)] and the standard analysis of [Kratzer(1978)], also [Stechow(1979)]).

(78.a_{rep})

e p t
α_{name}(u, [u / peter(u)])
suchen(e)
agent(e)=u
object(e)=p
p: [v / α_{ind}(v, [v / buch(v)]) / ?(x)]
n $\subseteq$ e $\subseteq$ t

Following (78.a_{rep}), (78.a) is interpreted as a searching for a proposition p, or, provided *suchen* is represented in more analytic terms, it is interpreted as an action the goal of which is a situation in which the proposition p holds, where p just describes the existence of a book, and, possibly, is refined by some further contextual restriction about the book, which is expressed by our conventional abbreviation '?(x)', for contextual variables (or anaphors).[40]

A preliminary representation of (78.b) is the following:

[40]Note that the propositional argument that is introduced here, does not completely correspond to the intensional arguments of Montague grammar. It is in a different way specific than the intensional *ein Buch* proper, with respect to interpretation. Where the latter denotes the set of the sets of properties that hold for *a book* in the different worlds considered, the first one denotes a DRS describing an information state which informs about the existence of a book. Loosely speaking, whereas the first one points to the sets of books of the different worlds, the latter one points to the sets of their properties. Since, through the specific form of the variable assignments of the information state, the first interpretation precisely distinguishes the objects the discourse introduces from those whose existence can be inferred from the discourse solely, this first interpretation is closer to what has been called *structured meaning*.

(78.b_{rep}')

s p t

α_{name}(u, [u | peter(u)])
glauben(s)
theme(s)=u
object(s)=p

p: [e
α_{pro}(w, [w])
α_{def}(v, [v | buch(v)])
finden(e)
agent(e)=w
object(e)=v
e $\subseteq$ t
t $\prec$ n]

n $\subseteq$ s $\subseteq$ t

Here, the content of the (current) belief state of Peter is assumed to contain the assumption that there is a finding of some book by someone, where the finding precedes the contextual *now* (of the utterance), where it is left open how the pronoun is resolved (to the believer or to someone else the believer is familiar with), and where the definite DP may be assigned a de re or a de dicto interpretation. All this is in line with the settings of this study as presented so far. However, we will revise on this representation (or, better, we will include it in a more general representation formalism) and, following the suggestion of [Kamp(1995a)], make use of a more abstract state type that allows for incorporating the information about the different types of attitudes, i.e., beliefs, intentions, desires into one description of the attitudinal state of the considered human being. The reason for this is that there is a decrease of accessibility connected to these different attitudes: intentions build upon beliefs, and desires upon intentions and beliefs; i.e., beliefs are the presupposed background of intentions, and beliefs and intentions the presupposed background of desires, where a consequence of this is that the DRFs of the presupposed level are accessible from the respective assertional level and obtain a perspectival factual status; that is, the DRFs of beliefs are accessible from intentions and these from desires, but not the other way round. It is easier to interpret and administrate these relations through updating the attitudinal states of the partaking agents when compositionally constructing the representation of the discourse, than to keep the corresponding information separate with the result of discourse representations with distributed information about the (simultaneous) attitudes of an agent (see also [Eberle(1995)]). We therefore assume the following rule for updating attitudinal states:

s1 s2 t ξ p
s1:ATT(ξ,{ ATT_CONT })
glauben(s2)
theme(s2)=ξ
object(s2)=p
p:BEL_CONT
t ⊆ s1
t ⊆ s2

⇒

s3
s3:ATT(ξ,{ ATT_CONT, ⟨BEL,BEL_CONT⟩ })
t ⊆ s3

Applying this rule to (78.b) and to the empty context, we obtain the following definitive representation (78.b$_{rep}$):

(78.b$_{rep}$)

s p t

α_{name}(u,[u peter(u)])

s:ATT(u,{ ⟨BEL,p:[e
α_{pro}(w,[w])
α_{def}(v,[v buch(v)])
finden(e)
agent(e)=w
object(e)=v
e ⊆ t
t ≺ n]⟩ })

n ⊆ s ⊆ t

Of course, when further working out the approach, one will assign similar representations to the other verbs reporting attitudinal states, like *wissen, wollen, wünschen / to know, to want, to desire*. Note that *knowing* will be assigned presuppositional facticity additionally. The range of attitude verbs also makes clear that a detailed working out must subclassify the different attitude dimensions by assigning different degrees of intensity (the believer trusts in his information to different degrees, depending on whether, by introspection, he classifies it as knowledge, belief or supposition etc.).

We conclude this section by the lexical entries and representation rules of *suchen* and *glauben* that reflect the uses discussed.

suchen ⟶verb_t [λ: ⟨χ,L1⟩) RES: suchen(χ,L1)]

suchen(ind,dpsem_l) ⇒satvpsem_l

suchen(χ,L1)

$$:= l_{e_{akt(hom),t}}: \boxed{\begin{array}{l} \text{e p} \\ \text{suchen(e)} \\ \text{theme(e)}=\chi \\ \text{object(e)=p} \\ \text{p:sat(L1)} \\ \text{s} \subseteq \text{t} \end{array}}$$

$$\text{glauben} \longrightarrow \text{verb\_t} \begin{bmatrix} \lambda: & \langle \chi,\text{L1}\rangle) \\ \text{RES:} & \underline{\text{glauben}}(\chi,\text{L1}) \end{bmatrix}$$

$\underline{\text{glauben}}$(ind,compssem_l) $\Rightarrow$satvpsem_l

$\underline{\text{glauben}}(\chi,\text{L1}_p)$

$$:= l_{s_{akt(hom),t}}: \boxed{\begin{array}{l} \text{s p} \\ \text{glauben(s)} \\ \text{theme(s)}=\chi \\ \text{object(s)=p} \\ \text{L1} \\ \text{s} \subseteq \text{t} \end{array}}$$

The entry of *glauben* follows the philosophy sketched above: From the sentence a *glauben*-state is constructed. This state is turned into an ATT-state (into the update part of a ATT-state) when incorporating the sentence representation into the context representation. Of course, one could have introduced the more general ATT-format directly at the lexicon level. Note that it is assumed that the sentence complement (*compssem_l*) provides a DRS-condition, L1 (standing for p:DRS), not a (underspecified) DRS. This comes from the impact of the sentence complementizer.

3.10 Complementizers

Often, complementizers are assigned the empty semantics, in the sense that their semantic contribution only consists of percolating the argument sentence semantics (into a subcategorized argument position of the verb meaning for instance—compare implementation accounts like [König(1994)] for this). We deviate from this.

In this study we have argued for proposition-DRFs and we have made use of them at various places. Such descriptors for DRSs simplify matters in many respects, above all the representation of reference to propositions, so the argument in short. Now, on the basis of this formal means, a rather natural interpretation of the sentence complementizer consists in making the representation of the sentential complement the argument of a p-description and making the corresponding propositional DRF available to the verb representation as bearer of the thematic role that corresponds to the sentential complement. We implicitly have made use of this procedure, when representing verbs or sentences with sentential complements.

Normally, when proposition-DRFs are used in discourse representations it is assumed that they be interpreted as sets of worlds. One of the reasons why we have deviated from this, we repeat it, is the following: The problem with the set of worlds interpretations is that propositions (proposition DRFs) are accepted at positions, where classical individuals (possibly including events) are accepted. Compare the following pair of sentences, for an example:

(79)

a. *Die Frau ist schön.*
The woman is beautiful.

b. *Die Aussage ist schön.*
The statement is beautiful.

Whatever the purpose of a statement like (79.b) may be, syntactically and semantically, the sentence is correct.

As it seems, the point can be made in a more general way. Often, in discourse, the logical distinction of first order and higher order objects seems to be irrelevant or is faded out, or it seems to be a common procedure to switch between first and higher order perspectives of the discourse subjects. Compare (80) to this end.

(80)

a. *Er liebt drei Frauen und drei Farben.*
He loves three women and three colours.

b. *Das Auto ist rot.*
The car is red.

c. *Rot ist eine Farbe.*
Red is a colour.

(80.a) suggests to interpret *Farbe* at the level of first order objects like *Frau*. (80.b) sees *Rot* as a predicate and (80.c) as an instance of *Farbe*.

The strategy of this study, therefore, has been and remains to follow the surface structure closely; i.e., we accept first order representatives for discourse subjects that 'normally' must be interpreted as sets etc. and we assume that the model provides functions that relate representatives and the 'things' they stand for accordingly.

The simplicity argument underlying this surface oriented representation style (with cascaded interpretation levels) is the reason or one of the reasons for using sums instead of sets of individuals and for using proposition DRFs and mapping them onto DRSs, not onto information states directly. As said, a statement p:K will be true if and only if the information state of the value of p in the model (which is a DRS K') is at least as informative as the information state described by K. Note that these information states take the context of the condition p:K into account, because their embedding functions must be extensions of the embedding function of the model of the discourse. Note that by considering information states instead of worlds we reach at an interpretation which notices structural differences of otherwise equivalent DRSs and which, therefore, is more fine-grained than the Montagovian interpretation in this respect. This will be worked out in greater technical detail in §5.3.

Here we can summarize what is relevant to the subject of this section as follows: the difference between DRFs for classical objects and DRFs for propositions is just a sortal difference. The proposition DRFs stand for DRS-instances. Of course, similarly, DRFs for properties (or for the aspects of section 3.8) can be interpreted as instances of partial DRSs.

The following examples illustrate the use of the proposition DRFs in connection with sentential versus nominal complementation.

(81)

a. Peter glaubt, daß Inge kommt.
Peter believes that Inge will come.
b. Peter glaubt die Aussage.
Peter believes the statement.
c. Daß Peter kommt ist möglich.
It is possible that Peter will come.
d. Die Behauptung ist möglich.
The assertion is possible.
e. Die Tatsache, daß Peter kam, überraschte ihn.
The fact that Peter came surprised him.
f. Die Aussage, daß Peter kam, ist falsch.
The assertion that Peter came is false.

We suggest the following representations for the sentences of (81):

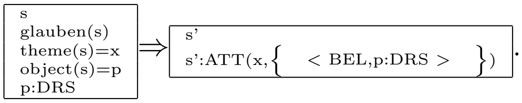
(81.a)

s p t
glauben(s)
theme(s)=peter
object(s) = p
p: [e t' | kommen(e), agent(e)=inge, $e \subseteq t'$, $n \prec t'$]
$n \subseteq s \subseteq t$

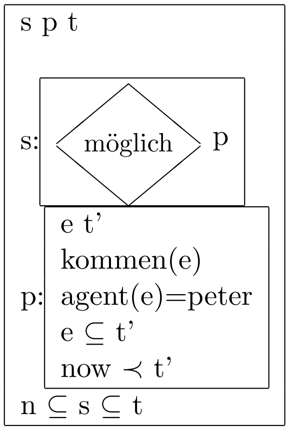
(81.b)

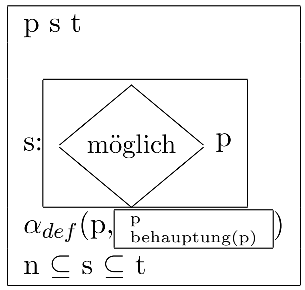
s t
glauben(s)
theme(s)=peter
object(s) = p
α_{def}(p, [p | aussage(p)])
now $\subseteq$ s $\subseteq$ t

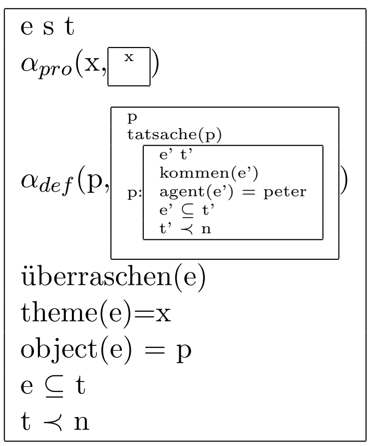
Here, and in the following, the names in the DRSs abbreviate corresponding α_{name}-conditions (and reference to the corresponding distinguished DRF respectively). Of course, the update function of the last section incorporates these sentence DRSs into the representations of the preceding discourse - we repeat this—in accordance with the transition:

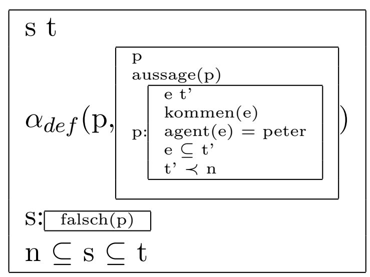


The remaining representations of (81) are as follows:

(81.c)


(81.d)


(81.e)


(81.f)


As above, we have accommodated the contribution of the tense information (and have used a simplified account of the names and have omitted the dotted line box-format of the s-descriptions, which, in the presence of empty situation universes is insignificant, of course).

(81.a) and (81.b) on the one hand and (81.c) and (81.d) on the other should reflect the similarity of the treatment of sentence complements and DPs that describe propositions. (81.e) and (81.f) treat the validity of propositions. Since the extension of *Tatsache* is understood to consist of representatives for propositions that are true in the actual world (i.e., to consist of facts), and, since, on the basis of the above first order modeling of propositions, *wahr* and *falsch* can be treated as completely 'normal' predicates, we can stipulate the following first order statement about the equivalence of predicates over propositions:

for all p: tatsache(p) ⇔wahr(p) ⇔¬: [falsch(p)]

Summarizing the considerations about *daß*, we can stipulate the following lexical entry:

daß $\longrightarrow$complementizer_t $\begin{bmatrix} \lambda: & < \text{L1} >) \\ \text{RES:} & \underline{\text{daß}}(\text{L1}) \end{bmatrix}$

$\underline{\text{daß}}$(satvpsem_l) $\Rightarrow$compssem_l

$\underline{\text{daß}}(\text{L1}) := {}^{compssem\_l}\text{l}_p$: $\boxed{\begin{array}{l} \text{p} \\ \text{p:tense\_sat(L1)} \end{array}}$ $\begin{array}{l} \langle \text{l1} \;\; < \text{l} \rangle \\ \text{L1} \end{array}$

There are other complementizers. *Ob / whether* is similar to *daß*. The function of the argument proposition is different however. It is used as a yes/no-question. In this study, we must omit saying something about questions or, more generally about the purposes of discourse, or about dialogue representation. Except for the fact that it assigns a specific discourse purpose to its argument, *ob* will obtain the same representation as *daß*.

Also *wie* can be used as complementizer, as in the following (82.a):

(82)

a. Peter sieht, wie Inge kommt.
Peter sees Inge coming

b. Peter sieht, daß Inge kommt.
Peter understands that Inge will come.

Comparing (82.a) to the similar (82.b), where *wie* is exchanged for *daß*, one feels a difference. The English translation, which emphasizes the difference, makes clear what it relies on: in connection with perceptions, *wie* requires that the agent and the object of the perception (which is an event or state) be in **direct** 'contact', so to speak, whereas *daß* requires an **indirect** 'contact' only, where, for the sentence to be true, it suffices that the agent concludes the truth of the complement sentence from some indications. Following [Bäuerle(1988)], we assume that, in the first case, the object of the perception verb is an event or state; i.e., we assume that the verb comes in its basic meaning, and that, in the second case, the perception verb gets a 'cognitive flavor' such that it can accept a propositional argument. Also following [Bäuerle(1988)], we think that the complementizers are responsible of this differentiation: whereas *daß* introduces a proposition variable, *wie* percolates the argument event DRF upwards. According to these assumptions, we stipulate the following entry for *wie*:

wie $\longrightarrow$complementizer_t $\begin{bmatrix} \lambda: & \langle \text{L1} \rangle) \\ \text{RES:} & \underline{\text{wie}}(\text{L1}) \end{bmatrix}$

$\underline{\text{wie}}$(satvpsem_l) $\Rightarrow$compssem_l

$\underline{\text{wie}}(L1_{\varepsilon\ akt(hom)}) := l_{\varepsilon\ akt(hom)}: \boxed{}$ {l1 ≤ l} L1

$\underline{\text{wie}}(L1_{\varepsilon\ akt(het)}) := l_{s_{akt(hom)}}:$ [s | s ∈ prog ε (L1)] {l1 < l} L1

The rules make a difference between homogeneous and heterogeneous argument event types. Heterogeneous event types are translated into homogeneous types (via progressivization), because the perception and the perceived situation must overlap, more precisely, the perception functions as reference event of the perceived situation and must be included in it. This is the typical temporal discourse setting of progressive states (provided underlying heterogeneous event types—[Vendler(1967), Kamp(1981a), Kamp/Rohrer(1983), Eberle et al.(1992)]). The given rules relate to the use of *wie* as complementizer in connection with perception verbs. We must omit discussing other uses here. Notice that it is the representation of the perception verb that must introduce the temporal relation between its referent and the complement referent.

We conclude this section by representing (82):

(82.a$_{rep}$)

e s t
s ∈ prog e' [e' / kommen(e') / agent(e') = inge]
sehen(e)
agent(e)=peter
object(e) = s
n ⊆ e ⊆ t
e ⊆ s

(82.b$_{rep}$)

e t p
α_{presp}(s, [s p / s:p / p: [e' t' / kommen(e') / agent(e') = inge / e' ⊆ t' / n ≺ t'] / n ⊆ s])
sehen(e)
agent(e)=peter
object(e) = p
n ⊆ e ⊆ t

(82.a$_{rep}$) is an instance of the coercion case explicated above. (82.b$_{rep}$) chooses one of the possible temporal settings of (82.b): the present tense can be read as locating its event at the contextual now. In this case, what has been said above about events of heterogeneous type that should include the reference time holds: there will be progressivization of the event description first. The present tense can be read as a kind of future also. This use is reflected by the chosen representation. The α-condition illustrates that the cognitive interpretation of the perception verb (*seeing, feeling* etc. interpreted as *understanding*) is a process variant of the stative *knowing* to the effect that the propositional argument is presupposed to be true.

3.11 Tense and aspect

The following pair of sentences exemplifies two central effects of tense and aspect:

(83)

a. *Peter öffnete die Tür. Er begrüsste Inge.*

Peter opened the door. He greeted Inge.

b. Peter öffnete die Tür. Es regnete.

Peter opened the door. It was raining.

First (83.a) and (83.b) show that, in contrast to the interpretations of classical tense logic, the meaning of a coherent text is not just the intersection of the meanings of the single sentences, normally the events and states of the sentences are temporally related to each other—as respective consequences of the discourse relations that hold between the sentences. In section 3.7, we have considered examples of the discourse relations *continuation* and *elaboration*, with the temporal relations of succession and of inclusion associated to them. According to this, the meaning of the tenses is not solely to existentially bind the (distinguished) event (state) variable of the sentence radical, but to anaphorically relate this DRF to some reference time of the preceding text and to introduce a corresponding suitable discourse relation.

Second, the Aktionsart or the aspect respectively of the sentence radical influences the type of relation that is chosen for incorporating the new sentence (and its event or state) into the representation of the preceding text: (83.a) is another example illustrating that, in narratives, the events of successive sentences normally follow each other, i.e., that the corresponding sentences are related by *continuation*, provided the tense level be the same and provided there be no other contradicting information. (83.b) exemplifies that stative sentences normally are interpreted as providing *background* information to the reference situation, with the consequence that the corresponding state (or process) will be anchored at the actual reference time (will include it) without introducing a new reference time. The anaphoric behavior of tense has been noticed long since and has been made an argument of the criticism of classical tense logic ([Partee(1973), Kamp(1977), Kamp(1981a)]). (Early) formal accounts of the diverging impact of Aktionsart and aspect respectively present [Kamp(1981a)],[Hinrichs(1981)] (or the more easily accessible [Hinrichs(1986)]), [Kamp/Rohrer(1983)]. There are other factors that contribute to the selection of a suitable reference time and to the type of relation to be introduced, among other things these are the temporal adverbial(s) of the new sentence, if any, and background knowledge about the event types involved. Considering the case of French, [Kamp/Rohrer(1985)] distinguish different types of adverbials and, based on this, suggest a typology of reference times that contributes to splitting up the Reichenbachian reference time (compare [Reichenbach(1947)]) into several parameters and, through this, to define a three dimensional analysis of the tense forms. According to this, the tenses are analysed into the *tense level* (*past, present, future*), which expresses the relation of the considered *perspective time* to the *speech time*, into *perfectivity (yes or no)*, which describes the relation between the *location time* and the (relevant) *perspective time* (where precedence means *perf: yes* and overlap *perf: no*, and into *progressivity (yes or no)*, which describes the relation of the event (or state) to the *location time* ($\subseteq$ or $\supseteq$), which, in turn, relates to a contextual *reference time*, where the *speech time* is a specific *perspective time*, and a *perspective time* a specific *reference time*. In [Eberle(1991a)], we have adopted this in essence, we have incorporated an Aktionsart calculus and we have made use of background knowledge, in order to spell out a temporal resolution component which makes weighted suggestions about the best anchoring of a new event or state with respect to the contextual parameters. Similar, with regard to the use of background knowledge, is the approach of [Lascarides/Asher(1991)]. Since the incorporation of the sentence events into the temporal structure of the preceding text, as an instance of the general procedure of resolving or accommodating presuppositions, is not the subject of this paper, we abstain from presenting details of such an algorithm. Since the formal setting of [Eberle(1991a)] easily is adapted to the one developed here, we simply assume, therefore, the approach here to be completed by the algorithm suggested there (see also [Eberle(1991b)]). Here, we just want to shed light onto some problems that are connected to different representation issues when expressing temporal relations and to the peculiarity of the underspecified scenario, which poses a number of problems which do not exist in the case of specific sentence representations. The discourse relational contrast between (83.a) and (83.b) provides the background against which we can discuss these problems. Therefore, let us start with representations of these examples.

(83.a$_{rep}$)

u v e1 t1 t1' e2
peter(u)
tür(v)
öffnen(e1)
agent(e1) = u
object(e1) = v
e1 $\subseteq$ t1
e1 $\prec$ t1'
inge(w)
begrüssen(e2)
agent(e2) = x
x = u
object(e2) = w
α_{rt}(t2, [t2 / t2 $\prec$ n / .... / t2 = t1'])
e2 $\subseteq$ t2

(83.b$_{rep}$)

u v e1 t1 t1' e2
peter(u)
tür(v)
öffnen(e1)
agent(e1) = u
object(e1) = v
e1 $\subseteq$ t1
e1 $\prec$ t1'
regnen(e2)
α_{rt}(t2, [t2 / t2 $\prec$ n])
e2 $\subseteq$ t2
....
e1 $\subseteq$ e2

The assumption of (83.a$_{rep}$) is that all α-conditions are resolved (accommodated), except the α-condition of the tense information of the second sentence, where the German *Präteritum* has been evaluated in so far as the location time is required to precede the perspective time which is identified to the *now*.[41] The location time,

[41] This interpretation of *Präteritum* does not differ from the temporal constellation introduced by *(present) Perfekt*. In [Kamp/Rohrer(1985)], with respect to the somehow similar contrast between French *imparfait* and *passé simple* (and *passé composé* respectively), there is made a relational difference however: whereas the passé simple/(and one reading of the) passé composé identifies

which must be resolved to a contextual reference time, is the focus time, which has been introduced by the verb representation. According to the above mentioned distinctions of properties of contextual times, we assume the α-conditions, which anaphoric temporal expressions introduce, to be classified as follows:

- α_{rt}-conditions refer to a contextual *reference time*,
- α_{pt}-conditions refer to a contextual reference time which, in addition, is a *perspective time*,
- α_{st}-conditions refer to the perspective time which, in addition, is the *speech time*.
  Here, we continue to use the constant n (or *now*) instead.

Using this, as an example, (one reading of) Plusquamperfekt (past perfect) will assume a perspective time in the past (which is referred to via an α_{pt}-condition) and a location time which precedes the perspective time (and which is referred to via an additional α_{rt}-condition). (For details of how a hierarchy of contextual reference times can be administrated and updated compare also [Eberle(1991b)]).

The setting of (83.a_{rep}) is such that the event of the first sentence, e1, which, at the time of the incorporation of the second sentence, is the actual reference event, is assigned a subsequent time t1'. The time t1' designates the focussed interval for which the recipient of the narrative expects the next event of the story (under the normal *continuation* assumption). Of course, the resolution of the α_{rt}-condition will identify t2 to this t1', such that the resulting temporal structure satisfies to the (default) functionality of heterogeneous (event) descriptions, as sketched further above. For simplicity, here, and throughout the rest of this section, we omit explicitly rendering the discourse relations holding between the corresponding sentence situations. We add that the location time t1 of e1 (which identifies e1's focus) stems from the preceding context, or, in case there is no context, it is a suitable accommodation.

the perspective time as the speech time and puts the location time into the past (of the speech time), by this expressing perfectivity, (one reading of) the imparfait identifies the location time to some perspective time situated in the past of the speech time, by this, representing the impression that the imparfait describes its event from an internal perspective so to speak. First, it is not clear whether the Präteritum/Perfekt contrast is a true picture of this perspective contrast of the corresponding French tenses. It seems that German Präteritum oscillates between the (basic) meaning of imparfait and passé simple. Second, because, from a semantic point of view, the resulting alternative temporal settings are undistinguishable, we content ourselves to represent the impact of the Präteritum/Perfekt contrast by the aspectual fine tuning of the event description as such: Whereas the Perfekt requires for a homogeneous event description that its validity be restricted to times before the perspective, that is the speech time in this case—we express this by applying the aspectual *max*-operator to the homogeneous description (compare section 3.6.5)—the Präteritum does nothing similiar, leaving open whether a corresponding state or process temporally overlaps the perspective (i.e.e the speech time) or not.

Also in accordance to the above mentioned (default) functionality of homogeneous (state or process) descriptions, the process of the second sentence, e2, is interpreted as a background of the reference event, the e1 of the first sentence. As a consequence, its focus time, t2, is interpreted as a time that includes the reference in its focus also (thus: $e1 \subseteq e2 \subseteq t2$). Probably it is identical to the focus time t1 of the reference event (t2=t1?). As before in the study, we render results of contextual resolution below dotted lines, at the DRS level, where the corresponding conditions should appear within the resolved text DRS (the content of α-conditions may be percolated upwards, of course, such that the landing site of the corresponding conditions may be ordered above the presupposition trigger).

Why do the verb entries introduce focus times? The exemplary representations (83.a_{rep}) and (83.b_{rep}) seem to suggest that, with respect to the resulting temporal structure, it would suffice to relate the event, process or state of the subsequent sentence to the reference event directly, without intermediate relations via focus times. As a reply, here, we can repeat the arguments presented in sections 2.5.3 and 3.4.4. Consider the following examples:

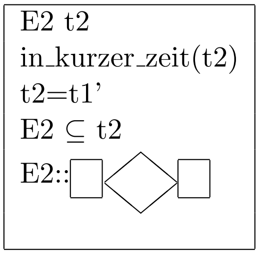
(84)

a. *Peter öffnete die Tür. Es regnete nicht.*
Peter opened the door. It didn't rain.

b. *Peter blickte zum Fenster hinaus. In kurzer Zeit gingen viele Schüler vorüber.*
Peter looked outside the window. In short time, many pupils passed.

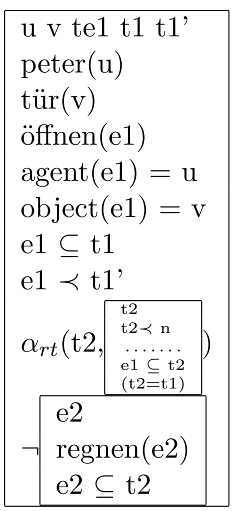
(84.a) varies on (83.b) and negates the second sentence. Obviously, the denial of existence of a process of raining is restricted to some relevant time in the past—Partee's argument, compare section 3.4.4. This time is not the more or less punctual *opening of the door*, e1, alone, but a time that includes this opening. In short, the first sentence of (84.a) should introduce a time that includes the event e1 (the t1 of (83.b)) and that can serve as the reference time for which the unnegated statement of the second sentence is excluded to be true.

As said above, normally t1 will be a reference time that a preceding event e0 provides as a focus for a successive event which continues the story under the narrative perspective. This time will be introduced by the textual composition, like t1' for e1 in (83.a_{rep}) and (84.a_{rep}). Why there should be a second focus time then, that comes from the verb representation, the t1 of e1, and the t2 of e2, in (83.a) and (83.b)? This is answered by the usefulness of a wide scope accessible temporal referent in the case of negated sentences which can be picked up and anchored at the context structure, as exemplified in section 2.5.3, and by the peculiarity of the case of sentences that introduce event sums, as in (84.b): The preferred reading of the second sentence of (84.b) introduces an event sum (that is abstracted from the duplex condition), call it E2. This sum is qualified by the frame adverbial *in kurzer Zeit*, t2, and, similarly to the case of (83.a) should be included in an actual reference time t1’ which the e1 of the first sentence provides. We obtain the following sketchy representation from this:

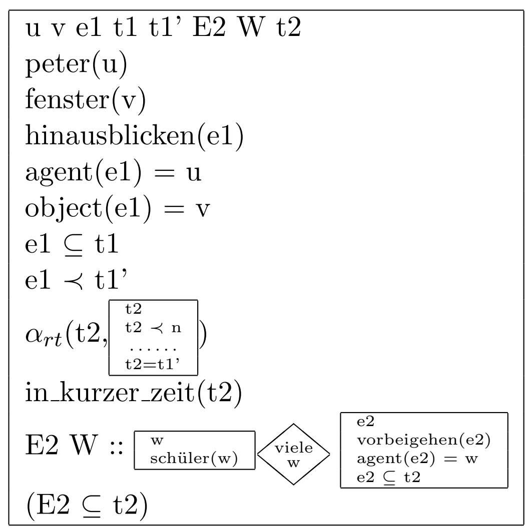


As outlined in sections 2.5.2 and 2.5.3 , the problem connected to this representation is that, according to the definition of ‘::’-operator, E2 will consist of **all** events that satisfy to restrictor and scope of the duplex condition, having for consequence that the representations stipulate all these events to be included in the past time t1’ (=t2) following e1. This, of course, is contrary to intuitions. In case, however, that the t2-restriction has narrow scope with respect to the verb representation, we get the correct representation, provided t2 is resolved to the wide scope available reference time. Summarizing, the desired representations of (84.a) and (84.b), which we obtain through percolating the verbal focus time upwards, as always done in the representations of this study, are the following:

(84.a_{rep})



(84.b_{rep})



There is an additional, as yet implicit assumption accompanying the percolation of the focus time: the impact of the tense and aspect information is evaluated at the sentence level only, not at the verb level. Note, one could do this by introducing a corresponding α-condition at the verb level, where it is assumed that the antecedent must have wide scope. The following pair of sentences should motivate why we deviate from this (more traditional) composition architecture.

(85)

a. *Peter kommt um 4 Uhr.*

Peter will come at 4 o'clock.

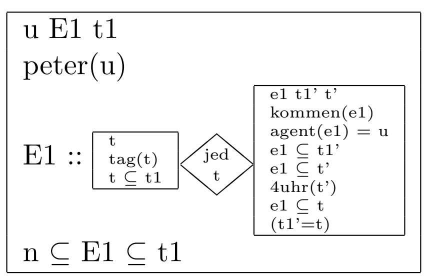
b. *Jeden Tag kommt Peter um vier.*
Every day Peter comes at four o'clock.

The German present tense (Präsens) can obtain different interpretations. Homogeneous descriptions normally are understood to hold at the speech time. Heterogeneous descriptions normally are reinterpreted as homogeneous descriptions (via progressivization) and treated accordingly, or the corresponding event is assumed to be located in the (near) future. As a rule,in connection with an additional location time from an adjunct (which does not overlap the speech time), German present tense gets the futurate interpretation, compare (85.a). In the presence of quantification and in case the additional location time gets narrow scope, this rule is suspended as (85.b) makes clear. The first case is explained by the fact that the two constraints—the speech time overlapping or the future-interpretation of the tense and the past or future-interpretation of the adjunct—are resolved to the one possible disambiguation, viz. the futurate interpretation. In the second case the focus time of the embedded description, together with the time of the narrow scope adjunct are bound within the scope of the duplex condition which is introduced by the frequency adverbial, according to the modelings of section3.6.8. Because the sum that is abstracted from this duplex condition is not temporally restricted by an (additional) specific location time and because the corresponding sum description is homogeneous, this sum is temporally related to the actual now according to the above described default interpretation of German present tense applied to stative event descriptions. Thus, we obtain the following representations of (85.a) and (85.b):

(85.a_{rep})

u e1 t1 t
peter(u)
kommen(e1)
agent(e1) = u
e1 $\subseteq$ t1
n $\prec$ t1
4uhr(t)
n $\prec$ t
e1 $\subseteq$ t

(85.b_{rep})



Now, in case we would interpret the tense information at the narrow scope position, similar to the case of (85.a), we would obtain that the e1 of the scope of the (85.b)-representation would have to follow the contextual *now*. That is, the representation would say that there **will** be a time in the (near) future such that for each day of this time *Peter will come at four o'clock*. This is not the (preferred default) meaning of (85.b). We take from this that the (unresolved) tense information has to be percolated upwards and that there may be intermediate operations of the argument representation that block the percolation of the argument focus time, that introduce new focus times, and that may change the Aktionsart of the description also. Sections 3.6.5 and 3.6.8 presented other examples and representations that are relevant in this respect.

As a kind of summary, in order to provide the suitable prerequisites for the temporal resolution, we make use of the following strategy: the verb introduces a time DRF, t, that locates the referential DRF, e, of the verb. This time DRF is stored in the index of e and is percolated through the labelled structure. Certain aspectual operations block the percolation and introduce new time DRFs for the new referential DRFs. Aspect operators like progressivization (*prog*) or inchoative coercion (*ingr*) do this, also the frequency adverbials. The time DRF is percolated by sum formation however. The *saturate_tense*-routine then computes suitable presupposition triggers, i.e., α-conditions, in accordance to the percolated tense information. The analysed tense information of the α-conditions controls the correct incorporating of the temporal DRF(s) of the actual main level into the available context structure. Here, background knowledge and the Aktionsart of the actual event description is taken into account. As seen, knowing the Aktionsart is a very important resource of the temporal resolution. However, we cannot go into detail with the corresponding computation either.[42] Instead, we can briefly sketch the strategy as follows. As illustrated in section 3.3, the verb entry introduces a basic Aktionsart value which is meant to characterize the Aktionsart of the event type that is described by the verb predicate under the assumption that the bearers of the subcategorized thematic roles are not mass terms, and not sums, but atomic objects. Thus, the transitive entry for *essen / to eat* is marked *het*, because the assumption is that the sentence is something like *someone eats a eatable thing*. This Aktionsart is the value that is assigned to the verb representation in the sentence DRS, i.e., to the innermost DRS that contains the verb predicate (and describes the Aktionsart of the corresponding predicate that develops through lambda abstraction of the event DRF). This is the case, if the subcategorized roles come according to the default. In case they do not, it is relevant of what type the roles are. We distinguish between *constant*, *gradual* and *characteristic* roles where, for example, *agent* is a constant role (because the agent is present at subevents in right the same way), *object* is a gradual role with respect to events of consumption or creation (because, then, subevents consider only parts of the initial bearers of the role), and where *spat_goal* is a characteristic role (because the corresponding bearer of the role is completely different in subevents).

Now, for example, a gradual role can change heterogeneous descriptions into

[42]In [Eberle(1998)] we have developed a treatment for Aktionsart phenomena in DRT that is based upon [Krifka(1989)], that shows a rather broad coverage and that we hope to adapt to the FUDRT framework as presented in this paper. We have mentioned this. In the older [Eberle(1991a)] we have presented a more complex algorithm that takes the impact of mass terms into account. A revised lean version of this algorithm which follows the design of the [Eberle(1998)] algorithm and subsumes the fragment of the latter has been implemented for the IBM system *Logic based Machine translation*. A documentation is forthcoming.

In this paper, we also cannot discuss alternative approaches like [Verkuyl(1972)], and the later [Verkuyl(1990), Verkuyl/Does(1991)], or [Egg/Herweg(1994)] ,[Naumann(1995)].

homogeneous descriptions, if its bearer is described by a homogeneous predicate (mass term) (*someone eats porridge*). We skip the details of this type of changing the Aktionsart of the verb representation.

As seen in the previous sections, there are VP-modifiers that change the Aktionsart under certain circumstances (duration adverbials for instance) and others that do never (spatial locations for instance). We have assumed and we continue to assume that the corresponding behavior is incorporated into the modifier rules, as illustrated in the relevant sections.

However, there is also another influence that we have not yet accounted for in this paper. Duplex conditions from quantified verb roles change event descriptions into more complex descriptions (into descriptions of the event sums that are abstracted from the duplex condition). Such changes can be accompanied by Aktionsart changes. Typically, for instance, bare plurals effectuate homogeneous event types, compare (86.a). However, they don't do this always, compare (86.b).

(86)

a. *Rocky öffnete die Tür. Frauen gingen vorüber, jede mit einem Kind.*
   Rocky opened the door. Women went by each accompanied by a child.
b. *Rocky öffnete die Tür. Reporter schossen auf ihn zu, jeder mit einem Micro.*
   Rocky opened the door. Reporters rushed over to him each with a mike.

The accompanying floated quantifier guarantees the distributive reading of (86.a), and of (86.b) also. However, whereas, in (86.a), the event sum gets the (more or less default) reading, where the atoms of the sum are ordered successively (according to what the control modifier *nacheinander* of section 3.6.6 makes explicit), in (86.b) background knowledge (about the considered event type and the related scenario) the reading with simultaneous subevents is preferred; we obtain:

(86.a$_{rep}$)

u v W e1 t1 t2
rocky(u)
tür(v)
öffnen(e1)
agent(e1) = u
object(e1) = v
e1 ⊆ t1
t1 ≺ n

E2 W :: [w | frau(w) | w ∈W] ⟨jed w⟩ [e2 c | vorübergehen(e2) | agent(e2) = w | kind(c) | mit(w,c) | e2 ⊆ t2]

nacheinander(E2)
t2 ≺ n
e1 ⊆ E2
E2 ⊆ t2

(86.b$_{rep}$)

u v R e1 t1 t2
rocky(u)
tür(v)
öffnen(e1)
agent(e1) = u
object(e1) = v
e1 ⊆ t1
t1 ≺ n

E2 R :: [r | reporter(r) | r ∈R] ⟨jed w⟩ [e2 m | zuschiessen(e2) | agent(e2) = r | micro(m) | mit(r,m) | spat_goal(e2) = u | e2 ⊆ t2]

gleichzeitig(E2)
t2 ≺ n
e1 ≺ t2
E2 ⊆ t2

In [Eberle(1998)] we have tried to explicate why representations of the (86.a$_{rep}$)-type can be assigned homogeneous Aktionsart, and why representations of the (86.b$_{rep}$)-type can be assigned heterogeneous Aktionsart, and on the basis of which Aktionsart definition. According to the assumptions there, one has to take into account that the distributive reading of a quantifier has to be split up into a simultaneous reading (which preserves the Aktionsart) and into a successive reading (which, depending on the quantifier may change the Aktionsart). The underspecified case will account for this through corresponding functional res- terms. We omit revising our quantifier entries by adding the described completions really, however we assume that the fragment allows for analysing the flat representations into correspondingly fine grained disambiguations, if relevant.

The collective reading, of course, percolates the value, compare (87):

(87) *Rocky öffnete die Tür. Reporter umzingelten ihn sofort.*
Rocky opened the door.Reporters surrounded him in a hurry.

With the sketched additional assumptions, the disambiguation routine of section 5.1 comes up with a specific reading that is evaluated with regard to the Aktionsart of the sentence radical. The corresponding value, then, can be used by the temporal resolution, as a parameter.

The default effect of homogeneous and heterogeneous descriptions has been repeatedly mentioned and we have exploited some aspects already. Approaches like [Kamp/Rohrer(1985), Kamp/Reyle(1993)] suggest that events are included in the reference time, whereas states include the reference time. We have followed this assumption in so far as new events are included in their focus time which is identified to the contextual reference time and states and processes include the reference event. We have deviated from this however, in so far as states and processes are included in their focus times also. We have done this mainly to get things right with quantification. Note that in case the states or processes of the scope of a quantificational duplex condition include the focus time, and in case this focus time is percolated upwards, these states or processes necessarily overlap. A consequence of this is that the *nacheinander*-reading of quantifiers never can be obtained. One could object that the focus time of this approach plays a specific role and that, with respect to explicit location times things are different. However, we think that sentences like *Heute regnet es (today it is raining) / Gestern war er dabei einen Brief zu schreiben (yesterday he was writing a letter)* illustrate that the homogeneous description not necessarily needs to hold throughout the location time (at least in German; it may be that French imparfait and other tense forms are more strict in this respect). Also, since the instance which is introduced by a homogeneous description is not necessarily a maximal representative of the description it is a matter of (nonmonotonic) reasoning, to decide whether there is a representative of the type of the reported state or process that holds throughout the entire location time.

It is an investigation of its own right how flat and underspecified representations as such can be reasonably classified in terms of Aktionsart. The considered ambiguity of quantifiers is one reason for that (often) there cannot be assigned a specific Aktionsart to the underspecified sentence representation. Another is that the scope relations as such are not resolved. There are constellations where this plays a role, for instance, when negation (which introduces homogeneous Aktionsart, as seen in section 3.6.5) interacts with other scope bearing elements, as in (88):

(88) *Nacheinander konnten sie nicht starten.*
They couldn't take off successively.

In (88), depending on the scope order (the negation may have scope over *nacheinander* or vice versa) the sentence can be assigned homogeneous or heterogeneous Aktionsart (there is a successive leaving out of taking off events (*het*) or there is no successive taking off (*hom*)). In this study, we cannot further investigate Aktionsarten of underspecified representations. Also, besides the suggested flat quantifier specification, various other types of flat semantics pose problems.

We conclude this section by pointing to the problem which is posed to the component of temporal resolution by the fact that it is not only the events of the matrix verbs that have to be temporally related to each other and that make up the temporal structure of the text. In section 3.6.3, we have presented examples which show that, next to the event from the verb, also (non-temporal) thematic roles may be related (i.e., relativized) to some contextual reference event or reference time (reference situation). Compare the following example (89) which repeats illustrating this phenomenon:

(89) *Damals kam ein junger Politiker auf ihn zu. Es war Mitterand.*
At this time a young politician came up to him. He was Mitterand.

We have treated examples like (89) by assuming wide scope for the temporal adjunct such that, next to the event from the verb, the representation of the subject phrase is related to the time of *damals*, which in turn is related to some contextual reference time. However, there is relativization of thematic roles without explicit temporal adjuncts (strip off the *damals* in (89)) and this 'syntactically empty' relativization, so to speak, has not been worked out sufficiently. The example also shows that, often, the matrix verb is not the temporal centre of the sentence (which is related to the context and which offers its time then for relativization of the thematic roles). In (89) the temporal centre is the adverb. Also the examples of the section about conjunctions and discourse relation, section 3.7, make clear, that, as a rather common feature, the temporal adjunct has to be resolved to the context first, not the matrix clause. The latter one often will be related to context only indirectly through its relations to the subclause. However, often, the possible relations of the subclause to the context will be controlled by the information from the matrix verb (by the tense information—also by event logic knowledge, if available). That is, often, the different resolution tasks will interact. This complicates matters.[43]

There is another problem connected to adjuncts. There are adjuncts which do not temporally relate to the actual contextual reference times in a direct way, which, nevertheless, have to be resolved to the context however. Subordinate clauses which do not introduce an explicitly temporal discourse relation are examples of such substructures which can introduce their 'own time' so to speak. Also, and in particular, relative clauses show this effect:

(90) *Dann hatte Peter die Frau, die mit Inge in Frankreich gewesen war, einfach angesprochen.*

[43]An algorithm that accords to this interactive architectural assumption has been spelled out in [Eberle/Kasper(1994)] for the French tense system.

Then Peter simply had talked to the woman who had been in France with Inge.

In (90) the time of *the woman being in France* is not the time of the story (whose actual reference time is provided by *dann*). In the next section, which deals with relative pronouns, we leave out further pursuing such ambitious resolution issues.

3.12 Relative pronouns

Relative clauses are not necessarily modifiers of the NP, they can modifyDPs also. In addition, their quantificational interpretation is rather independent of the specific reading of the modificandum. This is argued for, to our opinion by examples like the following:

(91)

a. Viele Bauern, die einen Esel haben, schlagen ihn.
Many farmers who own a donkey, beat it.

b. Zwei Männer und zwei Frauen, die am Nebentisch den Kuchen aufaßen, blickten plötzlich auf.
Two men and two women, who, at the neighboring table were eating up the cake, looked up.

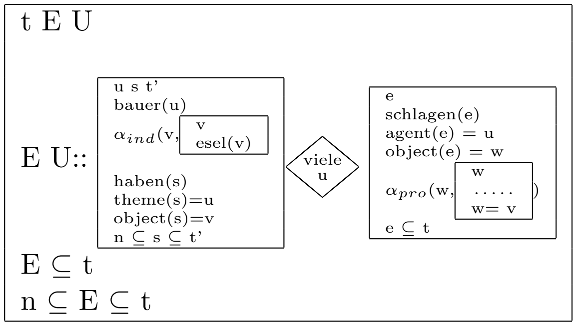
c. Die drei Männer, die am Nebentisch Skat spielten, waren verheiratet.
The three men who played Skat at the neighboring table were married.

d. Die drei Männer, die (übrigens) verheiratet waren, spielten am Nebentisch Skat.
The three men who were married (by the way) played Skat.

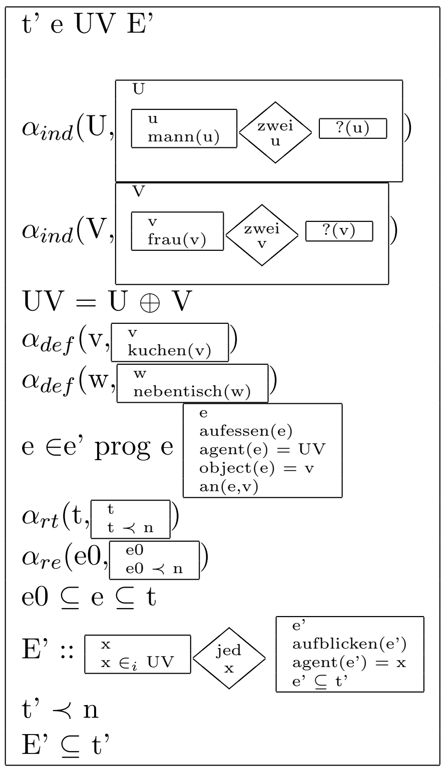
(91.a) corresponds to the nearly classical reference example motivating the development of DRT (see [Kamp(1981b)]). Here the relative clause modifies the noun *Bauer*, i.e., here, the relative clause obtains the NP-modifier reading. Obviously, with respect to the preferred reading of (91.b) the eating of the cake must be assigned to the collection of the men and the women. This collection is not available at the NP-level. It is only available at the DP-level. In addition, the example shows that the relative clause not necessarily follows the decision about distributivity and collectivity of the matrix sentence: The looking up will be distributed over the four persons, whereas the eating of the cake will be a collective event. (91.c) and (91.d) confirm these observations about the meaning of the relative clause.

We can depict the relevant readings of (91) as follows:

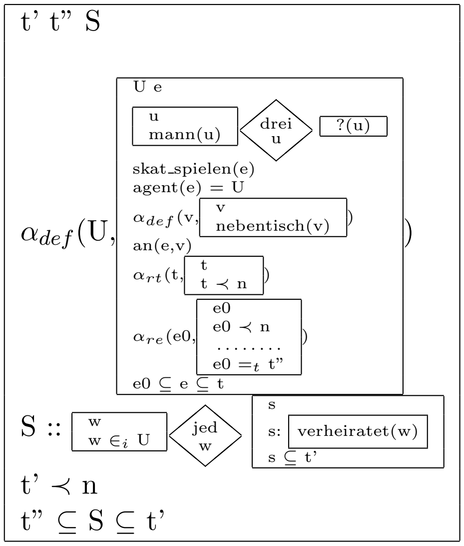
$(91.a_{rep})$



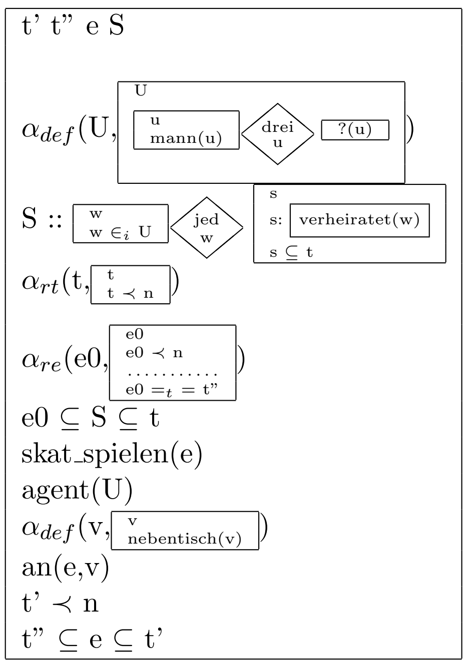
$(91.b_{rep})$



(91.c_{rep})



(91.d_{rep})



In all representations, the assumption is that the focus time of the matrix verb is accommodated and that, in case the matrix predication is homogeneous, the corresponding reference event, or its occurrence time t" respectively, is accommodated also, and that there are still unresolved temporal anaphors of the relative, i.e. the corresponding α-conditions. This is in accordance to the previous section. In all examples the time of the relative and the time of the matrix verb is intimately related (what is rendered by the corresponding identifications which are added as inferences to the α-conditions). This temporal coherence is not always at the basis of the information of the relative clause, as seen in the previous section.

Notice that by means of the α_{def}-condition we easily make a distinction between the appositional and the restrictive use of relative clauses. In our approach, the difference results from exchanging the positions of the determiner and the relative clause for each other in the sequence of the functional applications. In the disambiguation which results into (91.c_{rep}), the relative is applied to the *drei Männer*-DP, and then the determiner is applied. Therefore, the relative is part of the α-condition and effects a restrictive meaning. In the disambiguation of (91.d_{rep}), the determiner is applied first, and then the relative clause. This results into the appositional meaning, because the relative is not part of the α_{def}-condition. In section 5.2 we sketch extensions of the approach that should allow underspecification in this respect.

We conclude this section with the entry for the relative pronoun that allows for the considered readings of the corresponding relative clause:

$$\text{die} \longrightarrow \text{relpro\_t} \begin{bmatrix} \lambda: & \langle\ \lambda x.L1, L2\rangle) \\ \text{RES:} & \underline{\text{relpro}}(\ \lambda x.L1, L2) \end{bmatrix}$$

$$\underline{\text{relpro}}(\ \lambda \text{ind.vpsem\_l}, \text{xtype\_l}) \Rightarrow \text{xtype\_l}$$

$$\underline{\text{relpro}}(\ \lambda x.L1, {}^{npsem\_l}L2_x) := {}^{npsem\_l}l_x\!: \boxed{\text{sat\_tense(L1)}}\ \begin{matrix}\{l2 \leq l\} \\ L2\end{matrix}$$

$$\underline{\text{relpro}}(\ \lambda ①.L1, {}^{dpsem\_l}L2\varepsilon\ , \chi, \chi')$$

$$:= \quad {}^{dpsem\_l}l_{\varepsilon\ ,\chi,\chi'}\!:$$

$$\boxed{\text{sat\_tense}(l3\ \begin{matrix}\underline{\text{res}}(\langle E_{l1\leq l4,\varepsilon}\ '_{l1\leq_n l3}\rangle) \\ \chi \\ ①\underline{\text{res}}(\langle x_{l1\leq l4}, \chi_{l1\leq_n l3}\rangle)\end{matrix}\ :\ \boxed{E :: \boxed{\begin{matrix}x \\ x \in_i \chi\end{matrix}} \langle \substack{\text{jed} \\ x} \rangle L4}\ \begin{matrix}\{(l1 \leq l4 \vee l1 \leq_n l3)\} \\ L1_{\varepsilon}\ '\end{matrix}\ )}$$

$$\begin{matrix}\{l2 \leq l\} \\ L2\end{matrix}$$

Similarly to control verbs, like the deontic *können* of section 3.9.2, the relative pronoun takes a VP structure as first argument that is prefixed by a lambda operator which provides the remaining, not yet bound subcategorized variable. This variable is identified to the distinguished referent of the NP, or, in case of DP-modification, to a new lower referential index that comes from a new quantificational duplex condition which effectuates distributional underspecification with respect to the (upper) referential index of the modified DP.

Note that we really obtain the attributive/referential-distinction of (91.c_{rep}) and (91.d_{rep}) from this setting, because the application of numeral quantifiers results in DP-semantics. Therefore the relative can be applied before or after the determiner is applied to the numeral DP and in both cases the relative clause, as DP-modifier, can relate to a sum referent. Because of the possibility for NP and DP-modification, generally, for DPs with non-empty upper referential index, we obtain the (wide scope) referential and the (narrow scope) attributive interpretation of the relative clause.

3.13 Modifiers of functors

All of the lexical items considered so far are so called Xtypes or functors that take one or two Xtypes as argument and return an Xtype stucture, where Xtypes are either Etypes (*etype_l*) or Itypes (*itype_l*). Remember that *Etype* means *event type* and stands for structures that stem from verbs, verb phrases, sentence radicals (i.e., saturated verbal phrases), sentences and complement sentences. *Itype* means *individual type* and stands for structures that stem from nouns, noun phrases and determiner phrases. For instance, adverbs and adjectives designate subclasses of Xtype-modifiers. Determiners take NPsem types and result into DPsem types etc. There are modifiers that are of higher type. We introduce a small number of such modifiers in order to illustrate the formal treatment which we want to suggest for higher order modification.

(92)

a. Helmut sah ÜBERAUS *viele Rehe.*
Helmut saw exceedingly many roes.

b. Der Vorschlag ist ÜBERAUS *vernünftig.*
The suggestion is extremely reasonable.

c. Inge fährt ÜBERAUS *schnell*
Inge drives extremely rapidly.

d. Helmut sah WENIGSTENS *drei Rehe.*
Helmut saw at least three roes.

e. WENIGSTENS *in Hamburg schrieb Helmut Gedichte.*
At least in Hamburg, Helmut wrote poems.

The *überaus* of (92.a) modifies a quantifier, in (92.b) it modifies an adjective and in (92.c) an adverb. Similarly, *wenigstens* must be assigned different types. In (92.d), it modifies a quantifier also, whereas in (92.e), it is used as a focus adverb. To be precise, in (92.d), there is also the focus adverb interpretation of *wenigstens*), though less prominent.

According to these uses, we can stipulate the following interpretations:

überaus
⟶quantop_modifier_t [λ: ⟨^{quantop_t}QU⟩
RES: QU& RES: $^{\text{detpsem_l}}$l: [pdrs(member(quant_cond(type(comp_def)& mod(überaus))))]]

überaus
⟶mod_xtype_modifier_t [λ: ⟨$^{\text{mod_xtype_t}}$XM⟩
RES: XM& RES: l: [pdrs(member(rel_cond(mod(überaus))))]]

wenigstens
⟶quantop_modifier_t [λ: ⟨$^{\text{quantop_t}}$QU⟩
RES: QU& RES: $^{\text{detpsem_l}}$l: [pdrs(member(quant_cond(type(numb_def)& mod(wenigstens))))]]

wenigstens $\longrightarrow$mod_vpsem_t $\begin{bmatrix} \lambda\text{:} & \langle^{\text{vpsem\_l}}\text{L}\rangle \\ \text{RES:} & \underline{\text{wenigstens}}(\text{L}) \end{bmatrix}$

The assumption underlying the represented entries is that the labelled structures come as feature value matrices, such that *pdrs, member, quant_cond* etc. can be formulated as access functions that, applied to a particular node, pick up the (a) value of the corresponding feature. We note that *überaus* and *wenigstens* select for particular quantifiers, both for quantifiers that additionally accept a determiner (*überaus wenige—die wenigen, wenigstens drei—die drei*), i.e., for quantifiers that return QPsem labelled structures (*qpsem_l*, compare section 3.5 for the term). The application of the modifier prohibits this possibility for the result, i.e., here, the result is DetPsem labelled (*detpsem_l*).

Provided suitable syntactic underspecification, it makes sense to introduce flat semantics for parts of speech that, in the sentence, are a source of syntactic ambiguity. In case the corresponding semantic ambiguity cannot truly be expressed at the labelled structure level, i.e., at the level of the (typed) content of the resulting representation (the RES-value), it must be expressed at the type level as such. (92.d) presented an example, (93) presents further examples.

(93)

a. Peter hat nicht viele Bücher gelesen.
Peter hasn't read a lot of books / has read not many books.

b. Michael hat wenigstens drei Bücher verkauft.
At least, Michael has sold three books / Michael has sold at least three books.

We can assign 0-place multi-valued functions with delayed evaluation to such type ambiguous language elements. For example, for *nicht* and for *wenigstens*, we can do this in the following way:

nicht $\longrightarrow$$\underline{\text{nicht'}}$

$\underline{\text{nicht'}}$:$\Rightarrow$quantop_modifier_t $\begin{bmatrix} \lambda\text{:} & \langle^{quantop\_t}\text{QU}\rangle \\ \text{RES:} & \underline{\text{nicht''}}(\text{QU}) \end{bmatrix}$

$\underline{\text{nicht'}}$:$\Rightarrow$mod_vpsem_t $\begin{bmatrix} \lambda\text{:} & \langle^{vpsem\_l}\text{L}\rangle \\ \text{RES:} & \underline{\text{nicht}}(\text{L}) \end{bmatrix}$

wenigstens $\longrightarrow$$\underline{\text{wenigstens'}}$

$\underline{\text{wenigstens'}}$:$\Rightarrow$quantop_modifier_t $\begin{bmatrix} \lambda\text{:} & \langle^{quantop\_t}\text{QU}\rangle \\ \text{RES:} & \underline{\text{wenigstens''}}(\text{QU}) \end{bmatrix}$

$\underline{\text{wenigstens'}}$:$\Rightarrow$mod_vpsem_t $\begin{bmatrix} \lambda\text{:} & \langle^{vpsem\_l}\text{L}\rangle \\ \text{RES:} & \underline{\text{wenigstens}}(\text{L}) \end{bmatrix}$

In this study, we do not further discuss this issue of underspecification of the *sem_t*-level as such.

Chapter 4

Composition Rules

For the lexical fragment developed in the preceding sections, we need the following composition rules, where the general format is:
compose(sem_t,sem_t) ⇒sem_t
For simpler consumption of the elements of the subcategorization lists, we assume that the lambda prefixes of the descriptions are reversed.

The Determiner Phrase

- Adj + N ⇒NP:
  $\text{compose}(^{mod\_npsem\_t}[\text{RES: LA}],\ ^{basicnpsem\_t}\begin{bmatrix} \lambda\text{:} & \langle \text{IL} \rangle \\ \text{RES:} & \text{LN} \end{bmatrix})$
  $\Rightarrow^{structnpsem\_t}\begin{bmatrix} \lambda\text{:} & \langle \text{IL} \rangle \\ \text{RES:} & ^{structnpsem\_l}\text{l: } \Box \begin{matrix} \{\text{LA}\} \\ \text{LN} \end{matrix} \end{bmatrix}$
  An adjective applied to a noun (or a noun projection with *basic_l* labelled structure) builds up a labelled structure whose functor set consists of the adjectival labelled structure and whose bottom is the nominal labelled structure. This resulting labelled structure is prefixed by the lambda prefix of the noun description (which is non-empty, in case of a relational noun). The entire result structure is of type *npsem_t*, of course, more precisely, of type *structnpsem_t*.

- Adj + NP ⇒NP:
  $\text{compose}(^{mod\_npsem\_t}[\text{RES: LA}],\ ^{structnpsem\_t}\begin{bmatrix} \lambda\text{:} & \langle \text{IL} \rangle \\ \text{RES:} & \text{LN} \end{bmatrix}) \Rightarrow$
  $^{structnpsem\_t}\begin{bmatrix} \lambda\text{:} & \langle \text{IL} \rangle \\ \text{RES:} & ^{structnpsem\_l}\text{l: LN }_{[FSET/\{LA\} \cup FSET]\ ]} \end{bmatrix}$
  An adjective applied to a noun phrase (that comes with a *funct_l*-typed labelled structure, i.e., whose labelled structure shows a set of functors, in contrast to the semantics of a noun) adds its labelled structure to the functor set of the NP labelled structure. As before, the lambda prefix of the NP description is passed on to the new NP description.

- Quant + NP ⇒DP:
  compose($^{quantop\_t}\begin{bmatrix}\lambda: & \langle LN\rangle \\ RES: & LD\end{bmatrix}$, $^{npsem\_t}\begin{bmatrix}\lambda: & \langle IL\rangle \\ RES: & LN\end{bmatrix}$) ⇒$^{dpsem\_t}\begin{bmatrix}\lambda: & \langle IL\rangle \\ RES: & LD\end{bmatrix}$
  Applying a quantifier to a NP results in a DP, whose labelled structure is the result structure of the quantifier description. Here, the NP labelled structure is unified to the lambda argument of the quantifier. The possibly non-empty lambda prefix of the NP is passed on to the DP.[1]

- Det + DNP ⇒DP:
  compose($^{detsem\_t}\begin{bmatrix}\lambda: & \langle LDN\rangle \\ RES: & LD\end{bmatrix}$, $^{itype\_t}\begin{bmatrix}\lambda: & \langle IL\rangle \\ RES: & ^{qpsem\_l;npsem\_l}LDN\end{bmatrix}$)
  ⇒$^{dpsem\_t}\begin{bmatrix}\lambda: & \langle IL\rangle \\ RES: & ^{\text{detpsem\_l}}LD\end{bmatrix}$
  According to section 3.5 a determiner can be applied to a NP, but also to a DP with the specific *qpsem_l*-typed result structure (i.e., to a DP like *viele, wenige, drei X (many, few, three X)*). The resulting labelled structure will be typed *detpsem_l*. Except this, the rule corresponds to the rule for quantifiers.

  All of the rules considered so far are similar in that they percolate the possibly non-empty subcategorization list of the NP.

- DP + ModDP ⇒DP
  compose($^{dpsem\_t}[\text{RES: DP}]$, $^{mod\_dpsem\_t}\begin{bmatrix}\lambda: & \langle DP\rangle \\ RES: MDP & \end{bmatrix}$
  ⇒$^{dpsem\_t}[\text{RES: MDP}]$
  According to the setting of the last section, one could formulate an alternative composition rule that puts the DP-modifier into the Fset of the argument DP. The same is true for the determiner rule. The difference is that the rules here fix the scope of the determiner and the DP-modifier respectively. They allow for a simpler formalism and a simpler disambiguation routine, however. The formal working out of the extension should be clear, on the basis of what has been said in the last section.

- ModQuant + Quant ⇒Quant
  compose($^{quantop\_modifier\_t}\begin{bmatrix}\lambda: & \langle LQU\rangle \\ RES: & QU\end{bmatrix}$, $^{\text{quantop_t}}$LQU) ⇒QU

- ModXtypeMod + ModXtype ⇒ModXtype
  compose($^{mod\_xtype\_modifier\_t}\begin{bmatrix}\lambda: & \langle LM\rangle \\ RES: & M\end{bmatrix}$, $^{\text{mod_xtype_t}}$LM) ⇒M
  The last two rules reflect the examples for modifiers of functors that we have introduced in section 3.13.

[1] We assume this feature, in order to allow for simple representation construction without syntactic copying, in the presence of subcategorized noun roles having scope over DP coordinations, as in *die Zerstörung und der Wiederaufbau Heidelbergs (the destruction and the reconstruction of Heidelberg)*.

The Verbal Phrase

- DP + VP ⇒VP

  $$\text{compose}(\ ^{dpsem\_t}\Big[\text{RES: LD}_{\_,\_,\text{I}}\Big],\ ^{basicvpsem\_t}\begin{bmatrix}\lambda\text{:} & \langle\text{I}|\text{IL}\rangle \\ \text{RES: LV}_{e_{\left[\substack{\text{CAT}\\\text{MTV}}\right]}} & \end{bmatrix})$$

  $$\Rightarrow^{structvpsem\_t}\begin{bmatrix}\lambda\text{:} & \langle\text{IL}\rangle \\ \text{RES: L}_{\_\left[\substack{\text{CAT}\\\text{MTV}}\right]}\text{: } \square & \begin{matrix}\{\text{LD}\}\\ \text{LV}\end{matrix}\end{bmatrix}$$

  The application of a DP to a *basic_l* labelled VP (preferrably a verb) results in a VP whose result structure is a *funct_l*-typed structure with a functor set consisting of the labelled DP structure and a bottom structure which is the labelled structure of the argument verb. The percolation of *CAT* and *MTV* means that the categorial information and the mood and tense information of the verbal index is passed to the index of the resulting labelled structure.

- DP + VP ⇒VP

  $$\text{compose}(\ ^{dpsem\_t}\Big[\text{RES: LD}_{\_,\_,\text{I}}\Big],\ ^{structvpsem\_t}\begin{bmatrix}\lambda\text{:} & \langle\text{I}|\text{IL}\rangle \\ \text{RES: LV} & \end{bmatrix}\ )$$

  $$\Rightarrow^{structvpsem\_t}\begin{bmatrix}\lambda\text{:} & \langle\text{IL}\rangle \\ \text{RES: LV}_{\left[FSET/\{LD\}\ \cup\ FSET\right]} & \end{bmatrix}$$

  The application of a DP to a VP that is not a V semantics; i.e., a description whose labelled structure comes with a functor set (in contrast to the semantics of a verb) consists in adding the DP representation to the functor set of the labelled structure of the VP. We note that the application of DPs to VPs does not introduce ordering constraints, if there are no further constraints from the syntax semantics interface. In this study, we omit taking into account such constraints.[2]

- Adv + VP ⇒VP:

  $$\text{compose}(^{mod\_vpsem\_t}[\text{RES: MVP}],\ ^{basicvpsem\_t}\begin{bmatrix}\lambda\text{:} & \langle\text{IL}\rangle \\ \text{RES: V} & \end{bmatrix})$$

  $$\Rightarrow^{structvpsem\_t}\begin{bmatrix}\lambda\text{:} & \langle\text{IL}\rangle \\ \text{RES: }^{vpsem\_l}\text{l: } \square & \begin{matrix}\{\text{MVP}\}\\ \text{V}\end{matrix}\end{bmatrix}$$

  An adverb applied to a verb (or a l basic_l labelled VP) builds up a labelled structure whose functor set consists of the adverbial labelled structure and whose bottom is the verbal labelled structure.

- Adv + VP ⇒VP

  $$\text{compose}(\ ^{mod\_vpsem\_t}\ [\text{RES: MVP}],\ ^{structvpsem\_t}\begin{bmatrix}\lambda\text{: } \langle\text{IL}\rangle & \\ \text{RES:} & \text{VP}\end{bmatrix})$$

  $$\Rightarrow^{structvpsem\_t}\begin{bmatrix}\lambda\text{:} & \langle\text{IL}\rangle \\ \text{RES: VP}_{\left[FSET/\{MVP\}\ \cup\ FSET\right]} & \end{bmatrix}$$

---

[2] See [Frey(1993)] for some relevant phenomena in German and the corresponding UDRT account ([Frank/Reyle(1992)]), see also the more general *LexGram* account of [König(1994)].

With this, adverbial modification parallels adjectival modification. The subcategorization list of the argument remains unchanged.

- Cop + Itype ⇒V
  compose($^{cop\_t}\begin{bmatrix}\lambda: \langle \mathrm{IT,I}\rangle \\ \mathrm{RES:} \quad \mathrm{V}\end{bmatrix}$, $^{nsem\_t;dpsem\_t;pred\_mod\_npsem\_t}[\mathrm{RES: IT}]$)
  $\Rightarrow^{vsem\_t}\begin{bmatrix}\lambda: & \langle \mathrm{I}\rangle \\ \mathrm{RES:} & \mathrm{V}\end{bmatrix}$
  The copula *sein* takes nouns, DPs or adjectives. Further restrictions (onto a subset of the quantifier DPs for instance) can be obtained by suitable constraints of the labelled structures or by further subtypes. The result of applying the copula to its first argument is a 1-place verb.

- V + VP ⇒V
  compose($^{verb\_t}\begin{bmatrix}\lambda: \langle\ \lambda \mathrm{x.\ VL,I}\rangle \\ \mathrm{RES:} \quad \mathrm{V}\end{bmatrix}$, $^{vpsem\_t}\begin{bmatrix}\lambda: \langle \mathrm{x}\rangle \\ \mathrm{RES:} \quad \mathrm{VL}\end{bmatrix}$)
  $\Rightarrow^{vsem\_t}\begin{bmatrix}\lambda: & \langle \mathrm{I}\rangle \\ \mathrm{RES:} & \mathrm{V}\end{bmatrix}$
  This rule treats the case of verbs like *können* that take nearly saturated VPs, see section 3.9.2.

- V + DP ⇒V
  compose($^{verb\_t}\begin{bmatrix}\lambda: \langle \mathrm{DL,I}\rangle \\ \mathrm{RES:} \quad \mathrm{V}\end{bmatrix}$, $^{dpsem\_t}[\mathrm{RES: DL}]$)
  $\Rightarrow^{vsem\_t}\begin{bmatrix}\lambda: & \langle \mathrm{I}\rangle \\ \mathrm{RES:} & \mathrm{V}\end{bmatrix}$

- V + CS ⇒V
  compose($^{verb\_t}\begin{bmatrix}\lambda: \langle \mathrm{CL,I}\rangle \\ \mathrm{RES:} \quad \mathrm{V}\end{bmatrix}$, $^{compssem\_t}[\mathrm{RES: CL}]$)
  $\Rightarrow^{vsem\_t}\begin{bmatrix}\lambda: & \langle \mathrm{I}\rangle \\ \mathrm{RES:} & \mathrm{V}\end{bmatrix}$
  The last two rules treat the case of verbs with intensional arguments, like the verbs *suchen* and *glauben* of section 3.9.2.

Prepositional Phrases

- Prep + DP ⇒ModXtype
  compose($^{prepsem\_t}\begin{bmatrix}\lambda: & \langle \mathrm{IAS,EAS}\rangle \\ \mathrm{RES:} & \mathrm{REAS}\end{bmatrix}$, $^{dpsem\_t}[\mathrm{RES: IAS}]$)
  $\Rightarrow^{mod\_xtype\_t}\begin{bmatrix}\lambda: & \langle \mathrm{EAS}\rangle \\ \mathrm{RES:} & \mathrm{REAS}\end{bmatrix}$
  Though prepositions are classified as 2-place functors, we continue to assume a binary application schema. Therefore prepositions are applied to DPs and the result are Xtype-modifiers.

Subordinating Conjunctions

- Subconj + satVP ⇒ModEtype
  compose($^{subord\_t}\begin{bmatrix}\lambda: & \langle \text{IAS,EAS}\rangle \\ \text{RES: REAS} & \end{bmatrix}$, $^{satvpsem\_t}[\text{RES: IAS}]$)

  $\Rightarrow^{mod\_etype\_t}\begin{bmatrix}\lambda: & \langle \text{EAS}\rangle \\ \text{RES: REAS} & \end{bmatrix}$
  Here, it is made use of the same strategy as before: the conjunction, though a 2-place functor, is applied to its first argument and results in an Etype modifier. With regard to the conjunctions treated in section 3.7.1, the result, more precisely, is a VPsem modifier.

Coordinating Conjunctions

- Advcoconj + satVP ⇒S
  compose($^{adv\_coord\_conj\_t}\begin{bmatrix}\lambda: & \langle \text{S}\rangle \\ \text{RES: AS} & \end{bmatrix}$, $^{vpsem\_t}[\text{RES: S}]$)

  $\Rightarrow^{vpsem\_t}[\text{RES: AS}]$

- Coconj + Xtype ⇒ModXtype
  compose($^{coord\_t}\begin{bmatrix}\lambda: & \langle \text{X1,X2}\rangle \\ \text{RES: AS} & \end{bmatrix}$, $^{xtype\_t}[\text{RES: X1}]$)

  $\Rightarrow^{mod\_xtype\_t}\begin{bmatrix}\lambda: & \langle \text{X2}\rangle \\ \text{RES: AS} & \end{bmatrix}$
  These rules reflect the distinction that we have made in section 3.7.2 between non-proper coordinations, i.e., ‘adverbial’ coordinations like *deshalb*, which are applied to VPs and return VPs, and coordinations proper, where the only representative which we have considered, *und*, combined NPs, DPs and VPs. Generalizing the latter case, following the binary application schema, the result are subtypes of Xtype modifiers.

Relative Pronouns

- Relpro + VP ⇒ModItype
  compose($^{relpro\_t}\begin{bmatrix}\lambda: & \langle\ \lambda \text{I.VP,IT}\rangle \\ \text{RES: MIT} & \end{bmatrix}$, $^{vpsem\_t}\begin{bmatrix}\lambda: & \langle \text{I}\rangle \\ \text{RES: VP} & \end{bmatrix}$)

  $\Rightarrow^{mod\_itype\_t}\begin{bmatrix}\lambda: & \langle \text{IT}\rangle \\ \text{RES: MIT} & \end{bmatrix}$
  Relative pronouns incorporate their first argument and return modifiers: noun modifiers or NP- or DP-modifiers. Note that the single element list of the lambda prefix of the internal VP argument ensures that the VP is indeed saturated, except for the subject.

Complementizers

- Comp + S ⇒S
  compose($^{complementizer\_t}\begin{bmatrix}\lambda\text{:} & \langle\text{S}\rangle \\ \text{RES:} & \text{CS}\end{bmatrix}$, $^{satvpsem\_t}[\text{RES: S}]$)

  $\Rightarrow^{compssem\_t}\begin{bmatrix}\lambda\text{:} & \langle\rangle \\ \text{RES:} & \text{CS}\end{bmatrix}$

  Here, the distinction of *satvpsem_t*-descriptions (of sentence radicals) and *compssem_t*-descriptions (of complement sentences) prevents the recursive application of the rule. In section 3.10, we have defined the labelled structure of the complement sentence as a saturated structure, just like the labelled structure of the sentence, that is, as a structure with empty lambda prefix. Alternatively, one could have defined the complement sentence in close parallel to DPs, taking into account the common use of the complement sentence in the sentence. With regard to the given setting, we need a rule for combining complement sentences and VPs, the following:

- CompS + VP ⇒VP
  compose($^{compssem\_t}\begin{bmatrix}\lambda\text{:} & \langle\rangle \\ \text{RES:} & \text{l}_p\text{:CS}\end{bmatrix}$, $^{basicvpsem\_t}\begin{bmatrix}\lambda\text{:} & \langle\text{p}|\ \text{IL}\rangle \\ \text{RES:} & \text{VP}\end{bmatrix}$)

  $\Rightarrow^{vpsem\_t}\begin{bmatrix}\lambda\text{:} & \langle\text{IL}\rangle \\ \text{RES: l1:}\underset{\text{VP}}{\Box} & \{\text{l1}\_, p, p\text{: CS} \ \underset{\text{L2}}{\{\text{l2} \leq \text{l1}\}} \ \}\end{bmatrix}$

  We omit to specify the case of application to structured VPs.

Chapter 5

Interpretation

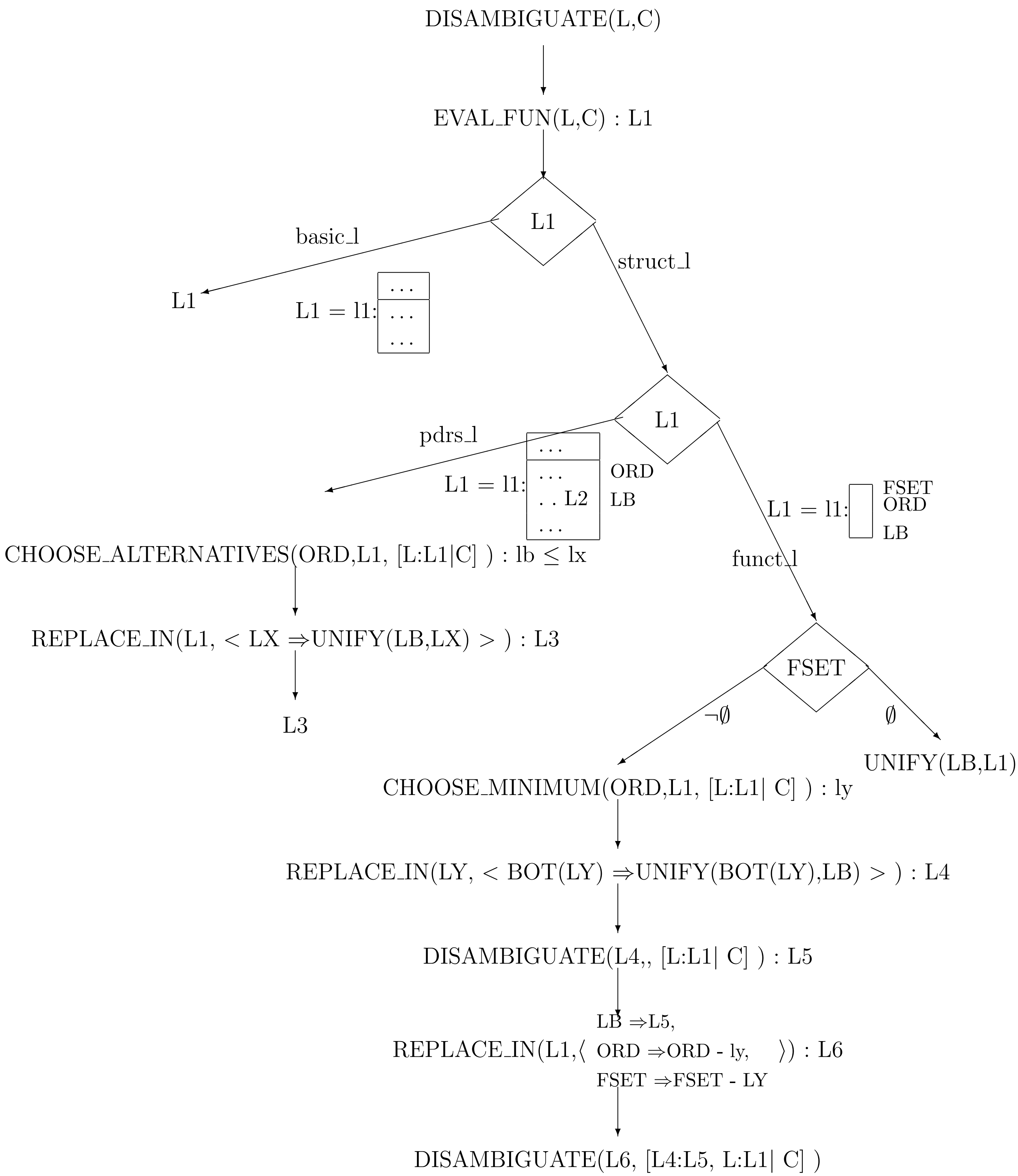
In section 5.1, we sketch a disambiguation algorithm called *DISAMBIGUATE* which disambiguates FUDRSs into DRSs. For reasons of simplicity, this first sketch of disambiguation disregards the so-called *first* conditions which represent functional ambiguities. In section 5.2 we sketch the subroutine which evaluates this type of condition and we sketch how this function is incorporated in the overall routine. We emphasize that the outcome of the different disambiguation functions depends (or may depend) on the contextual argument which is percolated through the entire recursive process. Also, the described total disambiguation is available only if the corresponding option is set. With respect to 'normal' text representation disambiguation is executed only as far as the context argument satisfies a particular contextual constraint of a particular possibility for evaluation of one of the disambiguation subroutines.

Since we have extended the DRT-inventory of condition types, for instance by so-called situational relativization, DRS-interpretation as defined in [Kamp/Reyle(1993)]) is not sufficient to interpreting the DRSs which can be computed from FUDRSs In section 5.3 we sketch ingredients of a suitable extended model theory therefore. On the basis of the corresponding interpretation function $|[]|_M$ (where M the interpreting model) and the disambiguation routine DISAMBIGUATE, we can define the meaning of a FUDRS as follows:

$|[\text{FUDRS}]|_M = |[\bigvee\{\text{DRS} \mid \text{DRS} \in \text{DISAMBIGUATE(FUDRS,C)}\}]|_M$
(where C the unspecified context representation as provided by FUDRS itself without refinement) i.e.,
FUDRS is true in model M iff
there is a DRS $\in$ *DISAMBIGUATE*(FUDRS,C) such that DRS is true in M (for C, the unspecified context).

5.1 Disambiguation routine

We abstain from working out the disambiguation algorithm in complete technical detail. Instead we just sketch a diagramm of its basic architecture. It is as follows:


DISAMBIGUATE(L,C)
EVAL_FUN(L,C) : L1
L1
basic_l
struct_l
L1
L1 = l1:
L1
pdrs_l
L1 = l1:
ORD
LB
. . L2
L1 = l1:
FSET
ORD
LB
funct_l
CHOOSE_ALTERNATIVES(ORD,L1, [L:L1|C]) : lb ≤ lx
REPLACE_IN(L1, < LX ⇒UNIFY(LB,LX) >) : L3
L3
FSET
¬∅
∅
UNIFY(LB,L1)
CHOOSE_MINIMUM(ORD,L1, [L:L1| C]) : ly
REPLACE_IN(LY, < BOT(LY) ⇒UNIFY(BOT(LY),LB) >) : L4
DISAMBIGUATE(L4,, [L:L1| C]) : L5
LB ⇒L5,
REPLACE_IN(L1,⟨ ORD ⇒ORD - ly, ⟩) : L6
FSET ⇒FSET - LY
DISAMBIGUATE(L6, [L4:L5, L:L1| C])

The algorithm makes use of three disambiguation subroutines which are: EVAL-FUN, CHOOSE-ALTERNATIVES, CHOOSE-MINIMUM. In addition, it makes use of two auxiliary functions REPLACE-IN, UNIFY for the revision of FUDRS structures. In this book, we we will not work out precise technical definitions of these functions. EVAL-FUN is a function wich triggers evaluation of all conditions of its argument which are functional terms. This means all lexical ambiguities of the argument representation are resolved. A consequence of this is that the context is extended by this argument of EVAL-FUN and the chosen disambiguation of it. CHOOSE-ALTERNATIVES chooses an alternative from a disjunctive order condition of a pdrs-Structure (mostly this corresponds to the decision between the distributive and the collective reading of a quantifier). Also here, the context is extended by the representation which is disambiguated and by the chosen disambiguation. CHOOSE-MINIMUM specifies ORD of a funct_l-structure by determining a functor from FSET which has narrow scope with respect to all other functors of FSET. Again, the context is extended by the considered FUDRS and its (partial) disambiguation. The instantiation of the context arguments obviously models the blackboard which we required in the introduction for making it possible to account for the parallelism phenomena of the different types of ambiguity: If there are several possibilities for disambiguating an argument representation (by one of the three functions) and if there has been already disambiguated a similar (isomorphic) structure, choose the type of disambiguation which corresponds to the one of the disambiguation of this latter structure, except that this is impossible or implausible for some reason. (In this latter case, the contextual information of the result will be such that it reports about two similar structures wich show different types of evaluation to the consequence that context is implicitly split into a narrow context and a more distant context, where, with respect to later disambiguations of similar structures, it has to be spelled out which context is more relevant for which reason).

Instead of going further into detail with the subroutines, we explain the functionality of the algorithm by running through an example:

(94) *Für einen Impresario traten drei Artisten auf.*
Three Artists appeared on stage for an impresario.

From the relevant lexical entries of section 3 and the composition rules, we obtain the representation (94_{rep}) of (94).

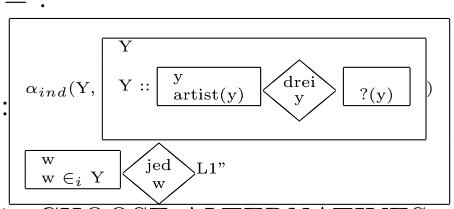
(94_{rep})
$$\text{l}_{\mathcal{E}\ mtv(tf(past,\_,\_))} : \boxed{}\ \begin{array}{l} \{\text{l1}_{\_,\_,\chi'}:\underline{\text{drei}}(\underline{\text{artisten}}(\chi))_{L2},\ \text{l3}:\underline{\text{für}}(\underline{\text{ein}}(\underline{\text{impresario}}(\text{x})),\text{L4})_{L4}\} \\ \{\} \\ \text{l5}_{e_{t,akt(het)\&mtv(tf(past,-,-))}} : \boxed{\begin{array}{l} \text{e} \\ \text{auftreten(e)} \\ \text{agent(e)} = \chi' \\ \text{e} \subseteq \text{t} \end{array}} \end{array}$$

Here, for the sake of simplicity, the tense information is not yet resolved.[1] Now, the routine applies EVAL-FUN to L first. EVAL-FUN, as said, evaluates flat descriptions of labelled structures according to one of the rules of the corresponding

[1]Applying *saturate_tense* to L would result in a structure that is like L, but has an additional

representation functions that are applicable to the description in the given context. Otherwise, i.e., in case L has no functional term or is no functional term, EVAL-FUN is the identity function. Thus, with regard to L of (94_{rep}) , EVAL-FUN returns the unchanged L. After this, it is tested whether L is a basic labelled structure (*basic_l*) or not (*struct_l*). The latter alternative holds. Next, we test whether L is a structure which shows a partial DRS and a bottom structure (*pdrs_l*) or whether it is a structure that comes with a set of functors over a bottom structure (*funct_l*). It is such a functor set structure. That is, it provides a set of functors, and this set is nonempty. Following the algorithm, we now have to choose an element of the functor set which is minimal with respect to the asserted ordering conditions. Since there are no ordering conditions in our specific case, the choice is free. We choose L1 (for LY). Next, we have to replace in L1 the bottom label of L1 (which is L2) by UNIFY(L2,L5) (where L5 is the verb representation). The functionality of UNIFY consists of merging the DRSs of the argument labelled structures and of suitably handling the relevant type information and the information about the distinguished DRFs. In the specific case, the result is L5. Now, the revised L1 undergoes the recursive call of DISAMBIGUATE. Since drei is applied to artisten(χ) the latter cannot be evaluated to its bare plural reading (drei would be incorrectly applied to a *dpsem_l*-structure in this case). The correct deep semantics is [y | artist(y)] with the distinguished DRF y for χ. Choosing the indefinite reading for drei, we come up with EVAL_FUN(L1) = :

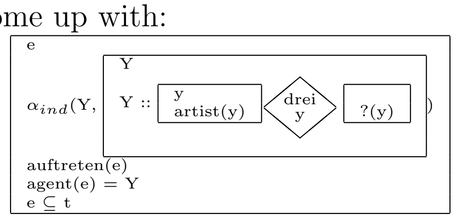
L1'$_{\varepsilon}$', Y, res($w_{l5 \leq l1''}$,$Y_{l5 \leq_n l1'}$) :



{(l5 ≤ l1" ∨ l5 $\leq_n$ l1')}
L5

L1' is a pdrs label. Via CHOOSE-ALTERNATIVES, we can determine a specific ordering constraint from a disjunctive ordering statement. We choose the specification l5 $\leq_n$ l1' which will lead us to the collective reading of the indefinite, because, by this choice, the lower referential index of L1' is evaluated to Y and because the structure L1' is replaced by UNIFY(L5,L1'). UNIFY(L5,L1') merges the DRS descriptions of L5 and L1' and, in this specific setting, determines the new labelled structure to be typed *vpsem_l* and the corresponding distinguished DRF to be the e of L5 with unchanged Aktionsart- and focus time- information. Thus, calling the new structure L1*, we come up with:

L1*$_{e_{t,akt(het)\&mtv(tf(past,-,-))}}$:



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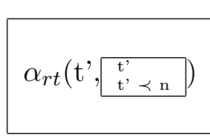
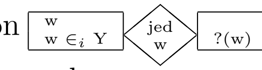
wide scope functor l0:$\varepsilon_{t',mtv(tf(past,-,-))}$:

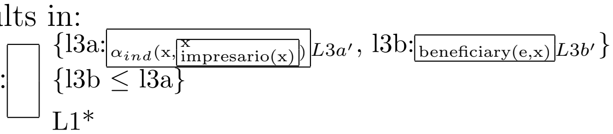


$L0'_{\varepsilon_{t'}}$.

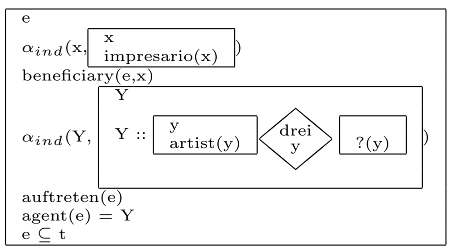
Here, we have omitted to represent the quantification 

of the collective reading of the indefinite, because it is equivalent to the true or empty condition.

The recursive call of DISAMBIGUATE coming up with L*, we have to replace the bottom of L1, L5, by L1* and to strip off the L1 contribution from the functor set and the list of ordering conditions. We apply DISAMBIGUATE on the thus revised L and, after some structural tests (similar to the described tests of the original L), we come up with the task of choosing a minimal functor. Since there is only L3 left, this must be L3. Then, we have to apply DISAMBIGUATE to the structure L3' that develops from L3 by replacing the bottom label by L1*. Choosing the beneficiary reading of *für* and the indefinite reading of *ein*, EVAL-FUN applied to L3' results in:

L3”: 

Skipping the details of the evaluation of this functor set structure, we come up with a labelled structure L3* which we can depict as follows:

$L3*_{e_{t,akt(het)\&mtv(tf(past,-,-))}}$: 

Stripping off the L3 contribution from the functor set and the list of ordering conditions of the current L and replacing the bottom by L3* results in a labelled structure with empty functor set. Therefore the FSET test of the DISAMBIGUATE routine determines UNIFY(L3*,L) (in essence the merge of the corresponding DRSs) to be the result of the entire procedure, where, note, the result is like L3*, because the L-DRS is empty.

To this result, (on the basis of a possibly existing context) we can apply the routine for tense resolution and the other presupposition resolving routines. Of course, the procedure for tense resolution has to take into account the Aktionsart information, as described in section 3.11. In case of homogeneity, the distinguished referent will include the actual reference event (which, in case of present tense sentences without further temporal location information, may be the actual *now*). In case of heterogeneity, the focus time of the index will be unified to a suitable contextual reference time. In both cases, the determination is controlled by the *mtv information*, which, next to the three dimensional tense analysis (which is stored in the *tense features*-term (*tf*), contains the mood analysis. In 3.11, we have nothing said about mood. Without working this out, we assume that the different mood analyses may trigger the introduction of modal (deontic) operators, or particular presuppositions or conventional implications or simply constrain the tense information of the relevant neighbored tensed elements.

The example illustrates how the tense information and the focus time is percolated along the disambiguation. With regard to more complicated examples, we have to take into account that the percolation of the relevant information can be (partly or completely) blocked or revised. In sections 3.6.5, 3.6.8 and 3.11, we have shown that certain aspectual operations and other modifications introduce new focus times. As it seems, the *perf-* and *prog*-information of the tf-term can be changed also. First, according to analyses like [Kamp/Rohrer(1985)], the information *perf: +* can be assigned the temporal interpretation that the event in question precedes some suitable contextual perspective time, but also the aspectual interpretation that the temporal object in focus is not the VP event , but a corresponding result state. Compare example (95).

(95) *Drei Jahre lang hatte Peter den Zenit schon überschritten, als ihm wieder ein Sieg gelang.*
For three years already, Peter had left to be at his zenith, when he won again.

Obviously, here, the *drei Jahre lang* does not modify an event of the type *x den Zenit überschreiten*, but a (resultive) state of the type *x den Zenit überschritten haben*. Therefore, the distinguished referent of the main clause is not an überschreiten-event, but an überschritten haben-state, which is no longer annotated *perf: +*, because the information *perf: +* has got an aspectual interpretation during the disambiguation (with narrow scope with respect to the for-adverbial). An additional (wide scope) temporal interpretation must be suppressed, in order to avoid wrong results (something like double perfectivity). Therefore, the optional intermediate interpretation of *perf: +*, which applies the aspectual *perf*-operator to the current VP representation, turns the *perf: +* of the tf-term into *perf: -*.

Similarly, *prog: +* may be evaluated during the disambiguation; i.e., the aspectual *prog*-operator doesn't necessarily obtain wide scope. Of course, evaluating *prog: +* returns *prog: -* for the result. (96) presents examples with wide and narrow scope of the *prog*-operator.

(96)

a. *Peter war dabei eine Minute lang die Luft anzuhalten.*
Peter tried to hold his breath for a minute.

b. *Peter war eine Minute lang am Luft anhalten.*
Peter was holding his breath for a minute.

Provided a compact account of the *dabei sein* periphrase and of the *Rheinische Verlaufsform* via *mtv(tf(past,-,+))*, (95.a) and the contrasting (95.b) show that the contribution of the *prog: +* information is scope sensitive. In (95.a), the progressivization obviously has scope over the for-adverbial, whereas in (95.b) it is just the other way round.

Our representation of (94) makes allusion to this possible changes of the *perf-* and *prog*-slots of the tf-term by avoiding the unification between the corresponding values of the verb label L5 and the values of the resulting index of L.

We have omitted however to present the disambiguation routine in such a detail that the evaluation of the tf-slots is worked out. As said in section 3.11, in [Eberle] we describe a tense resolution component with integrated Aktionsart calculus which can treat a number of complex resolution tasks. Among other things, a compositional account of the contribution of the *perf* and *prog* information of the mtv-feature is provided there. The long term goal is to make this component (that is designed for the case of classical DRSs) available not only as a subsystem of the disambiguation routine but for the case of underspecified representations as such.

Also, we have omitted to sketch how EVAL_FUN, through a supplementary functionality, should simplify functors whose bottom structures aren't labelled variables but (non-saturated) structures (which, in particular, is reflected by the case of DP-modifiers applied to DPs). This is rather straightforward: After analysing the structure into a deep representation, one will apply some type tests in order to filter out the relevant cases. Then, according to the Oset-information, one will unify the bottom description into the functor representation, or functor and bottom representation are merged and the bottom of the bottom will be the bottom of the result structure. This, at least, sketches the two relevant cases of DP-modification.

5.2 An extension of the framework

The following sample sentences are syntactically ambiguous:

(97)

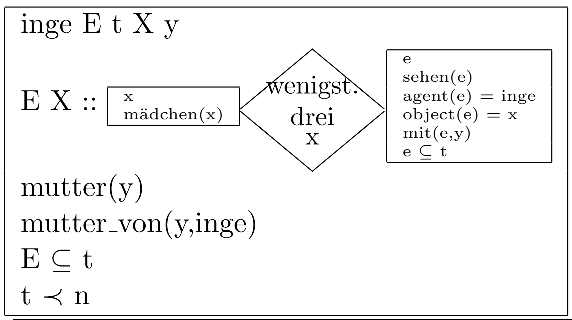
a. *Inge sah wenigstens drei Mädchen mit ihrer Mutter.*
Inge saw at least three girls with her / their mother.

b. *Die alten Männer und Frauen und Kinder aus Tirol warteten am Einlaß.*
The old men and women and children from Tirol waited at the entrance.

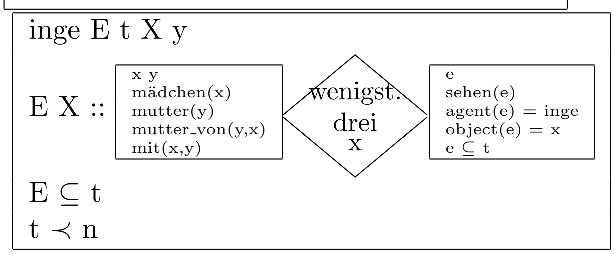
In case the syntactic analysis is able to underspecify the attachment of the PP in (97.a), or even the internal structure of the coordination in the more complicated (97.b), semantics should have a formal means to retain this type of underspecification. Note that, in (97.a), the PP may be attached to the DP (or to the NP which it contains) or to the VP. In (97.b), the adjective can be attached to the first noun conjunct, *Männer*, to the coordination of the first and the second noun conjuncts, *Männer und Frauen*, or to the coordination of the first, second and third noun. Depending on this choice for modification from the left, the aus-PP can modify the NP coordination from the right; it can modify the third, the second and the third, or all three NPs. As a further complicating feature the determiner may have scope over the first NP only, then (the coordination of) the second and third NP will be read as a DP, because, in this case, the first *und* must be a DP-conjoining operator. However, the determiner may have scope over the first and the second, or over all three conjuncts also. Because the aus-PP can be a NP-modifier, but also a DP-modifier, the *aus*-modification may be introduced within the α-condition of the determiner (in case this one has scope over all three conjuncts), where it may modify the NP-coordination from the right (to a certain extent), or it may be introduced outside the α-condition, modifying the last NP (or DP) or the DP-coordination of the second and third conjunct.

Let us start with the two readings of (97.a) which are most prominent and which illustrate the possibilites for attaching the PP. The one, (97.a$_{rep}$i), says that Inge saw at least three girls and that she did that together with her mother. The other, (97.a$_{rep}$ii), says that Inge saw at least three girls who where accompanied by their mother. We represent the scenarios after resolution of the α-conditions.

(97.a$_{rep}$i)

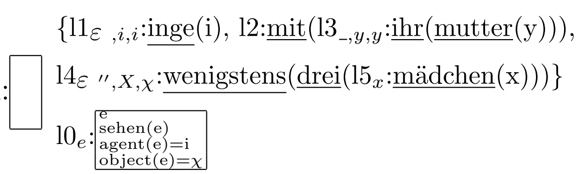


(97.a$_{rep}$ii)

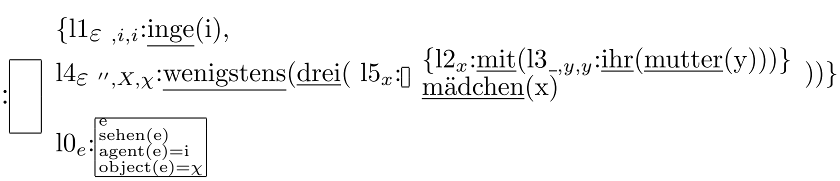


(97.a$_{rep}$i) and (97.a$_{rep}$ii) are disambiguations of the following FUDRT-representations:

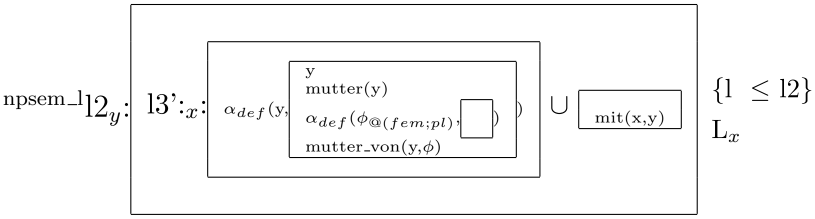
(97.a$_{rep}$i') l:



(97.a$_{rep}$ii') l:



The flat descriptions of the functors of the Fset can be evaluated, provided suited definitions of proper nouns and possessive pronouns (which we have omitted to state in this study and which must fit with the general noun and determiner representations). For example, the flat representation L2 of the second FUDRS can be evaluated to the following representation:

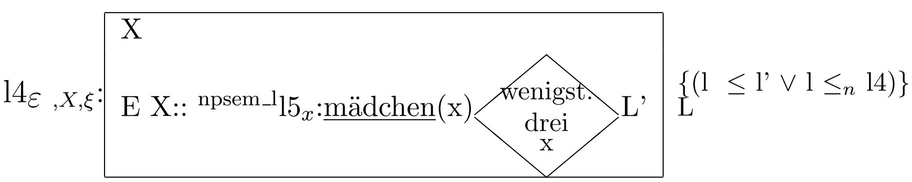


This evaluation uses the information that the PP, in the particular position of (97.a$_{rep}$ii'), is used as a NP-modifier (compare the corresponding choices for the prepositions, in particular for *mit*, as introduced in section 3.8) – where, according to this NP-modification variant, L3' is the saturation of L3.

With respect to (97.a$_{rep}$i') there is just the possibility of interpreting the PP as VP-modifier. How can we bring the different readings together on the basis of one underspecified representation? For this purpose, in section 1.2, we have introduced the additional ordering relation symbol *first*. Making use of *first*, we represent (97.a) by the one representation (97.a$_{rep}$):

(97.a$_{rep}$) l: [ ] {l1$_{\mathcal{E},i,i}$:inge(i), l2:mit(l3$_{_,y,y}$:ihr(mutter(y))), l4$_{\mathcal{E}'',X,\chi}$:wenigstens(drei(l5$_x$:mädchen(x)))}
{first(l4,l2)}
l0$_e$: [e | sehen(e), agent(e)=i, object(e)=χ]

first(l4,l2) says that, the disambiguation routine **can** apply L2 to L4 (before L4 is saturated by application to the VP-argument therefore *first*), It also says that, under this option, it can modify the L4-DP or it can apply to the (rightmost) modifier of the L4-representation also and so forth as long as these rightmost substructures satisfy the selectional restriction that L2 makes about its argument. hierarchy as long as the partial structures of the decreasing line of labels Since the l4-structure, roughly, is the following:



the PP-representation can also modify the l5-structure therefore. This is as desired.lCorresponding to this we complete the algorithm of the last section by incorporation of a fourth disambiguation subroutine CHOOSE-FIRST(ORD,L1,C) , which strips a condition *first(l2,l3)* from ORD and either incorporates L3 in the FSET of L2 and adds a *first(lx,l3)* condition to the Oset of L2, where Lx is a the rightmost functor of L2 or does nothing except to stripping off the *first*-statement from ORD.

We conclude this section by the FUDRS of the DP of (97.b) and illustrations of the different disambiguations as made possible by *first*-statements:
(97.b$_{rep}$)

dpsem_l l: [ ]

{t1: λL1 . die(L1), l2:alt(L3),
t2: λL4 . l5:und(L4,l6:frauen(χ)),
t3: λL7 . l8:und(L7,l9:kinder(ξ)),
l10:aus(tirol(y),L11)}

{l2 $\leq$ t1, t2 $\leq$ t3, t3 $\leq$ l10, first(t2,t3), first(t3,l10)}

$l4_x$:männer(x)

The representation makes use of a formal extension: Fset contains structures of the *sem_t*-type. Without spelling out the technical details, we assume a corresponding definition of the *labelled structure (label_s)* which is slightly extended and which accepts labelled *sem_t*-typed structures as functors of the Fset. Assume the corresponding canonical extention of *first*. We will say that the relation literal *first(t1,tl2)*, where t1 is the label of a *sem_t*-structure and tl2 the label of a *sem_t*- or a *label_s*-structure, allows the disambiguation routine to apply the tl2-structure to the structure in the scope of the lambda operator(s) of T1 directly, or to the internal arguments of this structure, as described above. Application of a *sem_t*-structure to a predecessor, of course, means unifying the predecessor to the lambda variable and stripping off the corresponding lambda operator.

Provided these interpreting extensions, one easily figures out that $(97.b_{rep})$ subsumes the readings that can be specified as follows (as usual the brackets denote scope):

Linearization: l4 $\leq$ l2 $\leq$ t1 $\leq$ t2 $\leq$ (t3 apply l10) $\Rightarrow$
(die (alten Männer)) und (Frauen) und (Kinder aus Tirol).
Linearization: l4 $\leq$ l2 $\leq$ t1 $\leq$ ((t2 apply t3) apply l10) $\Rightarrow$
(die (alten Männer)) und ((Frauen und Kinder) aus Tirol).
Linearization: l4 $\leq$ t2 $\leq$ l2 $\leq$ t1 $\leq$ (t3 apply l10) $\Rightarrow$
(die (alten (Männer und Frauen))) und (Kinder aus Tirol).
Linearization: l4 $\leq$ l2 $\leq$ t2 $\leq$ (t3 apply l10) $\leq$ t1 $\Rightarrow$
die ((alten Männer) und Frauen und Kinder aus Tirol)).
Linearization: l4 $\leq$ t2 $\leq$ l2 $\leq$ (t3 apply l10) $\leq$ t1 $\Rightarrow$
die (((alten (Männer und Frauen)) und (Kinder aus Tirol)).
Linearization: l4 $\leq$ t2 $\leq$ t3 $\leq$ l2 $\leq$ l10 $\leq$ t1 $\Rightarrow$
die (((alten (Männer und Frauen und Kinder)) aus Tirol)).
Linearization: l4 $\leq$ t2 $\leq$ t3 $\leq$ l10 $\leq$ l2 $\leq$ t1 $\Rightarrow$
die (alten ((Männer und Frauen und Kinder) aus Tirol).

In the assumed linearizations of the particular disambiguations, *apply* means that the the *first* statement is indeed realized, where the modifier is not applied to the predecessor as such however, but to its maximal instantiated substructure.

The combinatorial properties of the Oset-constraints would allow even more than the sketched disambiguations However, readings where the scope of left and right modifiers overlapp but do not include each other aren't admissible. This means that the following reading cannot be computed:

die ((alten ⟨Männer und ({Frauen⟩) und Kinder}aus Tirol)).

where *Frauen* is in the scope of *alt* and *aus Tirol*, though *alt*-and its scope structure is not in the scope of the *aus Tirol*-structure, and vice versa. This restriction is confirmed by the data

Note that we do not get readings where the determiner is distributed over the different NPs (die alten Männer und die Frauen ...). For these readings and others that are the result of such procedures, if possible at all, we assume the necessity of syntactic restructuring. Notice also that the different readings listed require different readings of *Frauen* und *Kinder* as bare plural-DPs on the one hand or as NPs on the other. Also, different deep analyses of coordination (as DP and as NP-coordination) and of the PP (as DP or as NP-modifier) are required. All this comes with the definitions of the corresponding lexical items and their functional results, as suggested in the sections 3.5, 3.7.2, 3.8.

5.3 Model theory

DRSs are interpreted in sets of worlds W, where a world is a structure:

w := ⟨D^*, SindR, SdepR⟩

with

D^*	:= the domain,	which is structured as a semi-lattice over D, where
D	:= Ind ∪ Rp ∪ Temp ∪ Loc ∪ Sit	
		the set of atoms of the domain consisting of:
Ind	:= { a, b, c, ... }	the set of individuals
Rp	:= DR ∪ pDR	the set of representations consisting of:
DR	:= { K1,K2, ... }	the set of DRSs
pDR	:= { λ⟨x⟩.K1, λ⟨y1,y2,...⟩.K2,... }	
		the set of partial DRSs
Temp	:= { t1,t2, ... }	the set of times
Loc	:= { l1,l2, ... }	the set of places (of different dimensionality)
Sit	:= E ∪ P ∪ S	the set of situations consisting of:
E	:= { e1, e2, ... }	the set of events (proper)
P	:= { p1, p2, ... }	the set of processes
S	:= { s1, s2, ... }	the set of states, with
S_{st}	:= { st1, st2, ... }	the subset of situations proper
		(denoting the set of the cartesian space-time regions)

SindR := a set of relations containing spatial, temporal, spatio-temporal relations (ST_{rel}), which includes:

IR :={ b, m, o, s, d, f, id, fi, di, si, oi, mi, bi ...}
the set of (Allen's) interval relations
(which is a subset of the temporal relations),
and which includes

temp := the temporal trace that maps situations to their temporal projection
loc := the spatial trace that maps situations onto their spatial projection
$\oplus$:= the sum formation over the elements of D^*
$\leq$:= the corresponding partial order
$\in_i$:= the subset of $\leq$, where the left argument is an atom
sim := the similarity relation over Rp
(in interpretations, the relations of SindR will be the values of the relation symbols of the DR-language which can be interpreted independently of the considered situation)
SdepR := a set of additional relations
(in interpretations, the relations of SdepR are the values of the relation symbols
whose interpretation depends on the considered situation,
i.e., the SdepR-symbols and the SindR-symbols are disjoint).

In addition, the considered worlds fulfill the following structural criteria:

$\langle D^*,\oplus\rangle$ is an atomic semi-lattice, where D is the set of atoms,
$\langle$Temp,IR$\rangle$ is an interval structure
such that there is a ST_{rel} isomorphism TS (for *time-space*) from S_{st} onto Temp $\otimes$ Loc, i.e.,
$\langle S_{st},ST_{rel}\rangle \cong \langle TS(S_{st}),ST_{rel}\rangle$.

Besides this, we assume that the worlds satisfy to a set of additional axioms which reflect common knowledge about worlds. Since such detail structuring is of minor interest here, we omit working out the model theory in this respect (compare for instance the axioms about the interdependencies of temporal relations, path descriptions, sum formation etc. as listed in [Eberle(1991a)], or the axioms for spatio-temporal reasoning of [Asher et al.(1995)]).

A model M for interpreting a DRS K is a structure:

$M := \langle W, RC, \{F'_w | w \in W\}\rangle$

where

W is a set of worlds (which share the atoms of the domain except Sit), and where
RC is a suitable reachability relation over the worlds of W (indexed by situations),

and where
$\{F'_w | \ w \in W\}$
is a set of interpretation functions, where
F'_w is a function from the situations proper (S_{st}) of the world w
into a function of relation symbols into the relations of SdepR $\cup$ SindR,
i.e., into specific sets of objects or sets of tuples of elements of D^*
(depending on the arity of the relation symbol).
Because, up to isomorphism, the worlds share the set of situations proper, S_{st},
instead of $F'_w(st)$, we can write $F_{w,st}$ and
instead of the different $S_{st,w}$ we can therefore assume the one S_{st}.

The models satisfy to the following homogeneity constraints:

- For all relation symbols R with $F_{w,st}(R) \in SindR_w$ for some st $\in S_{st}$,
  it holds that $F_{w,st'}(R)=F_{w,st''}(R)$ for all st',st" $\in S_{st}$.

Therefore, for such relations, we also write $F_w(R)$ instead of $F_{w,st}(R)$.

- For all relation symbols R with $F_{w,st}(R) \in SdepR_w$ for some st $\in S_{st}$,
  it holds that $F_{w,st'}(R)=F_{w,st''}(R)$ for all st',st" $\in S_{st}$ with temp(st')=temp(st"),
  and
  it holds that for all st, st' $\in S_{st}$ with temp(st) $\subseteq$ temp(st')
  and $\langle x_1,\ldots,x_n\rangle \in F_{w,st'}(R)$
  it follows that $\langle x_1,\ldots,x_n\rangle \in F_{w,st}(R)$.

This says that the SdepR-relations, i.e., the relations which are said to depend on the evaluating situation, really are dependent on the time of the situation only. Their extension does not vary with respect to the spatial parameter. In addition, these SdepR-relations are homogeneous with respect to the time parameter, or, to be precise, for t' $\subseteq$ t and $R_t(x_1,\ldots,x_n)$ with $R_t = F_{w,st}(R)$ and temp(st)=t, there is a $R_{t'} \in SdepR_w$ with $R_{t'} = F_{w,st'}(R)$ and temp(st')=t' for some st' and such that $R_{t'}(x_1,\ldots,x_n)$. Note that the setting assumes that there are no SindR-symbols and SdepR-symbols that are mapped onto the same extension. We think that this is justified having in mind what the symbols of the two classes should stand for.

We say that a DRS K is true in a world w at a situation st of a model M under a variable assignment f,
$M_{w,st,f} \models K$,
iff

1) for each x $\in$ U(K): f(x) $\in$ D and f(x) is 'known' in st, i.e.,
   f(x) $\subseteq^l_t$ loc(st) for some t $\subseteq$ temp(st) (i.e., *at t f(x) is spatially contained within loc(st)*)
   for each X $\in$ U(K): f(X) $\in D^+$ and f(X) is 'known' in st (where $D^+=D^*$-D),
   for each $\chi \in$ U(K): f(χ) $\in D^*$ and f(χ) is 'known' in st,

for each P $\in$ U(K): f(P) $\in$pDR and anchored according to f
for each free predicate variable '?' of C(K): f(?) $\in$pDR and anchored according to f,
where, for a representation Rep $\in$Rp *anchored according to f* means that its free variables are in the domain of f and are interpreted according to f, we write Rep$\langle$f$\rangle$in this case,

2) for each R(x1,...,xn) $\in$ C(K) with R a SindR-relation symbol: $\langle$f(x1),...,f(xn)$\rangle \in F_w$(R),
for each R(x1,...,xn) $\in$ C(K) with R a SdepR-relation symbol: $\langle$f(x1),...,f(xn)$\rangle \in F_{w,st}$(R),
for each R(x1,...,xn, λy.Q(y)) $\in$ C(K) with R a SdepR-relation symbol:
$\langle$f(x1),...,f(xn), λy.Q(y)$\langle$f$\rangle\rangle \in F_{w,st}$(R),
(this interprets the *aspect relational predications* of section 3.6.2;
we do not think that the complementary case of SindR-relations is relevant and therefore omit it;
and correspondingly in the following:)
for each P= λx.K1 $\in$ C(K) with P a SdepR-relation symbol: sim_w(f(P)$\langle$f$\rangle$, λx.K1$\langle$f$\rangle$)
(where 'similarity' (sim) is as defined further below),
for each ?(x) $\in$ C(K):
there is an extension g of f onto U(f(?)$\langle$f$\rangle$(x)) (formally: g $\supseteq_{K1}$ f, where K1=f(?)$\langle$f$\rangle$(x)) such that $M_{w,st,g} \models$ f(?)$\langle$f$\rangle$(x)

3) for each K1 $\langle^{jed}_{x}\rangle$ K2 $\in$ C(K):
for each extension g of f onto U(K1) (g $\supseteq_{K1}$ f) with $M_{w,st,g} \models$ K1 there is h with h $\supseteq_{K2}$ g such that $M_{w,st,h} \models$ K2,
for each K1 $\langle^{QU}_{x}\rangle$ K2 $\in$ C(K) where QU a *numb_def*-quantifier:
it holds that $\langle${i | exists g $\supseteq_{K1}$ f with g(x)=i $\wedge$ $M_{w,st,g} \models$ K1}, {i | exists g $\supseteq_{K1\,\cup\,K2}$ f with g(x)=i $\wedge$ $M_{w,st,g} \models$ K1 $\cup$ K2}$\rangle \in F_w$(QU),

4) for each $\neg$:K1 $\in$ C(K): there is no g $\supseteq_{K1}$ f, such that $M_{w,st,g} \models$ K1,

5) for each K1 $\vee$ K2 $\in$ C(K): there is a g $\supseteq_{K1}$ f, such that $M_{w,st,g} \models$ K1 or there is a g $\supseteq_{K2}$ f, such that $M_{w,st,g} \models$ K2,

6) for each condition p:K1 $\in$ C(K): f(p) is a DRS K' with sim_w(K',K1$\langle$f$\rangle$)

7) for each condition s:K1 $\in$ C(K): there is an embedding function g, with g $\supseteq_{K1}$ f, such that
$M_{w,f(s),g} \models$ K1,
for each condition s:p $\in$ C(K): there is an embedding function g, with g $\supseteq_{f(p)}$ f, such that
$M_{w,f(s),g} \models$ f(p),

8) for each condition ◇mögl:p ∈ C(K): there is an embedding function g, with g $\supseteq_{f(p)}$ f, and a w' which is reachable from w at st (i.e.: R(w,st,w')) such that $M_{w',st,g} \models$ f(p),

9) for each condition X = Σ x K1 ∈ C(K): it holds that f(X) = sup $_\leq$ {i | exists g $\supseteq_{K1}$ f with g(x) = i ∧ $M_{w,st,g} \models$ K1,

10) for each condition s = AO e K1 ∈ C(K), where AO an aspect operator (i.e., *prog, ingr, iter, perf, max*): f(s) ∈AO_w({{e' | exists g $\supseteq_{K1}$ f with g(e) = e' ∧ $M_{w',st,g} \models$ K1}| w' ∈W})

This definition of truth of a DRS K in a model M is not complete with respect to the types of conditions as introduced in section 3. The basics are given by a rather canonical extrapolation of the common extensional case of DRT-model theory, which introduces the modal and temporal splitting of the interpreting world (see [Kamp/Reyle(1993)]).

- Definition 1) makes clear what is meant by *a DRF is known in an interpreting situation*: it must have been at the place of the situation at some time of the situation. Besides this, the interpretation of the DRFs for individuals, for sums and for individuals or sums follows the common interpretation of these formal means (compare [Link(1983)], [Kamp/Reyle(1993)]). Predicate variables which are introduced as DRFs by the universe of the DRS are interpreted as representations, i.e. structured objects of a specific class of the w-domain. According to 1), the meta-variables '?' of a DRS K (which we have introduced in section 2.7.2 in order to define the non-specific *saturation* of a quantifier) are interpreted as some predicative representation. Note that this identification is done for all such variables of a DRS K by the variable assignment of the K-interpretation. In particular, this means that '?'-variables of embedded DRSs K1 are interpreted before considering extensions of the interpretation to interpretations of K1. Without this, the model theory would fail to render the intuitive quantifier saturation, because then the interpretation of the '?' of the nuclear scope could vary in dependence on the interpretation of the restrictor. Also, in the presence of other operators (negation, above all) the model theory would fail to reflect the intuitions. In the end, the interpretation chosen will correspond to interpret the variable as a presupposition trigger asking for wide scope accommodation.

- Definition 2) lists the different cases of relation statements. Note that we interpret the aspect variables of the relations as representations. Since representations will be said to correspond if and only if they describe the same information state, one can say that the qualification *klein(I, λx. P(x))* means that I is *klein* in the **sense** of P (i.e., according to its intension), not with respect to the extension of P. The equality of predicates (which we have introduced for identifying such aspects amongst other things) is interpreted in accordance with this sense of intensionality also.

- Definition 3) presents the common interpretation of universal quantification (relativized to worlds and situations) and of the (other) types of quantification that we have called *number defined* quantification. We have omitted to try definitions of the more complex quantifiers.

- Definitions 4) and 5) follow the common interpretation of negation and disjunction omitting (as is common also) to discuss the problems of reference connected to this disjunction modeling.

- Definition 6) treats the condition type of describing a proposition variable p by a DRS K. Our models provide DRSs as objects of the domain. Therefore, assigning p to a DRS is no problem. But what is *similarity of DRSs K and K'?*:
  We call DRSs K and K' of the domain of a world w similar in w iff they share the same set of free variables and the same anchor, which interprets these variables and if the information state which is described by K1, i.e., $\{\langle$M,w,st,g$\rangle|$ where M model, w world of M, st situation proper of M and g variable assignment with g $\supseteq_{K1}$ f, for f the anchor of K1 and $M_{w,st,g} \models$ K1$\}$, is identical to the information state described by K2, i.e., $\{\langle$M,w,st,g$\rangle|$ where M model, g $\supseteq_{K1}$ f and $M_{w,st,g} \models$ K2$\}$. This definition picks up the interpretation of belief states as information states as suggested in [Kamp(1995b)], and uses it in order to obtain a more precise characterization than can be obtained by the common proposition logical interpretation of propositions as sets of worlds.[2] Without spelling it out, we assume the canonical extension of this definition of similarity to the case of partial DRSs.

- Definition 7) treats situational relativization in the spirit of classical tense logic: The evaluation is shifted to the time of the characterizing situation. Note that the spatial parameter plays the rather restricted role of claiming the objects of the universe to be at the location of the situation at least once at a time of the occurrence time of the situation.

- Definition 8) reflects just one case (the simplest one) of modal embedding. Note that *possibility* is interpreted as *possibility at a certain time*. This, to our opinion, is legitimated by the fact that *es war möglich, daß er am 12. kommen würde* and *es ist möglich, daß er am 12. kommt* may have different truth values even if the twelth is in the future of the speech time. *Necessity* would be defined in close correspondence to this (by stipulating that all worlds

[2] The definition traces back to and is inspired by the approaches of [Asher(1986)] and [Eberle(1988)] also.

reachable at st satisfy to the argument proposition), and *likelihood* by some ratio between the set of worlds, reachable at st, and the subset of the worlds which are reachable at st and which satisfy to the argument proposition.

- Definition 9) interprets sum formation.

- Definition 10) interprets the aspectual operations. It assumes that the model provides aspect operator PROG, PERF, INGR, ITER, MAX which, applied to the intension of an event description, output the corresponding progressive state description, result state description etc. (for an early suggestion of aspect operators which has inspired the approach here, see [Galton(1984)]). We must omit presenting axioms that characterize the functionality of these operators.

As said, the definitions leave out a number of the considered condition types. Here, some comments must suffice about the kinds of extension we can think of:

- In section 3.9.2, we have introduced the deontic operator $\langle \text{kann} \rangle$. For its interpretation and for the interpretation of the other deontic operators, we assume the models to be extended by a second reachability relation over the set of worlds such that, the meaning of the deontic operators can be modeled in close parallel to the modal operators.

- For attitudinal state descriptions, we assume interpretations as suggested in [Kamp(1995b)], i.e., as a relation between an individual and an information state (in case of the description of a belief—where the interpretation of the *internal anchors* defines a stable kernel of the variable assignments of the information state), or as a relation between an individual and a characteristic extension of a presupposed information state (in case of reported intentions—which build on the presupposed beliefs of the individual, or in case of the similar desires of the individual). In section 3.9.2, using the example of *glauben*, we have sketched how our representation of attitudinal verbs should relate to the representation of attitudinal states: the description of the propositional role of the verb representation should be part of the description of the belief, intention, desire (depending on the verb) of the simultaneous attitudinal state which is attributed to the individual in question. Under this axiomatic setting, the attitudinal verb is interpreted as an event (or state respectively) which is related to an individual i and a structured object, a DRS K, by its thematic roles such that the belief, intention, desire described by K is part of the belief, intention, desire that is assigned to i in the considered situation st; i.e., the information state described by K approximates (that is, is less informative than) the corresponding belief, intention, desire of i at st.

- With regard to the perspectival relativizations as introduced in section 3.8, we assume interpretations which reduce the case to the case of assigning attitudes to individuals. That is, we assume that the relativization of a statement p to the perspective of some individual i should be equivalent to saying that i *believes* p. Thus, the interpretation function will map a thus relativized statement onto the relation of an individual and a belief state.

- Similarly, some of the aspectual relativizations (as introduced in section 3.8 also) can be reduced to the case of an already interpretable statement (to the case of the *aspect relational* predication as dealt with above in definition 2). However, for the remaining relativizations, which are those where the embedded representation does not show a (presuppositional) aspect argument that could be resolved to the aspect operator at present, we don't see a simple and natural interpretation that could extend our setting suitably.

Chapter 6

Concluding Remarks

We have spelled out a representation formalism on the basis of DRT which provides compact semantic representations for lexical , structural and presuppositional ambiguities and for the representation of ambiguous elliptical structures. The representation of lexical ambiguities includes the ambiguity between collective and distributive readings of quantifiers and the ambiguity between referential and attributive readings of (definite) descriptions. The representation of structural amiguities concerns the ambiguity which arises from the different possibilities of relating the scope bearing substructures of the sentence to each other, including the so-called attachment ambiguity and the functional ambiguity which is connected to it. Representation of presuppositional ambiguity includes the representation of nominal referential terms, introduction and administration of an inventory of temporal parameters connected to the events of the new sentence and to the representation of the preceding text and the representation of propositional presupposition. Ellipsis has been treated as a particular case of presupposition, in which the elided structure, as a kind of zero-VP-anaphor, relates to a VP-antecedent; thus the ellipsis can be reconstructed as a representation which is isomorphic to its antecedent with the semantic function of the constituents of the ellipsis corresponding to the function of their counterparts in the structure which contains the antecedent. Representation of these types of ambiguities is made possible by a number of new conditions which extend the common DRT-condition-inventory – in particular, by specific conditions for presuppositional terms and expressions, by a UDRT-like partitioning of the sentence information into partial representations which are connected to each other by ordering relations and by the use of functional representation terms which map (disambiguating) contexts (viz. the corresponding representation) onto DRT-conditions or DRSs (depending on the type of the functional term).

Partial representations are decorated by information from the syntax-semantics interface. This information is used for constraining semantic composition and making it independent of information from non-semantic representation layers. As a consequence it is possible to relate the formalism to a wide range of syntactic theories and parsing strategies simply by defining (relatively) lean interfaces which translate specific syntactic vocabularies into the coarse-grained vocabulary of the decoration structures and which specify which information of an underlying syntactic analyis is represented where and how in the decoration of the corresponding partial representations. This means that the decoration is an API or can be used as an API which makes it very easy to put the formalism on top of a syntactic analysis system and to define a corresponding semantic component for this system. The decoration-information is organized in index structures which center relevant syntactic and semantic (type) information around so-called distinguished discourse referents; these are the discourse referents which the corresponding structure introduces (in its so-called bottom representation), or which it provides for the purpose of their being taken up by its semantic argument(s) or by the structure which applies to it.

There are several advantages connected to the use of distinguished discourse referents and indices. Firstly, they are very helpful for stating the conditions which govern the correct instantiation of the arguments of predicates (i.e. which effectuate *linking* with respect to subcategorization and modification). Secondly, they can be used for anchoring information about the corresponding DRFs which results from compositional processes and which may depend on the shape of the respective partial representation. We have made use of this feature when we sketched how an Aktionsart calculus may accompany the V-projection line. Thirdly, the distinguished DRFs are very helpful with respect to representing ambiguity phenomena which arise in connection with collective and distributive readings of quantifiers. Amongst other things they make it possible to obtain compositional representations of cumulative readings. [1] Also, they make it easy to represent some puzzling phenomena which arise in connection with interpreting tense information with respect to quantificational structures (see 3.11 for this).

On the basis of these formal means, we partitioned most of the word classes into subclasses so that the members of these classes could obtain similar representations with respect to the condition types of the formalism and we gave representations for representatives of those classes which included the representation of focussing and quantifying modifiers, of the modal, temporal or other embeddings (or 'relativizations' produced by 'operator-like' words and structures), like the copula *sein*, modal verbs, adverbs, adjectives, relativizing prepositional phrases, etc. Composition rules were defined for the fragment of German as is described by the phrases obtainable from these classes, which included outlining the computation of intersentential discourse and temporal relations.

We have suggested a two-level interpretation for the representations of this fragment according to which the meaning of a flat underspecified representation of a sentence or text is the set of meanings of its DRS-disambiguations, where the meaning of a DRS is the set of models which satisfy the DRS and where a model consists of

[1] We could only indicate this in this book. But compare [Eberle(1998)] where, using distinguished discourse referent and abstraction of discourse referents from duplex condition , such readings are generated.

a set of worlds with a distinguished actual world. The set of disambiguations of a flat underspecified representation is obtained by applying the so-called disambiguation routine to it, which, among other things, applies the partial representations of the FUDRS to each other according to the given ordering constraints and it evaluates the flat representations (i.e. the conditions which use multivalued functions) according to the (remaining possibilities of the) definition of the corresponding functions. A relevant feature of this algorithm is that it keeps track of the disambiguations effectuated so that, in the presence of a disambiguation task where information is lacking which could definitely decide about the correct choice, it can test whether there has been a similar task before. If the answer is yes, meaning that there has been diambiguation of an isomorphic representation in a similar context before, the type of disambiguation must be the same as before. In this way we prevent that ambiguity leads to a simple (and false) disjunctive interpretation.

The formalism and its interpretation make it possible to correctly represent and interpret a number of well-known puzzling linguistic phenomena, including quantificational phenomena like narrow scope quantification of de re referential expressions and underspecification of scope, distributive, collective or cumulative reading in the presence of several scope bearing elements, attachment ambiguities in complex (coordinated) structures, aspectual and Aktionsart phenomena in quantificational structures and the representation of elliptical structures with pronouns and scope ambiguities.

Disambiguation of FUDRs is a stepwise process which translates FUDRSs into FUDRSs. Note that, with respect to a text, the representation is disambiguated only as far as single disambiguations are justified by contextual information. The case of total disambiguation (via completed runs of the disambiguation routine) is reserved to evaluating a representation in a model or for other purposes which assume common, disambiguated DRSs. Note also that implementations are recommended which make disambiguation steps dependent on triggering conditions.

Contextually triggered variable depth of analysis is especially useful in connection with applications like Machine Translation systems (compare [Kay et al.(1994)]). Normally, translation should preserve ambiguity: It shouldn't either overspecify or underspecify the meaning of the source text. Elsewhere we have explained in detail why we think that FUDRSs are particularly suited as input and output of the transfer component of a Machine Translation system (compare [Eberle(2001b), Eberle(2001a)]). In short, the reasons are, firstly, that transfer on semantic structures is simpler than transfer on syntactic structures. Secondly, FUDRSs can precisely reflect the degree of evaluation which is appropriate with respect to a particular context. Thirdly, if ambiguity preserving translation is not possible (because there are no logically equivalent translations of the source words), cautious additional disambiguation can be triggered (and guided by the translational needs, i.e. by the information from the bilingual lexicon) so that the resulting refinement satisfies the conditions about the source which the bilingual lexicon assumes for the specific translation equivalent(s) considered. Note that the refined structure is of the same type as the original structure (it is a FUDRS), i.e. it remains in the domain of transfer. We think that this is an advantage of this type of transfer when compared to approaches which formulate transfer for other levels of representation, for example for the level of functional description as in [Kaplan et al.(1989)]. Currently, FUDRSs (or, to be precise, compact data structures which correspond to FUDRSs) define the level of transfer of some of the systems of the *Personal Translator* product line of *linguatec* Entwicklung & Services (which, with respect to the architectural basis traces back to IBM's LMT-system, cf. [McCord(1989)]).

An additional positive feature of the formalism is that it promises to be very useful in the area of generating controlled language from arbitary natural language input (and using it for translation), because it makes it possible to keep the partial representations and the information about application constraints separate so that the partial representations closely correspond to syntactic structures while they are at the same time equipped with semantic information and, through the decorations which encode this information from the syntax-semantics-interface. Because of this, there are a number of restructuring schemata (of the sort typically stipulated by language control) which can be expressed by meaning postulates for the more abstract logical level of FUDRS (compare [Eberle(2003b)] for this). So the process of controlling text can be seen as one of translating text into text via transfer at the level of FUDRS.

Besides these applications, we see four main lines for further research and development. Firstly, the fragment must be enlarged. This means elaborating the representation schemata that have been given for representatives of the different word classes, adding representations for other members of these classes, contrastively relating such representations to each other (elaborating them further) and adding representatives of classes (subclasses) which are missing until now, primarily for so-called *discourse particles* which are very relevant with respect to text coherence and which can help determining the discourse relations between the different textual parts (for a recent contribution in this respect compare [Zeevat(2000), Zeevat(2003)]).

When compared to DRT as formulated in [Kamp/Reyle(1993)] and UDRT as introduced in [Reyle(1993b)], the DRSs which the disambiguation routine can compute from FUDRSs can contain conditions which are new with respect to these formalisms. This means that, besides the means for underspecification, FUDRT is more expressive than these formalisms. We have sketched interpretation of these new types of condition, which mainly concern the representation of attitudinal states of author and recipient and the 'relativization' of propositions to situations and perspectives, nevertheless we haven't said anything to how a DRT-calculus could be extended to catch at least some of the consequences which, semantically, can be inferred from DRSs which use such conditions. Next to investigating ways to designing corresponding DRS-calculi which incorporate (some of) the new condition types and to optimizing them with respect to balancing the additional expressivity against tractability, it must be investigated how UDRT-logic (cf. [Reyle(1993b)]) which can deal with a restricted set of the scope underspecification phenomena can be extended to a 'logic of underspecification' wich includes (a relevant subset of) the additional underspecification phenomena (wichconcern lexical, functional and presuppositional ambiguity).

As a prerequisite of this, thirdly, it must be investigated how information wich can constrain the routines of the different types of disambigation can be propagated effectively so that an interleaved architecture of the disambiguation modules becomes possible. As a starting point, in [Eberle(2003a)] we have tried to sketch a pronoun resolution component for underspecified structures which uses a syntactic and a semantic filter, where the latter uses DRT-accessibility knowledge as is available for the different partial representations and semantic type information about selectional restrictions as can be propagated within and across the different partial representations without knowing details about scoping. (For instance, selectional restrictions about the complements of a head can be propagated, using the distinguished discourse referents of the complements, without either knowing the scope order or the internal structure of the complements with respect to the collective/distributive-distinction). A very relevant feature of this approach is that the choice of an antecedent for a pronoun, which is justified by such information, can alter this information and, therefore, can constrain the other disambiguation modules, in particular the structural disambiguation. This is because for a discourse referent to be chosen as antecedent it is sufficient to know that it is not inaccessible from the pronoun, if it is chosen, it must be (explicitly) accessible however. This means that the FUDRS must allow that the partial representation which introduces the antecedent takes scope over the partial representation of the pronoun. If the choice is made, the order constraints of the FUDRS are extended correspondingly (so that additional consequences for disambiguation may result from this).

Most suggestions for pronoun resolution components use weighting in one way or another, because normally the filters aren't precise enough (and, as it seems, cannot be precise enough in principle) to single out just one discourse referent from the discourse universe as possible antecedent, where, often, the weights of distribution patterns like fronting position, subject position etc. are obtained from data by statistical training, with very encouraging results (for an overview of systems and the relevance of statistics in pronoun resolution, see [Mitkov(1999)]). With respect to the other types of disambiguation, weighting of alternatives on the basis of analyzed corpora seems to be similarly promising. Therefore, as a fourth line of future research, it must be investigated how the approach can be extended so that it can incorporate statistical knowledge from corpora and use it for disambiguation: The theory must be developed further so that it includes a hybrid model of disambiguation.

Appendix A

The semantic fragment in attribute value notation—explication of partial flat underspecified DRSs in AVM

In the following we compile the definitions that we have introduced in the preceding sections and, if not yet done, translate them in an attribute value notation. Here, we relate to the AVM representation style of [Pollard/Sag(1994)]. In addition, we present the declarations as in the appendix of this book, i.e., classified into partitions and feature declarations of the (primitive) sort hierarchy (section A.1) and subsumption constraints for relevant (non primitive) sort expressions (section A.2), which in [Pollard/Sag(1994)] are the principles and schemata. The aim is to show that the semantics of this paper easily can be made available for a HPSG grammar. Therefore, the spelling out of the semantics principles in section A.2 will relate to the principles of HPSG, i.e., section A.2 formulates a part of the syntax semantics interface: the part that treats the composition of the representation from the representations of the lexical items. In section A.3 we describe the second part of the syntax semantics interface: the integration of the semantics in the lexicon.

We repeat what we have said in the introduction that the design of the semantics aspires to independence of specific grammar formalisms. This presupposes a certain disintegration of the representation of syntactic and semantic information. Partly this is realized in that categorial or syntactic information that is relevant to the semantic processing is made part of (the decoration of) the semantic representation in a format that is independent of the terminology of a specific grammar formalism. Since our representations distinguish presuppositions from assertions and allow for describing scopal relations with more expressivity than the quantifier storage mechanism of HPSG does, we can give up the HPSG specific distributed representation of semantic information via CONTEXT, CONTENT, QSTORE, RETRIEVED. Section A.2 does this simplification and, together with section A.3, where among other things the translation of categorial information into the semantic decoration is specified, it exemplifies the minimization of the syntax semantics interface that results from this setting. The assumption is that the properties of our semantics allow for similar minimization of the syntax semantics interface with respect to other grammar formalisms also and, thus, for easy portability.

The AVM description to follow of our semantic fragment is also the documentation of a CUF implementation of the semantics fragment which has been done at the IMS in Stuttgart.

A.1 The sort hierarchy

A.1.1 Partitions

We use '|' for the exclusive 'or'. We use ';' for the not necessarily exclusive 'or'. [1] In addition to the formal means of [Pollard/Sag(1994)], we accept the sort subsumption symbol ' < ' in order to define the sort signature. We can understand this means as a defined extension of the HPSG-language expressivity: replace formulas 'S1 < S2' by 'S2 = S1 | ˜S1', where '˜' is some prefix that signals (local) negation. We also use the sort intersection symbol '&'. Some similar reflexions show the reducibility of this extension too (for the restricted use that we make of it).

The following equations essentially summarize the structuring of the sort symbols, as stipulated in the sections 2.8, 3.1, adding isolated statements of the other sections of §3 and further completing sortal information.

[1] In a number of grammar formalisms the closed world assumption guides the interpretation of expressions. If we want to be neutral about this alternative, in case where we assume that there may be a common subsort of sorts A and B, with 'A ; B', we can explicitly introduce such a subsort (even if not needed by the declarations). Then, under both interpretation assumptions the sort hierarchy that is defined structures a considered domain in the same way (except minor irrelevant atomic sort details). We skip completing the hierarchy in this respect, however.

sem_entity	=	sem_types | list.
sem_types	=	sem_t | label_s | ind |
		ref | cati | cat_abbr | akt | mood | tlevel | diathesis |
		dm_sort | th_role | role_type | role_spec | mod_spec |
		prtcl_info |
		pdrs | cond | descr | qu_type | facet | ord | s_ord | ref_op |
		rel_constant |
		yn.
sem_t	=	detorquant_t | xtype_t | mod_xtype_t |
		compssem_t | rltvzd_vpsem_t | prepsem_t |
		relpro_t | rltvzr_t | complementizer_t |
		funcmod_t | coord_t | subord_t.
% rltvzr_t corresponds to the HPSG-null relativizer and		
% rltvzd_vpsem_t to the result of applying it to a relative pronoun and a VP		
detorquant_t	=	detsem_t | quantop_t.
xtype_t	=	itype_t | etype_t.
etype_t	=	vpsem_t | ssem_t.
itype_t	=	npsem_t | dpsem_t.
npsem_t	=	basicnpsem_t | structnpsem_t.
nsem_t	<	basicnpsem_t
vpsem_t	=	basicvpsem_t | structvpsem_t.
basicvpsem_t	>	vsem_t | cop_t .
nsatvpsem_t	>	vsem_t | cop_t .
vpsem_t	=	satvpsem_t | nsatsvpsem_t.
mod_xtype_t	=	mod_itype_t | mod_etype_t.
mod_xtype_t	=	ppsem_t | nppmod_xtype_t.
mod_itype_t	=	mod_npsem_t | mod_dpsem_t.
mod_etype_t	=	mod_vpsem_t | mod_ssem_t.
adv_coord_conj_t	<	mod_vpsem_t
mod_xtype_t	=	rel_mod_t | embop_mod_t.
% we distinguish relational from embedding modifiers.		
embop_mod_t	=	modop_t | nmod_embop_t.
% modal operators are embedding modifiers.		
mod_npsem_t	=	pred_mod_npsem_t | npred_mod_npsem_t.
% license or do not license predicative use.		

funcmod_t	=	quantop_modifier_t | mod_xtype_modifier_t.
mod_xtype_modifier_t	=	mod_npsem_modifier_t | mod_vpsem_modifier_t.
coord_t	=	npcoord_t | dpcoord_t | vpcoord_t.

label_s	=	labelvar | labeldescr.
label_s	=	basic_l | struct_l.
label_s	=	refind_l | nrefind_l.
label_s	=	xtype_l | nxtype_l.

basic_l > nsem_l | vsem_l.
struct_l = pdrs_l | funct_l.
refind_l = qind_l | nqind_l.
qind_l = dpsem_l | qind_ndpsem_l.
xtype_l = etype_l | itype_l.
itype_l = npsem_l | dpsem_l | sat_dpsem_l.
basicnpsem_l = basic_l & npsem_l.
structnpsem_l = struct_l & npsem_l.
nsem_l < basicnpsem_l.
dpsem_l = detpsem_l | qpsem_l.
etype_l = vpsem_l | ssem_l | compssem_l.
basicvpsem_l = basic_l & vpsem_l.
structvpsem_l = struct_l & vpsem_l.
vsem_l < basicvpsem_l.
vpsem_l = satvpsem_l | nsatvpsem_l.

ind = iind | eind.
ind = basic_ind | struct_ind.
ind = sit_ind | obj_ind.
ind = rolespec_ind | norolespec_ind.
eind = vind | structeind.
iind = nind | structiind.
basic_ind = vind | nind.
iind = enomind | obj_ind.
basic_sit_ind = vind | nind & enomind.

ref = basic_ref | comp_ref.
comp_ref = sum_ref | nsum_ref.

cati = nverb | verb.
nverb = noun | prp | prtcl.

case = nom | akk | dat | gen.

cat_abbr = n | es_n | dass_s | binf | inf | fin | ob_s | a | p | ptcl.
% cat_abbr is used in lexical entries
akt = het | hom.
akt = ext | punct.
het = acc | ach.
hom = stative | act.
ext = act | acc | stative.

mood = indi | conj | imp | quest.

tlevel = past | pres | fut.

diathesis = passive | active | res_passive.

This says that the entities used in semantic expressions are lists or elements of lists which can be:
• semantic types proper, labelled structures,
• indices (of labelled structures), referents (of indices),
• categorial information (about the syntactic category), abbreviations of categorial informations (which interface the implementation with (inference) components which stem from the LMT-system–compare [Eberle]),
• descriptions of the Aktionsarten, of mood, of the tense level, of diathesis;
there are:
• domain model sorts (taxonomic world knowledge),
• thematic roles, classifications of these roles, role specifications (which inform about the name of the thematic role, its class and about whether it is obligatory–w.r.t. the verb to which the role specification is assigned),
• modifier specifications (which inform whether a modifier of a functor is an intensifier, or whether it delimits a numeral modification by a least upper bound or a greatest lower bound respectively),
• information about particles (name, Aktionsart-changing power, effectuated sortal shift);
also there are
• partial DRSs, conditions(of these DRSs), descriptions (of the different condition types),
• quantifier types, facets (which correspond to the *aspect*-predicates of §3.6.2,
• ordering statements (of the Osets of labelled structures), sortal subsumption statements,
• operators for referents (like sum formation),
• relation constants (for relations which order labels, or sorts or localizations; where localizations are either temporal or spatial localizations or path descriptions and where the localizations are subclassified into Allen's relations and corresponding relations for the spatial and directional domain)
• and boolian yes/no.

We abstain from informally describing these (structure) types further. For additional information about their meaning and use, see the partitioning into subsorts below, which should helpful; also, we hope that the naming contributes to understand what is meant by the types, and, above all, the feature declarations of the next section.

Note, however, that the structuring of the domain sorts below provides an explicit 0-element (which, mainly, is used for indicating the non-existence of referents in decorations of labelled structures).

```
dm_sort            =   empty | nonempty.
     % The upper structure of the domain sorts
nonempty           =   mass | count.
nonempty           =   natural | cultural.
nonempty           =   material ; temporal ; spatial.
detspatmaterial    <   material.
temporal           =   time | situation.
situation          =   event | process | state.
event              <   count.
process            <   mass.
state              <   mass.
object             <   material & count.
substance          <   material & mass.
animate            <   natural.
animate            =   plant | animal0 | organismpart.
animal0            =   human | animal.
animate            =   masc | fem | neutr.
artifact           <   cultural.
     % Some statements of the lower structure
move               <   situation.
discuss            <   situation & cultural.
institution        <   cultural.
prop               <   cultural.
seat               <   artifact.
city               <   artifact ; institution.
artifact           <   object.
bodypart           <   organismpart.

th_role            =   agent | instr | object | commitative | patient | experiencer | causa_finalis |
                       beneficiary | source | goal | path | theme | theme1 | theme2.
th_role            =   arg1 | arg2 | arg3 | arg4.

role_type          =   const | grad | char.
lmt_role_spec      <   role_spec.

rel_constant       =   ord_rel | sort_rel | loc_rel.
ord_rel            =   less | succ | leq | next | first.
sort_rel           =   subs | notsubs.
loc_rel            =   temp_rel | path_rel | spat_rel.

temp_rel           =   prec | t_ov | follow.
prec               =   before | t_meets.
t_ov               =   t_overlap | t_superseq | t_subset | t_inv_overlap.
follow             =   after | t_inv_meets.
t_superseq         =   t_superset | t_equal.
t_subseq           =   t_subset | t_equal.
t_superset         =   t_isstarted | t_includes | t_isfinished.
t_subset           =   t_starts | during | t_finishes.
```

path_rel	=	p_connected | p_nconnected.
p_connected	=	p_disjends | p_meets | p_ov | p_inv_meets.
p_ov	=	p_overlap | p_superseq | p_subset | p_inv_overlap.
p_superseq	=	p_superset | p_equal.
p_superset	=	p_isstarted | p_includes | p_isfinished.
p_subset	=	p_starts | p_isincluded | p_finishes.
ref_op	=	sum | prog | max | iter | inc.
cond	=	quant_cond | alfa_cond | rel_cond | facet_cond | foc_cond | neg_cond | or_cond | and_cond | s_decr_cond | p_descr_cond | modal_cond | persp_cond | abstrop_cond.
descr	=	quant_descr | modal_descr | facet_descr | persp_descr | rel_descr.
qu_type	=	sg_qu | pl_qu.
qu_type	=	pos_qu | neg_qu.
qu_type	=	incr_qu | decr_qu.
pos_qu	=	exist_qu | numb_qu | univ_qu | numb_def_qu | comp_def_qu.
exist_qu	<	incr_qu.
numb_qu	<	incr_qu.
univ_qu	<	incr_qu.
neg_qu	<	decr_qu.
qu_comp_val	=	empty | number.
det_cond	<	alfa_cond.
alfa_type	=	alfa_pn | alfa_descrp | alfa_pro | alfa_temp | alfa_loc | alfa_sit | alfa_presp.
alfa_descrp	=	alfa_def | alfa_indef.
alfa_temp	=	rt | re | st | pt.
sl	<	alfa_loc.
mod_spec	=	intense | lub | glb. % *very, at most, at least*
yn	=	yes | no.
% Abbreviations:		
result_type	=	labeldescr | sem_t.
ref_type	=	ref | facet | label_s.
reforlabel	=	ref | label_s.
atom_ref	=	basic_ref | nsum_ref.
l_arg	=	ind | facet | label_s.
qnpsem_l	=	npsem_l | qpsem_l.
vnpsem_l	=	vpsem_l | npsem_l.
nsatstructvpsem_t	=	nsatvpsem_t & struct_l.
nsatstructvpsem_l	=	nsatvpsem_l & struct_l.

A.1.2 Feature declarations

sem_t	::	[LAMBDA: list RESULT: result_type].
detsem_t	::	[LAMBDA: ⟨qnpsem_l⟩ RESULT: detpsem_l].
quantop_t	::	[LAMBDA: ⟨npsem_l⟩ RESULT: dpsem_l].
npsem_t	::	[LAMBDA: list(l_arg) RESULT: npsem_l].
nsem_t	::	[RESULT: nsem_l].
dpsem_t	::	[LAMBDA: list(l_arg) RESULT: dpsem_l].
vpsem_t	::	[LAMBDA: list(l_arg) RESULT: vpsem_l].
vsem_t	::	[RESULT: vsem_l].
cop_t	::	[LAMBDA: ⟨itype_l,ind⟩ RESULT: vsem_l].
nsatvpsem_t	::	[LAMBDA: nelist RESULT: nsatvpsem_l].
satvpsem_t	::	[LAMBDA: elist RESULT: satvpsem_l].
prepsem_t	::	[LAMBDA: ⟨dpsem_l,ind⟩ RESULT: xtype_l].
complementizer_t	::	[LAMBDA: ⟨satvpsem_l⟩ RESULT: compssem_l].
relpro_t	::	[LAMBDA: ⟨⟩ RESULT: dpsem_l].
mod_npsem_t	::	[LAMBDA: ⟨npsem_l⟩ RESULT: npsem_l].
mod_dpsem_t	::	[LAMBDA: ⟨dpsem_l⟩ RESULT: dpsem_l].
mod_ssem_t	::	[LAMBDA: ⟨satvpsem_l⟩ RESULT: ssem_l].
mod_vpsem_t	::	[LAMBDA: ⟨vpsem_l⟩ RESULT: vpsem_l].
npcoord_t	::	[LAMBDA: ⟨npsem_l,npsem_l⟩ RESULT: npsem_l].
dpcoord_t	::	[LAMBDA: ⟨dpsem_l,dpsem_l⟩ RESULT: dpsem_l].
vpcoord_t	::	[LAMBDA: ⟨vpsem_l,vpsem_l⟩ RESULT: vpsem_l].
subord_t	::	[LAMBDA: ⟨vpsem_l,vpsem_l⟩ RESULT: vpsem_l].

quantop_modifier_t :: $\left[\begin{array}{ll}\textsc{lambda}: & \langle\text{quantop\_t}\rangle \\ \textsc{result}: & \text{quantop\_t}\end{array}\right]$.

mod_npsem_modifier_t :: $\left[\begin{array}{ll}\textsc{lambda}: & \langle\text{mod\_npsem\_t}\rangle \\ \textsc{result}: & \text{mod\_npsem\_t}\end{array}\right]$.

mod_vpsem_modifier_t :: $\left[\begin{array}{ll}\textsc{lambda}: & \langle\text{mod\_vpsem\_t}\rangle \\ \textsc{result}: & \text{mod\_vpsem\_t}\end{array}\right]$.

label_s :: $\left[\begin{array}{ll}\textsc{rind}: & \text{ind} \\ \textsc{num}: & \text{number}\end{array}\right]$.

basic_l :: $\left[\textsc{drs}: \text{pdrs}\right]$.

% where

% l_χ:DRS $_{\text{L1}}$ abbreviates $^{\text{basic\_l}}\left[\begin{array}{ll}\textsc{rind}: & \chi \\ \textsc{numb}: & l \\ \textsc{drs}: & \text{DRS} \\ \textsc{bot}: & \text{L1}\end{array}\right]$.

struct_l :: $\left[\begin{array}{ll}\textsc{subs}: & \text{list(ord)} \\ \textsc{bot}: & \text{label\_s}\end{array}\right]$.

pdrs_l :: $\left[\textsc{pdrs}: \text{pdrs}\right]$.

% where

% l_χ:DRS $^{\text{Oset}}_{\text{L1}}$ abbreviates $^{\text{pdrs\_l}}\left[\begin{array}{ll}\textsc{rind}: & \chi \\ \textsc{numb}: & l \\ \textsc{pdrs}: & \text{DRS} \\ \textsc{subs}: & \text{Oset} \\ \textsc{bot}: & \text{L1}\end{array}\right]$.

funct_l :: $\left[\textsc{fset}: \text{list(result\_type)}\right]$.

% where

% $l_\chi{:}\boxed{}\begin{array}{l}\text{Fset} \\ \text{Oset} \\ \text{L1}\end{array}$ abbreviates $^{\text{funct\_l}}\left[\begin{array}{ll}\textsc{rind}: & \chi \\ \textsc{numb}: & l \\ \textsc{fset}: & \text{Fset} \\ \textsc{subs}: & \text{Oset} \\ \textsc{bot}: & \text{L1}\end{array}\right]$.

refind_l :: $\left[\textsc{refind}: \text{ind}\right]$.

% where

% $l_{\chi,\psi}$ abbreviates $^{\text{refind\_l}}\left[\begin{array}{ll}\textsc{rind}: & \chi \\ \textsc{refind}: & \psi \\ \textsc{numb}: & l\end{array}\right]$.

qind_l :: $\left[\textsc{lrefind}: \text{ind}\right]$.

% where

% $l_{\xi,\text{X},\chi}$ abbreviates $^{\text{qind\_l}}\left[\begin{array}{ll}\textsc{rind}: & \xi \\ \textsc{refind}: & \text{X} \\ \textsc{lrefind}: & \chi \\ \textsc{numb}: & l\end{array}\right]$.

% Of course $\chi_{\left[\begin{array}{ll}\text{A1}: & \text{V1} \\ \vdots & \\ \text{An}: & \text{Vn}\end{array}\right]}$ abbreviates $^{\text{ind}}\left[\begin{array}{ll}\textsc{ref}: & \chi \\ \text{A1}: & \text{V1} \\ \vdots & \\ \text{An}: & \text{Vn}\end{array}\right]$.

etype_l :: $\left[\textsc{rind}: \text{eind}\right]$.

npsem_l :: $\left[\textsc{rind}: \text{iind}\right]$.

dpsem_l :: $\left[\begin{array}{ll}\textsc{refind}: & \text{iind} \\ \textsc{lrefind}: & \text{iind}\end{array}\right]$.

ind :: $\begin{bmatrix}\text{REF: ref}\\ \text{CATI: cati}\end{bmatrix}$.

rolespec_ind :: [ROLESPEC: role_spec].

iind :: [CATI: nverb].

eind :: [CATI: verb].

sit_ind :: $\begin{bmatrix}\text{AKT: akt}\\ \text{MTV: mtv}\\ \text{RT: ref}\end{bmatrix}$.

basic_sit_ind :: [BASIC_AKT: akt].

ref :: [SORT: dm_sort].

comp_ref :: $\begin{bmatrix}\text{OP: ref\_op}\\ \text{ARG: ref}\end{bmatrix}$.

sum_ref :: $\begin{bmatrix}\text{OP: sum}\\ \text{ARG: ref}\end{bmatrix}$.

noun :: $\begin{bmatrix}\text{CASE: case}\end{bmatrix}$. (% repeats the HPSG setting)

verb :: $\begin{bmatrix}\text{VFORM: vform}\end{bmatrix}$. (% repeats the HPSG setting)

prp :: $\begin{bmatrix}\text{PRPFORM:} & \text{afs}\\ \text{PPCASE:} & \text{case}\end{bmatrix}$. (% revises the HPSG setting by adding case information)

prtcl :: $\begin{bmatrix}\text{PRFORM: afs}\end{bmatrix}$.

role_spec :: $\begin{bmatrix}\text{ROLENAME:} & \text{th\_role}\\ \text{ROLETYPE:} & \text{role\_type}\\ \text{ROLE\_OBL:} & \text{yn}\end{bmatrix}$.

lmt_role_spec :: $\begin{bmatrix}\text{REAL:} & \text{cat\_abbr}\\ \text{ROLESORT:} & \text{dm\_sort}\end{bmatrix}$.

p :: $\begin{bmatrix}\text{PRP:} & \text{afs}\\ \text{PCASE:} & \text{case}\end{bmatrix}$.

ptcl :: $\begin{bmatrix}\text{PTCL: afs}\end{bmatrix}$.

prtcl_info :: $\begin{bmatrix}\text{PRTCL\_NAME:} & \text{top}\\ \text{NEW\_AKT:} & \text{akt}\\ \text{NEW\_SORT:} & \text{dm\_sort}\\ \text{PRTCL\_OBL:} & \text{yn}\end{bmatrix}$.

% in the lexicon, mainly w.r.t. flat
% semantics entries, role_spec - prtcl_info
% specify information about optional roles,
% possible affixes and the like.

mtv :: $\begin{bmatrix}\text{MOOD:} & \text{mood}\\ \text{TENSE:} & \text{tfeat}\\ \text{DIATHESIS:} & \text{diathesis}\end{bmatrix}$.

tfeat :: $\begin{bmatrix}\text{LEVEL:} & \text{tlevel}\\ \text{PERF:} & \text{yn}\\ \text{PROG:} & \text{yn}\end{bmatrix}$.

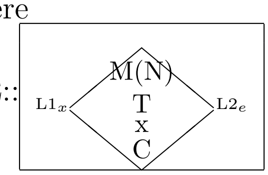
pdrs :: $\begin{bmatrix}\text{UNIV:} & \text{list(ref)}\\ \text{CONDS:} & \text{list(cond)}\end{bmatrix}$.

$$\text{quant\_cond} \quad :: \quad \begin{bmatrix} \text{QUANT:} & \text{quant\_descr} \\ \text{QU\_RES :} & \text{label\_s} \\ \text{QU\_SCOPE:} & \text{label\_s} \\ \text{QUANT\_VAR:} & \text{ref} \\ \text{QUANT\_SUM:} & \text{ref} \\ \text{QUANT\_SCOPE:} & \text{ref} \end{bmatrix}.$$

$$\text{quant\_descr} \quad :: \quad \begin{bmatrix} \text{QU\_NAME :} & \text{afs} \\ \text{QU\_TYPE:} & \text{qu\_type} \\ \text{QU\_MOD:} & \text{afs} \\ \text{QU\_COMP\_VAL:} & \text{qu\_comp\_val} \end{bmatrix}.$$

% where

% X,E::



$$\text{\% abbreviates} \quad \text{\%} \ {}^{\text{quant\_cond}}\begin{bmatrix} \text{QUANT:} & {}^{\text{quant\_descr}}\begin{bmatrix} \text{QU\_NAME :} & \text{N} \\ \text{QU\_TYPE:} & \text{T} \\ \text{QU\_MOD:} & \text{M} \\ \text{QU\_COMP\_VAL:} & \text{C} \end{bmatrix} \\ \text{QU\_RES :} & \text{L1} \\ \text{QU\_SCOPE:} & \text{L2} \\ \text{QUANT\_VAR:} & \text{x} \\ \text{QUANT\_SUM:} & \text{X} \\ \text{QUANT\_SCOPE:} & \text{E} \end{bmatrix}.$$

$$\text{alfa\_cond} \quad :: \quad \begin{bmatrix} \text{A\_TYPE:} & \text{alfa\_type} \\ \text{A\_REF:} & \text{ref\_type} \\ \text{A\_RES:} & \text{label\_s} \\ \text{A\_ANTE:} & \text{label\_s} \end{bmatrix}.$$

% where

$$\text{\%} \quad \alpha_T(\text{R,L}) \quad \text{abbreviates} \quad {}^{\text{alfa\_cond}}\begin{bmatrix} \text{A\_TYPE:} & \text{T} \\ \text{A\_REF:} & \text{R} \\ \text{A\_RES:} & \text{L} \\ \text{A\_ANTE:} & ? \end{bmatrix}.$$

$$\text{det\_cond} \quad :: \quad \begin{bmatrix} \text{A\_TYPE:} & \text{alfa\_descrp} \\ \text{A\_REF:} & \text{ref} \\ \text{A\_RES:} & \text{npsem\_l ; sat\_dpsem\_l} \\ \text{A\_ANTE:} & \text{label\_s} \end{bmatrix}.$$

% where

$$\text{\%} \quad \alpha_T(\chi,\text{L}) \quad \text{abbreviates} \quad {}^{\text{det\_cond}}\begin{bmatrix} \text{A\_TYPE:} & \text{T1} \\ \text{A\_REF:} & \chi \\ \text{A\_RES:} & \text{L} \\ \text{A\_ANTE:} & ? \end{bmatrix},$$

% with T1= alfa_indef iff T=ind and T1= alfa_def iff T=def.

$$\text{rel\_cond} \quad :: \quad \begin{bmatrix} \text{R\_REL:} & \text{rel\_descr} \\ \text{R\_ARGS:} & \text{list(ref\_type)} \end{bmatrix}.$$

$$\text{rel\_descr} \quad :: \quad \begin{bmatrix} \text{R\_NAME:} & \text{afs} \\ \text{R\_TYPE:} & \text{top} \\ \text{R\_MOD:} & \text{afs} \end{bmatrix}.$$

% where

$$\text{\%} \quad \text{M(R)}(\text{A}_1,\ldots,\text{A}_n) \quad \text{abbreviates} \quad {}^{\text{rel\_cond}}\begin{bmatrix} \text{R\_REL:} & {}^{\text{rel\_descr}}\begin{bmatrix} \text{R\_NAME:} & \text{N} \\ \text{R\_TYPE:} & \text{T} \\ \text{R\_MOD:} & \text{M} \end{bmatrix} \\ \text{R\_ARGS:} & \langle \text{A}_1,\ldots,\text{A}_n \rangle \end{bmatrix},$$

% with R=T or R=N, depending on the phenomenon considered:
% Normally Ts are rendered for well explored and structurally formalized lexical fields.
% Typical Ms are *sehr ; fast . . .* ,
% typical Ns are *mann, bei, vor, . . .* ,
% typical Ts are domain model sorts for objects or relations
% like *mass ; count ; vehicle; temp_rel ; before; loc_rel . . . .*

$$\text{foc\_cond} \quad :: \quad \begin{bmatrix} \text{FOC:} & \text{label\_s} \\ \text{BACK:} & \text{label\_s} \end{bmatrix}.$$

% where

% $$\begin{array}{|l l|l l|} \boxed{\text{F}} & \chi_1,\ldots,\chi_n & \boxed{\text{B}} & \psi_1,\ldots,\psi_m \\ \text{C}_1 & & \text{C'}_1 & \\ \vdots & & \vdots & \\ \text{C}_k & & \text{C'}_l & \\ \hline \end{array} \quad \text{abbreviates} \quad {}^{\text{foc\_cond}}\begin{bmatrix} \text{FOC:} & {}^{\text{basic\_l}}\begin{bmatrix} \text{DRS:} & \begin{array}{|l|} \hline \chi_1,\ldots,\chi_n \\ \text{C}_1 \\ \vdots \\ \text{C}_k \\ \hline \end{array} \end{bmatrix} \\ \text{BACK:} & {}^{\text{basic\_l}}\begin{bmatrix} \text{DRS:} & \begin{array}{|l|} \hline \psi_1,\ldots,\psi_m \\ \text{C'}_1 \\ \vdots \\ \text{C'}_l \\ \hline \end{array} \end{bmatrix} \end{bmatrix}.$$

$$\text{neg\_cond} \quad :: \quad \begin{bmatrix} \text{N\_ARG:} & \text{xtype\_l} \end{bmatrix}.$$

% where

% $\neg$:L abbreviates ${}^{\text{neg\_cond}}\begin{bmatrix} \text{N\_ARG:} & \text{L} \end{bmatrix}$.

$$\text{and\_cond} \quad :: \quad \begin{bmatrix} \text{AN\_ARG1:} & \text{label\_s} \\ \text{AN\_ARG2:} & \text{label\_s} \end{bmatrix}.$$

% where

% L1 $\wedge$ L2 abbreviates ${}^{\text{and\_cond}}\begin{bmatrix} \text{AN\_ARG1:} & \text{L1} \\ \text{AN\_ARG2:} & \text{L2} \end{bmatrix}$

$$\text{or\_cond} \quad :: \quad \begin{bmatrix} \text{OR\_ARG1:} & \text{label\_s} \\ \text{OR\_ARG2:} & \text{label\_s} \end{bmatrix}.$$

% where

% L1 $\vee$ L2 abbreviates ${}^{\text{or\_cond}}\begin{bmatrix} \text{OR\_ARG1:} & \text{L1} \\ \text{OR\_ARG2:} & \text{L2} \end{bmatrix}$

$$\text{s\_descr\_cond} \quad :: \quad \begin{bmatrix} \text{SD\_SIT:} & {}^{\text{ref}}\begin{bmatrix} \text{SORT:} & \text{state} \end{bmatrix} \\ \text{SD\_DESCR:} & \text{reforlabel} \end{bmatrix}.$$

% where

% s:L abbreviates ${}^{\text{s\_descr\_cond}}\begin{bmatrix} \text{SD\_SIT:} & \text{s} \\ \text{SD\_DESCR:} & \text{L} \end{bmatrix}$.

$$\text{p\_descr\_cond} \quad :: \quad \begin{bmatrix} \text{PD\_PROP:} & {}^{\text{ref}}\begin{bmatrix} \text{SORT:} & \text{prop} \end{bmatrix} \\ \text{PD\_DESCR:} & \text{label\_s} \end{bmatrix}.$$

% where

% p:L abbreviates ${}^{\text{p\_descr\_cond}}\begin{bmatrix} \text{PD\_PROP:} & \text{p} \\ \text{PD\_DESCR:} & \text{L} \end{bmatrix}$.

$$\text{modal\_cond} \quad :: \quad \begin{bmatrix} \text{M\_OP:} & \text{modal\_descr} \\ \text{M\_ARG:} & \text{reforlabel} \end{bmatrix}.$$

$$\text{modal\_descr} \quad :: \quad \begin{bmatrix} \text{M\_NAME:} & \text{afs} \\ \text{M\_TYPE:} & \text{afs} \\ \text{M\_MOD:} & \text{afs} \end{bmatrix}$$

% where

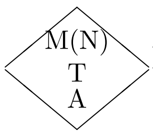
% $$\Diamond_{\substack{\text{M(N)} \\ \text{T}}}\text{L} \quad \text{abbreviates} \quad {}^{\text{modal\_cond}}\begin{bmatrix} \text{M\_OP:} & {}^{\text{modal\_descr}}\begin{bmatrix} \text{M\_NAME:} & \text{N} \\ \text{M\_TYPE:} & \text{T} \\ \text{M\_MOD:} & \text{M} \end{bmatrix} \\ \text{M\_ARG:} & \text{L} \end{bmatrix},$$

% where typical Ns are ‘möglich, vielleicht, wahrscheinlich . . . ’,
% typical Ts are ‘mod_exist ; mod_univ ; mod_numb_def . . . ’ and
% typical Ms are ‘gut ; sehr ; überaus . . . ’.

$$\text{facet\_cond} \quad :: \quad \begin{bmatrix} \text{F\_OP:} & \text{facet\_descr} \\ \text{F\_ARG:} & \text{reforlabel} \end{bmatrix}.$$

$$\text{facet\_descr} \quad :: \quad \begin{bmatrix} \text{F\_NAME:} & \text{afs} \\ \text{F\_TYPE:} & \text{afs} \\ \text{F\_INT\_ARG:} & \text{top} \\ \text{F\_MOD:} & \text{afs} \end{bmatrix}.$$

% where

% 

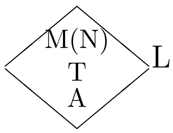
L abbreviates $\;{}^{\text{facet\_cond}}\begin{bmatrix} \text{F\_OP:} & {}^{\text{facet\_descr}}\begin{bmatrix} \text{F\_NAME:} & \text{N} \\ \text{F\_TYPE:} & \text{T} \\ \text{F\_INT\_ARG:} & \text{A} \\ \text{F\_MOD:} & \text{M} \end{bmatrix} \\ \text{F\_ARG:} & \text{L} \end{bmatrix},$

% where typical Ns are ‘als, für . . . ’,
% typical Ts are ‘f_factual; f_nonfactual . . . ’,
% there might be no Ms, if not ‘allein, ausschließlich . . . ’.
% Typical As are ‘Richter, einen Kellner . . . ’
% (*as judge, he goes to the assembly; he is rich for a waiter*).

persp_cond :: $\begin{bmatrix} \text{P\_OP:} & \text{persp\_descr} \\ \text{P\_ARG:} & \text{reforlabel} \end{bmatrix}$.

persp_descr :: $\begin{bmatrix} \text{P\_NAME:} & \text{afs} \\ \text{P\_TYPE:} & \text{afs} \\ \text{P\_INT\_ARG:} & \text{ref} \\ \text{P\_MOD:} & \text{afs} \end{bmatrix}$.

% where

%  abbreviates $_{\text{persp\_cond}}\begin{bmatrix} \text{P\_OP:} & _{\text{persp\_descr}}\begin{bmatrix} \text{P\_NAME:} & \text{N} \\ \text{P\_TYPE:} & \text{T} \\ \text{P\_INT\_ARG:} & \text{A} \\ \text{P\_MOD:} & \text{M} \end{bmatrix} \\ \text{P\_ARG:} & \text{L} \end{bmatrix}$,

% where typical Ns are 'für; aus; ...',
% typical Ts are 'p_factual; p_nonfactual ...',
% there might be no Ms, if not 'allein, ausschließlich ...'.
% Typical As are 'Peter, ...' (*for Peter, the man is guilty; from the perspective of x, ...*).

abstrop_cond :: $\begin{bmatrix} \text{ABSTR\_INST:} & \text{comp\_ref} \\ \text{ABSTR\_OP:} & \text{ref\_op} \\ \text{ABSTR\_VAR:} & \text{ref} \\ \text{ABSTR\_ARG:} & \text{xtype\_l} \end{bmatrix}$.

% where

% χ' OP χ L abbreviates $_{\text{abstrop\_cond}}\begin{bmatrix} \text{ABSTR\_INST:} & \chi' \\ \text{ABSTR\_OP:} & \text{OP} \\ \text{ABSTR\_VAR:} & \chi \\ \text{ABSTR\_ARG:} & \text{L} \end{bmatrix}$,

% where a typical abstraction condition is

% X=Σ x $\boxed{\begin{array}{l} \text{x} \ldots \\ \vdots \end{array}}$ or s=prog e $\boxed{\begin{array}{l} \text{e} \ldots \\ \vdots \end{array}}$.

ord :: $\begin{bmatrix} \text{O\_REL:} & \text{ord\_rel} \\ \text{O\_ARG1:} & \text{number} \\ \text{O\_ARG2:} & \text{number} \end{bmatrix}$.

% where

% l1 R l2 abbreviates $_{\text{ord}}\begin{bmatrix} \text{O\_REL:} & \text{R'} \\ \text{O\_ARG1:} & \text{l1} \\ \text{O\_ARG2:} & \text{l2} \end{bmatrix}$,

% where $\leq, \leq_n, \leq_f, <_s, <$, for R, in turn translate into 'leq, next, first, succ, less' for R'.

s_ord :: $\begin{bmatrix} \text{SO\_REL:} & \text{sort\_rel} \\ \text{SO\_ARG1:} & \text{dm\_sort} \\ \text{SO\_ARG2:} & \text{dm\_sort} \end{bmatrix}$.

% where

% S1 $\leq$ S2. S1 $\not\leq$ S2 translate into $_{\text{s\_ord}}\begin{bmatrix} \text{SO\_REL:} & \text{R} \\ \text{SO\_ARG1:} & \text{S1} \\ \text{SO\_ARG2:} & \text{S2} \end{bmatrix}$,

% with R = 'subs' and 'nsubs' respectively.

facet :: $\begin{bmatrix} \text{FAC\_LAMBDA:} & \text{list(ref)} \\ \text{FAC\_FORMULA:} & \text{label\_s} \end{bmatrix}$.

% where

% $\lambda\chi_1, \ldots \chi_n.\text{P}(\chi_1, \ldots \chi_n)$ translates into $_{\text{facet}}\begin{bmatrix} \text{FAC\_LAMBDA:} & \langle\chi_1, \ldots \chi_n\rangle \\ \text{FAC\_FORMULA:} & \text{P}(\chi_1, \ldots \chi_n) \end{bmatrix}$.

% Normally FAC_FORMULA will denote a DRS (a proposition).

A.2 Syntax semantics interface I—subsumption of sort expressions

A.2.1 The principles

(Most) HPSG principles can be expressed via subsumption (schemata) of feature expressions, among others the

Semantics Principle (original HPSG version)

a)

$$\left[\text{DTRS: head-struc}\right] < \begin{bmatrix} \text{RETRIEVED:} & \textcircled{L} \\ \text{QSTORE:} & \textcircled{S} \\ \text{DTRS:} & \begin{bmatrix} \text{HEAD-DTR:} & [\text{QSTORE: } \textcircled{Q}] \\ \text{COMP-DTRS:} & \langle[\text{QSTORE: } \textcircled{Q1}],\ldots,[\text{QSTORE: } \textcircled{Qn}]\rangle \end{bmatrix} \end{bmatrix} \ \&$$

$$\textcircled{L}\ \textit{disjoint}\ \textcircled{S}\ \&$$

$$\textcircled{L} \bigcup \textcircled{S} = \textcircled{Q} \bigcup (\textcircled{Q1} \bigcup \ldots \bigcup \textcircled{Qn}).$$

and similarly for the other headed phrases.

(Since $\textcircled{L}$ is a list, we interpret the relation *disjoint* as referring to the set of elements in case of a list argument and correspondingly for the $\bigcup$-operation).

b)

$$[\text{DTRS: } \tilde{}\text{head-adj-struc} \ \& \ [\text{HEAD-DTR:SYNSEM:LOC:CONT: psoa}]] \ <$$

$$\begin{bmatrix} \text{SYNSEM:LOC:CONT:} & \begin{bmatrix} \text{NUCLEUS:} & \textcircled{S} \\ \text{QUANTS:} & \text{append}(\textcircled{L1},\textcircled{L2}) \end{bmatrix} \\ \text{RETRIEVED:} & \textcircled{L1} \\ \text{DTRS:HEAD-DTR:} & \text{SYNSEM:LOC:CONT:} \begin{bmatrix} \text{NUCLEUS:} & \textcircled{S} \\ \text{QUANTS:} & \textcircled{L2} \end{bmatrix} \end{bmatrix}$$

$$[\text{DTRS: } \tilde{}\text{head-adj-struc} \ \& \ [\text{HEAD-DTR:SYNSEM:LOC:CONT: } \tilde{}\text{psoa}]] \ <$$

$$\begin{bmatrix} \text{SYNSEM:LOC:CONT:} & \textcircled{S} \\ \text{RETRIEVED:} & \langle\rangle \\ \text{DTRS:HEAD-DTR:} & \text{SYNSEM:LOC:CONT: } \textcircled{S} \end{bmatrix}$$

and similarly with HEAD-DTR exchanged for ADJ-DTR, in case of a head-adjunct structure (since then, the semantic head is the adjunct).

Now, in order to replace the common HPSG semantics by the semantics developed in this paper, we reject this Semantics Principle, the Quantifier Binding Condition and the Principle of Contextual Consistency and introduce instead the one new

Semantics Principle (version for flat underspecified DRT-style representation):

$$\left[\text{DTRS: head-comp-struc}\right]$$

$$< \begin{bmatrix} \text{SYNSEM: LOC:CONT:SEM: m\_apply(reverse(\textcircled{L}),\textcircled{A})} & \\ \text{DTRS:} & \begin{bmatrix} \text{HEAD-DTR: SYNSEM:LOC:CONT:SEM: \textcircled{A}} \\ \text{COMP-DTRS: \textcircled{L}} \end{bmatrix} \end{bmatrix}$$

$$\text{DTRS: head-adj-struc} \; < \begin{bmatrix} \text{SYNSEM: LOC:CONT:SEM: compose(\textcircled{F},\textcircled{A})} & \\ \text{DTRS:} & \begin{bmatrix} \text{HEAD-DTR:SYNSEM:LOC:CONT:SEM: \textcircled{A}} \\ \text{ADJ-DTR:SYNSEM:LOC:CONT:SEM: \textcircled{F}} \end{bmatrix} \end{bmatrix}$$

DTRS: head-mark-struc

$$< \begin{bmatrix} \text{SYNSEM: LOC:CONT:SEM: compose(\textcircled{F},\textcircled{A})} & \\ \text{DTRS:} & \begin{bmatrix} \text{HEAD-DTR:SYNSEM:LOC:CONT:SEM: \textcircled{A}} \\ \text{MARKER-DTR:SYNSEM:LOC:CONT:SEM: \textcircled{F}} \end{bmatrix} \end{bmatrix}$$

$$\text{DTRS: head-filler-struc} \; < \begin{bmatrix} \text{SYNSEM: LOC:CONT:SEM: \textcircled{S}} & \\ \text{DTRS:} & \begin{bmatrix} \text{HEAD-DTR:SYNSEM:LOC:CONT:SEM: \textcircled{S}} \end{bmatrix} \end{bmatrix}$$

$$\text{DTRS: } {}^{\sim head-adj-struc} \;\&\; \begin{bmatrix} \text{DTRS:HEAD-DTR:SYNSEM:LOC:CONT: nom\_obj} \end{bmatrix} \; <$$
$$\begin{bmatrix} \text{SYNSEM:LOC:CONT:IND: \textcircled{I}} \\ \text{DTRS:HEAD-DTR:SYNSEM:LOC:CONT:IND: \textcircled{I}} \end{bmatrix}$$

$$\text{DTRS: } {}^{head-adj-struc} \begin{bmatrix} \text{DTRS:ADJ-DTR:SYNSEM:LOC:CONT: nom\_obj} \end{bmatrix} \; <$$
$$\begin{bmatrix} \text{SYNSEM:LOC:CONT:IND: \textcircled{I}} \\ \text{DTRS:ADJ-DTR:SYNSEM:LOC:CONT:IND: \textcircled{I}} \end{bmatrix}$$

where *m_apply* is defined as follows:

$$\begin{array}{lcl} \text{m\_apply}(\langle\rangle,\textcircled{A}) & := & \textcircled{A}. \\ \text{m\_apply}(\langle[\text{SYNSEM:LOC:CONT:SEM: }\textcircled{F}] \mid \textcircled{R}\rangle,\textcircled{A}) & := & \text{m\_apply}(\textcircled{R},\text{compose}(\textcircled{F},\textcircled{A})). \end{array}$$

compose will be defined further below in the spirit of the stipulations in section 4.

As a prerequisite of this revision of the principle, we modify the HPSG signature and feature declaration as follows:

$$\begin{array}{lcl} \text{content} & = & \text{nom\_obj} \mid \text{psoa}. \\ \text{content} & :: & [\text{SEM: sem\_t}] \\ \text{nom\_obj} & :: & [\text{INDEX: index}] \\ \text{sign} & :: & \begin{bmatrix} \text{PHON:} & \text{list(phonstring)} \\ \text{SYNSEM:} & \text{synsem} \end{bmatrix} \end{array}$$

Thus, *signs* (and the more specific *phrases*) no longer specify features QSTORE and RETRIEVED. *quant* is no longer a subsort of *content*. *nom_obj* still specifies an HPSG index. However, *nom_obj* and *psoa* are redefined in that they inherit a feature SEM from *content* with value *sem_t*.

By this revision the other HPSG grammar specifications are not affected, in particular the remaining principles are usable and contribute to a consistent theory. However, the binding theory and the control theory must be adapted to the revised scenario. We omit this here, we also omit spelling out constraints for the resolution (or accommodation) of presuppositions.

We will comment on the redefinition of the Semantics Principle in the next section only, where more material is introduced that motivates the change. We now formulate a percolation principle that controls the shape of specific semantic structures.

Index Information Percolation Principle

a)

$$^{\text{npsem\_l}}\left[\text{BOT: } ^{\text{npsem\_l}}\right] < \begin{bmatrix} \text{RIND:CATI: } \textcircled{1} \\ \text{BOT:RIND:CATI: } \textcircled{1} \end{bmatrix}$$

b)

$$^{\text{npsem\_l}}\left[\text{BOT: } ^{\text{npsem\_l}}\left[\text{RIND: } ^{\text{sit\_ind}}\right]\right] < \begin{bmatrix} \text{RIND: } & ^{\text{sit\_ind}}\begin{bmatrix} \text{MTV: } \textcircled{1} \\ \text{RT: } \textcircled{2} \end{bmatrix} \\ \text{BOT:RIND: } & ^{\text{sit\_ind}}\begin{bmatrix} \text{MTV: } \textcircled{1} \\ \text{RT: } \textcircled{2} \end{bmatrix} \end{bmatrix}$$

c)

$$^{\text{etype\_l}}\left[\text{BOT: } ^{\text{vpsem\_l}}\right] < \begin{bmatrix} \text{RIND: } & ^{\text{sit\_ind}}\begin{bmatrix} \text{CATI: } \textcircled{1} \\ \text{MTV: } \textcircled{2} \\ \text{RT: } \textcircled{3} \end{bmatrix} \\ \text{BOT:RIND: } & ^{\text{sit\_ind}}\begin{bmatrix} \text{CATI: } \textcircled{1} \\ \text{MTV: } \textcircled{2} \\ \text{RT: } \textcircled{3} \end{bmatrix} \end{bmatrix}$$

d)

$$^{\text{dpsem\_l}} < \begin{bmatrix} \text{REFIND:CATI: } \textcircled{1} \\ \text{LREFIND:CATI } \textcircled{1} \end{bmatrix}$$

e)

$$^{\text{dpsem\_l}}\left[\text{REFIND: } ^{\text{sit\_ind}}\right] < \begin{bmatrix} \text{REFIND: } & \begin{bmatrix} \text{MTV: } \textcircled{1} \\ \text{RT: } \textcircled{2} \end{bmatrix} \\ \text{LREFIND: } & \begin{bmatrix} \text{MTV: } \textcircled{1} \\ \text{RT: } \textcircled{2} \end{bmatrix} \end{bmatrix}$$

f)

$$^{\text{dpsem\_l\&struct\_l}} < \begin{bmatrix} \text{RIND:CATI: } \textcircled{1} \\ \text{BOT:RIND:CATI: } \textcircled{1} \end{bmatrix}$$

g)

$$^{\text{dpsem\_l}}\left[\text{BOT:RIND: } ^{\text{sit\_ind}}\right] < \begin{bmatrix} \text{RIND: } & ^{\text{sit\_ind}}\begin{bmatrix} \text{MTV: } \textcircled{1} \\ \text{RT: } \textcircled{2} \end{bmatrix} \\ \text{BOT:RIND: } & ^{\text{sit\_ind}}\begin{bmatrix} \text{MTV: } \textcircled{1} \\ \text{RT: } \textcircled{2} \end{bmatrix} \end{bmatrix}$$

h)

$$^{\text{dpsem\_l}}\left[\text{BOT: } ^{\text{dpsem\_l\&labeldescr}}\right] < \begin{bmatrix} \text{LREFIND: } \textcircled{1} \\ \text{BOT:LREFIND: } \textcircled{1} \end{bmatrix}$$

i)

$$\text{detorquant\_t}[\textsc{lambda}: \langle^{\text{npsem\_l}}\rangle] \;<\; \begin{bmatrix} \text{LAMBDA: } \langle[\text{RIND: } \textcircled{1}]\rangle \\ \text{RESULT:LREFIND: } \textcircled{1} \end{bmatrix}$$

j)

$$\text{det\_t}[\textsc{lambda}: \langle^{\text{qpsem\_l}}\rangle] \;<\; \begin{bmatrix} \text{LAMBDA: } \langle[\text{REFIND: } \textcircled{1}]\rangle \\ \text{RESULT:REFIND: } \textcircled{1} \end{bmatrix}$$

k)

$$\text{prepsem\_t} \;<\; \begin{bmatrix} \text{LAMBDA: } \langle^{\text{dpsem\_l}}[\text{REFIND:CATI:CASE: } \textcircled{1}],^{\text{vnpsem\_l}}\rangle \\ \text{RESULT:REFIND:PPCASE: } \textcircled{1} \end{bmatrix}$$

l)

$$\text{prepsem\_t} \;<\; \begin{bmatrix} \text{LAMBDA: } \langle^{\text{dpsem\_l}}[\text{REFIND:CATI:CASE: } \textcircled{1}],^{\text{dpsem\_l}}\rangle \\ \text{RESULT:REFIND:CASE: } \textcircled{1} \end{bmatrix}$$

It remains to define *compose*. We adapt what has been specified in chapter 4 to the particular framework in which we work here.

A.2.2 Composition rules

First we define the auxiliary routine *l_apply* that eases treating applications of functors to VPs and NPs which, without this, could not abstract away from the structural difference of V and VP (and N and NP) representations:

$$\text{l\_apply}(\textcircled{1},\textcircled{2}^{\text{vpsem\_l\&basic\_l}}) := {}^{\text{vpsem\_l}}\begin{bmatrix} \text{FSET: } \langle\textcircled{1}\rangle \\ \text{SUBS: } \langle\rangle \\ \text{BOT: } \textcircled{2} \end{bmatrix}.$$

$$\text{l\_apply}(\textcircled{1},{}^{\text{vpsem\_l}}\begin{bmatrix} \text{RIND: } \textcircled{2} \\ \text{FSET: } \textcircled{3} \\ \text{SUBS: } \textcircled{4} \\ \text{BOT: } \textcircled{5} \end{bmatrix}) := {}^{\text{vpsem\_l}}\begin{bmatrix} \text{RIND: } \textcircled{2} \\ \text{FSET: } \langle\textcircled{1}|\textcircled{3}\rangle \\ \text{SUBS: } \textcircled{4} \\ \text{BOT: } \textcircled{5} \end{bmatrix}.$$

$$\text{l\_apply}(\textcircled{1},\textcircled{2}^{\text{npsem\_l\&basic\_l}}) := {}^{\text{npsem\_l}}\begin{bmatrix} \text{FSET: } \langle\textcircled{1}\rangle \\ \text{SUBS: } \langle\rangle \\ \text{BOT: } \textcircled{2} \end{bmatrix}.$$

$$\text{l\_apply}(\textcircled{1},{}^{\text{npsem\_l}}\begin{bmatrix} \text{RIND: } \textcircled{2} \\ \text{FSET: } \textcircled{3} \\ \text{SUBS: } \textcircled{4} \\ \text{BOT: } \textcircled{5} \end{bmatrix}) := {}^{\text{npsem\_l}}\begin{bmatrix} \text{RIND: } \textcircled{2} \\ \text{FSET: } \langle\textcircled{1}|\textcircled{3}\rangle \\ \text{SUBS: } \textcircled{4} \\ \text{BOT: } \textcircled{5} \end{bmatrix}.$$

$$\text{l\_apply}(\textcircled{1},\textcircled{2}^{\text{dpsem\_l\&(basic\_l;pdrs\_l)}}) := {}^{\text{dpsem\_l}}\begin{bmatrix} \text{FSET: } \langle\textcircled{1}\rangle \\ \text{SUBS: } \langle\rangle \\ \text{BOT: } \textcircled{2} \end{bmatrix}.$$

$$\text{l\_apply}(\textcircled{1},{}^{\text{dpsem\_l}}\begin{bmatrix} \text{RIND: } \textcircled{2} \\ \text{REFIND: } \textcircled{3} \\ \text{LREFIND: } \textcircled{4} \\ \text{FSET: } \textcircled{5} \\ \text{SUBS: } \textcircled{6} \\ \text{BOT: } \textcircled{7} \end{bmatrix}) := {}^{\text{dpsem\_l}}\begin{bmatrix} \text{RIND: } \textcircled{2} \\ \text{REFIND: } \textcircled{3} \\ \text{LREFIND: } \textcircled{4} \\ \text{FSET: } \langle\textcircled{1}|\textcircled{5}\rangle \\ \text{SUBS: } \textcircled{6} \\ \text{BOT: } \textcircled{7} \end{bmatrix}.$$

The Determiner Phrase

- Adj + NP ⇒NP:

$$\text{compose}(^{mod\_npsem\_t\&nppmod\_xtype\_t}\begin{bmatrix}\text{LAMBDA: } \langle \text{npsem\_l \& labelvar}\rangle \\ \text{RESULT: } \textcircled{1}\end{bmatrix}, {}^{npsem\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{2} \\ \text{RESULT: } \textcircled{3}\end{bmatrix})$$
$$:= {}^{npsem\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{2} \\ \text{RESULT: l\_apply}(\textcircled{1},\textcircled{3})\end{bmatrix}$$

- PP + NP ⇒NP:

$$\text{compose}(^{ppsem\_t}\begin{bmatrix}\text{LAMBDA: } \langle^{\text{npsem\_l\&labeldescr}}\begin{bmatrix}\text{RIND: } \textcircled{1} \\ \text{DRS: } [\,]\end{bmatrix}\rangle \\ \text{RESULT: } \textcircled{2}[\text{RIND: } \textcircled{1}]\end{bmatrix}, {}^{npsem\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{3} \\ \text{RESULT: } \textcircled{4}\end{bmatrix})$$
$$:= {}^{npsem\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{3} \\ \text{RESULT: l\_apply}(\begin{bmatrix}\text{RIND: } \textcircled{1} \\ \text{NUMB: } \textcircled{a} \\ \text{PDRS: } \boxed{\textcircled{2} \wedge [\,]} \\ \text{SUBS: } \langle \textcircled{b} \leq \textcircled{a} \rangle \\ \text{BOT: } ^{\text{labelvar}}\begin{bmatrix}\text{RIND: } \textcircled{1} \\ \text{NUMB: } \textcircled{b}\end{bmatrix}\end{bmatrix}, \textcircled{4})\end{bmatrix}$$

- DetorQuant + DNP ⇒DP:

$$\text{compose}(^{detorquant\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{1} \\ \text{RESULT: } \textcircled{2}\end{bmatrix}, {}^{npsem\_t;dpsem\_t}\begin{bmatrix}\text{LAMBDA:}\langle\rangle \\ \text{RESULT: } ^{\text{qnpsem\_l}}\textcircled{1}\end{bmatrix})$$
$$:= {}^{dpsem\_t}[\text{RESULT: } \textcircled{2}]$$

- ModDP + DP ⇒DP

$$\text{compose}(^{mod\_dpsem\_t;ppsem\_t}\begin{bmatrix}\text{LAMBDA: } \langle \text{dpsem\_l \& labelvar}\rangle \\ \text{RESULT: } \textcircled{1}\end{bmatrix}, {}^{dpsem\_t}[\text{RESULT: } \textcircled{2}])$$
$$:= {}^{dpsem\_t}[\text{RESULT: l\_apply}(\textcircled{1},\textcircled{2})]$$

- ModQuant + Quant ⇒Quant

$$\text{compose}(^{quantop\_modifier\_t}\begin{bmatrix}\text{LAMBDA:}\langle\textcircled{1}\rangle \\ \text{RESULT: } \textcircled{2}\end{bmatrix}, {}^{\text{quantop\_t}}\textcircled{1}) := \textcircled{2}$$

- ModXtypeMod + ModXtype ⇒ModXtype

$$\text{compose}(^{mod\_xtype\_modifier\_t}\begin{bmatrix}\text{LAMBDA:}\langle\textcircled{1}\rangle \\ \text{RESULT: } \textcircled{2}\end{bmatrix}, {}^{\text{mod\_xtype\_t}}\textcircled{1}) := \textcircled{2}$$

The Verbal Phrase

- DP + VP ⇒VP

$\text{compose}({}^{dpsem\_t}\begin{bmatrix}\text{RESULT: } \textcircled{1}[\text{LREFIND: } \textcircled{2}]\end{bmatrix}, {}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA:}\langle \textcircled{2} | \textcircled{3} \rangle \\ \text{RESULT: } \textcircled{4}\end{bmatrix})$

$:= {}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{3} \\ \text{RESULT: l\_apply}(\textcircled{1},\textcircled{3})\end{bmatrix}$

- PP + VP ⇒VP

$\text{compose}({}^{ppsem\_t}\begin{bmatrix}\text{LAMBDA: } \langle{}^{\text{vpsem\_l}}\rangle \\ \text{RESULT: } \begin{bmatrix}\text{REFIND:CATI: } \textcircled{1}^{\text{prp}} \\ \text{FSET: } \langle \textcircled{2}^{\text{dpsem\_l}}[\text{LREFIND:REF: } \textcircled{3}],\_\rangle\end{bmatrix}\end{bmatrix},$

${}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA:}\langle \begin{bmatrix}\text{CATI: } \textcircled{1} \\ \text{REF: } \textcircled{3}\end{bmatrix} | \textcircled{4} \rangle \\ \text{RESULT: } \textcircled{5}\end{bmatrix})$

$:= {}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{4} \\ \text{RESULT: l\_apply}(\textcircled{2},\textcircled{5})\end{bmatrix}$

- CompS + VP ⇒VP

$\text{compose}({}^{compssem\_t}\begin{bmatrix}\text{LAMBDA: } \langle{}^{\text{vpsem\_l\&labelvar}}\rangle \\ \text{RESULT: } \textcircled{1}[\text{REFIND: } \textcircled{2}]\end{bmatrix}, {}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA:}\langle \textcircled{2} | \textcircled{3} \rangle \\ \text{RESULT: } \textcircled{4}\end{bmatrix})$

$:= {}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{3} \\ \text{RESULT: l\_apply}(\textcircled{1},\textcircled{3})\end{bmatrix}$

- Xtype + VP ⇒VP

$\text{compose}({}^{xtype\_t}[\text{RESULT: } \textcircled{1}^{\text{labeldescr}}], \quad {}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA:}\langle \textcircled{1} | \textcircled{2} \rangle \\ \text{RESULT: } \textcircled{3}\end{bmatrix}) \quad :=$

${}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{2} \\ \text{RESULT: } \textcircled{3}\end{bmatrix}$

- Adv + VP ⇒VP:

$\text{compose}({}^{mod\_vpsem\_t;ppsem\_t}[\text{LAMBDA: } \langle{}^{\text{vpsem\_l\&labelvar}}\rangle$

$\text{RESULT: } \textcircled{1}], {}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{2} \\ \text{RESULT: } \textcircled{3}\end{bmatrix})$

$:= {}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA:}\textcircled{2} \\ \text{RESULT: l\_apply}(\textcircled{1},\textcircled{3})\end{bmatrix}$

- Adv + S ⇒S:

$\text{compose}({}^{mod\_ssem\_t}\begin{bmatrix}\text{LAMBDA: } \langle \textcircled{1} \rangle \\ \text{RESULT: } \textcircled{2}\end{bmatrix}, {}^{satvpsem\_t}[\text{RESULT: } \textcircled{1}])$

$:= {}^{ssem\_t}\begin{bmatrix}\text{LAMBDA:}\langle\rangle \\ \text{RESULT: } \textcircled{2}\end{bmatrix}$

- Itype + Cop ⇒V

$\text{compose}({}^{nsem\_t;dpsem\_t;mod\_npsem\_t\&nppmod\_xtype\_t}[\text{RESULT: } \textcircled{1}], \quad {}^{cop\_t}$

$\begin{bmatrix}\text{LAMBDA: } \langle ①,② \rangle \\ \text{RESULT: } ③\end{bmatrix})$

$:= {}^{vsem\_t}\begin{bmatrix}\text{LAMBDA: } \langle ② \rangle \\ \text{RESULT: } ③\end{bmatrix}$

- PP + Cop ⇒VP

compose($^{ppsem\_t\&rel\_mod\_t}\begin{bmatrix}\text{RESULT:FSET: } \langle ①^{\text{dpsem\_l}},②^{\text{npsem\_l}} \rangle\end{bmatrix}$, $^{cop\_t}$

$\begin{bmatrix}\text{LAMBDA: } \langle ②,③ \rangle \\ \text{RESULT: } ④\end{bmatrix})$

$:= {}^{vpsem\_t}\begin{bmatrix}\text{LAMBDA: } \langle ③ \rangle \\ \text{RESULT: l\_apply}(①,④)\end{bmatrix}$

Prepositional Phrases

- Prep + DP ⇒ModXtype

  compose($^{prepsem\_t}\begin{bmatrix}\text{LAMBDA: } \langle ①,② \rangle \\ \text{RESULT: } ③\end{bmatrix}$, $^{dpsem\_t}\begin{bmatrix}\text{RESULT: } ①\end{bmatrix}$) := $^{ppsem\_t}\begin{bmatrix}\text{LAMBDA: } \langle ② \rangle \\ \text{RESULT: } ③\end{bmatrix}$

Subordinating Conjunctions

- Subconj + S ⇒ModEtype

  compose($^{satvpsem\_t}\begin{bmatrix}\text{RESULT: } ①\end{bmatrix}$, $^{subord\_t}\begin{bmatrix}\text{LAMBDA: } \langle ①,② \rangle \\ \text{RESULT: } ③\end{bmatrix}$) := $^{mod\_etype\_t}\begin{bmatrix}\text{LAMBDA: } \langle ② \rangle \\ \text{RESULT: } ③\end{bmatrix}$

Coordinating Conjunctions

- Coconj + Xtype ⇒ModXtype

  compose($^{xtype\_t}\begin{bmatrix}\text{RESULT: } ①\end{bmatrix}$, $^{coord\_t}\begin{bmatrix}\text{LAMBDA: } \langle ①,② \rangle \\ \text{RESULT: } ③\end{bmatrix}$) := $^{mod\_xtype\_t}\begin{bmatrix}\text{LAMBDA: } \langle ② \rangle \\ \text{RESULT: } ③\end{bmatrix}$.

Complementizers

- Comp + S ⇒S

  compose($^{comp\_t}\begin{bmatrix}\text{LAMBDA: } \langle ①,② \rangle \\ \text{RESULT: } ③\end{bmatrix}$ $^{satvpsem\_t}\begin{bmatrix}\text{RESULT: } ①\end{bmatrix}$) :=

$$ {}_{compssem\_t}\begin{bmatrix}\text{LAMBDA: } \langle ② \rangle \\ \text{RESULT: } ③\end{bmatrix} $$

Relative Pronouns

- Null-RLTVZR + VP ⇒RLTVZD-VP

$$ \text{compose}({}^{\text{vpsem\_t}}[\text{RESULT: } ①], {}^{\text{rltvzr\_t}}\begin{bmatrix}\text{LAMBDA: } \langle ①,② \rangle \\ \text{RESULT: } ③\end{bmatrix}) := $$

$$ {}_{\text{rltvzd\_vpsem\_t}}\begin{bmatrix}\text{LAMBDA: } \langle ② \rangle \\ \text{RESULT: } ③\end{bmatrix} $$

- Relpro + RLTVZD-VP

$$ \text{compose}({}^{relpro\_t}\left[\text{RESULT: } ①^{\text{dpsem\_l}}[\text{REFIND:REF: } ②]\right], $$

$$ {}_{\text{rltvzd\_vpsem\_t}}\begin{bmatrix}\text{LAMBDA: } \langle ① \rangle \\ \text{RESULT: } ③\end{bmatrix}) $$

$$:= {}^{\text{mod\_npsem\_t}}\begin{bmatrix}\text{LAMBDA: } \langle {}^{\text{npsem\_l}}[\text{RIND:REF: } ②] \rangle \\ \text{RESULT: } ③\end{bmatrix}. $$

$$:= {}^{\text{mod\_dpsem\_t}}\begin{bmatrix}\text{LAMBDA: } \langle {}^{\text{dpsem\_l}}[\text{REFIND:REF: } ②] \rangle \\ \text{RESULT: } ③\end{bmatrix}. $$

A.3 Syntax semantics interface II—the lexicon

In [Netter] it is argued that for German, for reasons of agreement, it is more appropriate to assume that the determiner subcategorizes for the NP than that the noun subcategorizes for the determiner, as suggested in [Pollard/Sag(1994)]. We have nothing to say about this alternative here, if not that it would be more in line with the semantic picture, that, in the paper, had lead us to our own terminology, see section 2. Since with regard to semantics, both syntactic alternatives seem equally workable, we refrain from revising the HPSG setting of [Pollard/Sag(1994)] in this respect. Therefore, in the feature descriptions, the abbreviations NP, N', N (also VP, V', V) are as in [Pollard/Sag(1994)]. Nevertheless, when commenting on the feature descriptions, we continue to use our semantically motivated terminology, as sketched in the introductory section 2. That is, in a feature description, the abbreviation NP stands for a feature description that characterizes a DP, N' abbreviates a structure that in our terminology characterizes a NP (and V' refers to what here is called VP). N (and also V) is as here.

A.3.1 Verbs

Following the classification of section 3.9, we distinguish relational from embedding verbs and copula.

- **relational verbs**

An example for a relational verb is the following (3rd person, singular, past) *aß* (ate):

$$\text{aß} \longrightarrow^{\text{word}} \left[\text{SYNSEM:LOC:} \left[\begin{array}{l} \text{CAT:} \left[\begin{array}{l}\text{HEAD: } \textcircled{V} \\ \text{SUBCAT: } \textcircled{L}\end{array}\right] \\ \text{CONT:SEM: } {}^{\text{lexsem(ass)}}\left[\begin{array}{l}\text{LAMBDA: relational}(\textcircled{L}) \\ \text{RESULT:SEM:RIND:CATI:} \textcircled{V}\end{array}\right]\end{array}\right]\right]$$

Here, the function *relational* coindexes the (lower) referential indices of the subcategorized verb arguments with the indices of the lambda prefix of the verb semantics. Since, for reasons of efficiency, the semantic description of the verb may summarize different uses of the verb with different semantic valence, this coindexing ensures that optional semantic roles are introduced (or not) such that the semantic valence corresponds to the syntactic valence. In order to specify the correct linking of the referents of the subcategorized functions to the corresponding semantic roles *relational* translates the categorial information of the SUBCAT items (which, here, is expressed in HPSG description style) into corresponding information of the format that is used in the decorations of our semantic representations; i.e., it defines a HPSG specific syntax semantics interface.

$$\text{relational}(\langle\rangle) \quad := \quad \langle\rangle.$$

$$\text{relational}(\langle \textcircled{F} |\ \textcircled{R} \rangle) \quad := \quad \text{append}(\text{relational}(\textcircled{R}), \langle \text{relational1}(\textcircled{F})\rangle).$$

$$\text{relational1}(\text{LOC:} \left[\begin{array}{l}\text{CAT:} \left[\begin{array}{ll}\text{HEAD:} & \text{noun} \ \& \ \textcircled{N} \\ \text{SUBCAT:} & \langle\rangle\end{array}\right] \\ \text{CONT: SEM:RESULT:LREFIND: } \textcircled{I}\end{array}\right]) \quad := \quad \textcircled{I} \ \& \ \text{CATI: } \textcircled{N}.$$

$$\text{relational1}(\text{LOC:} \left[\begin{array}{l}\text{CAT:} \left[\begin{array}{ll}\text{HEAD:} & \text{verb} \ \& \ \textcircled{V} \\ \text{MARKING:} & \text{comp} \\ \text{SUBCAT:} & \langle\rangle\end{array}\right] \\ \text{CONT: SEM:RESULT:REFIND: } \textcircled{I}\end{array}\right]) \quad := \quad \textcircled{I} \ \& \ \text{CATI: } \textcircled{V}.$$

$$\text{relational1}(\text{LOC:} \left[\begin{array}{l}\text{CAT:} \left[\begin{array}{ll}\text{HEAD:} & \text{PFORM: } \textcircled{P} \\ \text{SUBCAT:} & \langle\rangle\end{array}\right] \\ \text{CONT: SEM:RESULT:LREFIND: } \textcircled{I}\end{array}\right]) \quad := \quad \textcircled{I} \ \& \ \text{CATI:PRPFORM: } \textcircled{P}.$$

As far as the specification of *relational* is worked out, it treats relational verbs that subcategorize for DPs, PPs or complement sentences.

The semantics *lexsem(aß)* is defined as follows:

lexsem(aß) := lexsem(essen) & tmtv(ind,tfeat(past,no,no),active).

where

lexsem(essen) := vsem(essen,_,act,[subj(n,agent,const,human),obj0(n,object,grad,_)],rel).

vsem is a macro that takes the following arguments:

N	the name of the predicate (here *essen*),
S	the sort of the event DRF that is introduced (here not specified),
Akt	the Aktionsart of the basic event predicate (here *act(ivity)*),
L	the specification of the thematic roles - which are given by a term that declares the grammatical function (*subj, obj, iobj, gobj*) (where a possible suffix '0' marks optionality) together with a short description of the realization (expressed by the *cat-abbr(eviation)* instances and corresponding macros—*n* for nominal, i.e., a DP, *prep(auf,akk)* for a auf-PP with case accusative etc.), the name of the thematic role (here *agent* and *object*) its behavior when applied to events of the introduced event predicate (the role type, here *const(ant)* and *grad(ual)*—this is relevant for the Aktionsart calculus), the sortal restriction to which the bearer of the role has to satisfy, and, next to L
T	the type of the verb that, here, is *rel(ational)*.

Since the example specifies an optional role the description can be expanded into two feature descriptions:

$$
\text{vsem\_t}\begin{bmatrix}
\text{LAMBDA:} & \left\langle {}^{\text{iind}}\begin{bmatrix}\text{CATI: CASE: nom}\\ \text{REF: } \textcircled{1}[\text{SORT: } \textcircled{s}\text{human}]\end{bmatrix}\right\rangle \\
\text{RESULT:} & {}^{\text{vsem\_l}}\begin{bmatrix}\text{RIND:} & {}^{\text{eind}}\begin{bmatrix}\text{CAT: verb}\\ \text{REF: } \textcircled{2}\text{ atom\_ref}\\ \text{BASIC\_AKT: (Akt) act}\end{bmatrix}\\ \text{DRS:} & \boxed{\begin{array}{l}\textcircled{2}\\ \hline \text{essen}(\textcircled{2})\\ \text{agent}_{const}(\textcircled{2},\textcircled{1})\end{array}}\end{bmatrix}
\end{bmatrix}
$$

$$
\text{vsem\_t}\begin{bmatrix}
\text{LAMBDA:} & \left\langle {}^{\text{iind}}\begin{bmatrix}\text{CATI: CASE: akk}\\ \text{REF: } \textcircled{3}\end{bmatrix}, {}^{\text{iind}}\begin{bmatrix}\text{CATI: CASE: nom}\\ \text{REF: } \textcircled{1}[\text{SORT: } \textcircled{s}\text{human}]\end{bmatrix}\right\rangle \\
\text{RESULT:} & {}^{\text{vsem\_l}}\begin{bmatrix}\text{RIND:} & {}^{\text{eind}}\begin{bmatrix}\text{CAT: verb}\\ \text{REF: } \textcircled{2}\text{ atom\_ref}\\ \text{BASIC\_AKT: (Akt) act}\end{bmatrix}\\ \text{DRS:} & \boxed{\begin{array}{l}\textcircled{2}\\ \hline \text{essen}(\textcircled{2})\\ \text{agent}_{const}(\textcircled{2},\textcircled{1})\\ \text{object}_{grad}(\textcircled{2},\textcircled{3})\end{array}}\end{bmatrix}
\end{bmatrix}
$$

In both cases the *tmtv* specification constrains the tense/mood/diathesis information, which is stored at the resulting index, as follows:

$$
\text{RESULT:RIND:MTV:}\begin{bmatrix}
\text{MOOD:} & \text{ind}\\
\text{TFEAT:} & \begin{bmatrix}\text{LEVEL: past}\\ \text{PERF: no}\\ \text{PROG: no}\end{bmatrix}\\
\text{DIATHESIS:} & \text{active}
\end{bmatrix}
$$

In the entry (entries) for *essen* it is thus the syntactic valence—the specification of the SUBCAT feature—that decides which of the two semantic descriptions are built up. This is similar in even more complicated cases with different optional roles or with different syntactic descriptions of the roles.

• embedding verbs

In 3.9.2, we have treated the verbs of deontic relativization as a special case of embedding verbs. In the following, we content ourselves with this case and work out the example of (3d pers, sing, past of) *dürfen*:

durfte $\longrightarrow$

$$
{}_{\text{word}}\left[\text{SYNSEM:LOC:}\left[\begin{array}{l}
\text{CAT:}\left[\begin{array}{l}
\text{HEAD: ⓥ}\\
\text{SUBCAT:}\ \left\langle \begin{array}{l}\text{NP}_{\boxed{1}}\text{LOC:CONT:SEM:RESULT:LREFIND:②},\\ \text{VP[inf,SUBCAT:}\langle\text{NP}_{\boxed{1}}\rangle\text{]LOC:CONT:SEM:}\left[\begin{array}{l}\text{LAMBDA:}\langle ②\rangle\\ \text{RESULT: ③}\end{array}\right]\end{array}\right\rangle
\end{array}\right]\\
\text{CONT: SEM: }{}^{\text{lexsem(durfte)}}\left[\begin{array}{l}\text{LAMBDA: }\langle ③,②\rangle\\ \text{RESULT:RIND:CATI: ⓥ}\end{array}\right]
\end{array}\right]\right]
$$

It holds:

lexsem(durfte) := lexsem(dürfen) & tmtv(ind,tfeat(past,no,no),_).
where
lexsem(dürfen) :=
vsem(dürfen,deont,stative,[subj(n,theme,const,animal0),obj(binf,propcont,const,prop)],ss_raising).

Notice, first, that the description is conservative with respect to the usual HPSG setting for subject control verbs in that the index of the nominal object from the subcategorized DP is coindexed with the index of the DP for which the subcategorized VP subcategorizes and notice, second, that the lower referent of the subcategorized DP is coindexed with the corresponding index of the lambda prefix of the semantics of the subcategorized VP.

The instantiated *vsem* defines the following constraints:

$$
{}_{\text{vsem\_t}}\left[\begin{array}{l}
\text{LAMBDA: }\left\langle ①^{\text{vpsem\_l}},\ {}^{\text{iind}}\left[\begin{array}{l}\text{CATI: CASE: nom}\\ \text{REF: ②}\end{array}\right]\right\rangle\\
\text{RESULT:}\left[\begin{array}{l}
\text{RIND:}\left[\begin{array}{ll}\text{BASIC\_AKT:} & ③\text{stative}\\ \text{AKT:} & ③\\ \text{REF:} & ④\text{SORT: state}\end{array}\right]\\
\text{DRS:}\ \boxed{\begin{array}{l}④,\ ⑤@^{\text{prop}}\\ ④:\ \langle\text{dürfen deont}\rangle\ ⑤\\ ⑤:①\end{array}}
\end{array}\right]
\end{array}\right]
$$

• copula

We specify the copula use of *sein* as follows—using the example of 3d person, sing, past *war*:

war

$$\longrightarrow^{word}\begin{bmatrix}\text{SYNSEM:LOC:}\begin{bmatrix}\text{CAT:}\begin{bmatrix}\text{HEAD: ⓥ}\\ \text{SUBCAT: }\left\langle \begin{matrix}\text{LOC:CONT:SEM:RESULT:LREFIND: ①,}\\ \text{LOC:CONT:SEM:RESULT:②}\end{matrix}\right\rangle\end{bmatrix}\\ \text{CONT:SEM: }^{lexsem(war)}\begin{bmatrix}\text{LAMBDA: }\langle ②,①\rangle\\ \text{RESULT:RIND:CATI: ⓥ}\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

The semantics *lexsem(war)* is defined as follows:

lexsem(war) := lexsem(sein) & tmtv(ind,tfeat(past,no,no),_).

where

lexsem(sein) := copsem.

The *copsem* definition treats different cases of predicative complements. In case this complement is a singular indefinite DP, the copula extracts the representation of the maximal NP from the DP representation and, interpreting it as a one-place predicate, applies it to the referent of the subject:

$$^{cop\_t}\begin{bmatrix}\text{LAMBDA: }\left\langle^{dpsem\_l}\begin{bmatrix}\text{PDRS:CONDS: }\left\langle\begin{bmatrix}\text{A\_REF: } ① \text{ atom\_ref}\\ \text{A\_TYPE: indef}\\ \text{A\_RES: Ⓛ}\end{bmatrix}|\ldots\right\rangle\end{bmatrix}, [\text{REF: } ②]\right\rangle\\ \text{RESULT:}\begin{bmatrix}\text{RIND:}\begin{bmatrix}\text{BASIC\_AKT: } ③ \text{ stative}\\ \text{AKT: } ③\\ \text{REF: } ④\text{SORT: state}\end{bmatrix}\\ \text{DRS: } \boxed{\begin{matrix}④\\ ④{:}\boxed{Ⓛ \wedge \boxed{①=②}}\end{matrix}}\end{bmatrix}\end{bmatrix}$$

In case the predicative complement is a bare plural, quantified or definite DP, *copsem saturates* the DP (see 2.7.2) and identifies the DP referent with the subject referent:

$$^{cop\_t}\begin{bmatrix}\text{LAMBDA: }\left\langle ①^{dpsem\_l}[\text{REFIND:REF: } ②]\ \&\ ^{\sim}\begin{bmatrix}\text{PDRS:CONDS:}\left\langle\begin{bmatrix}\text{A\_REF atom\_ref}\\ \text{A\_TYPE: indef}\end{bmatrix}|\ldots\right\rangle\end{bmatrix}, [\text{REF: } ③]\right\rangle\\ \text{RESULT:}\begin{bmatrix}\text{RIND:}\begin{bmatrix}\text{BASIC\_AKT: } ④ \text{ stative}\\ \text{AKT: } ④\\ \text{REF: } ⑤\text{SORT: state}\end{bmatrix}\\ \text{DRS: } \boxed{\begin{matrix}⑤\\ ⑤{:}\boxed{\text{sat}(①) \wedge \boxed{②=③}}\end{matrix}}\end{bmatrix}\end{bmatrix}$$

For the definition of *saturation*, we stipulate:

$$\text{sat}(\textcircled{1}^{\text{sat\_dpsem\_l}}) := \textcircled{1}$$

$$\text{sat}\left({}^{\text{dpsem\_l}}\begin{bmatrix}\text{REFIND:} & \textcircled{1} \\ \text{PDRS:CONDS:} & \langle \textcircled{2}^{\text{alfa\_cond}}_{\text{labelvar}} | \ldots \rangle \\ \text{BOT:} & \end{bmatrix}\right) := {}^{\text{sat\_dpsem\_l}}\begin{bmatrix}\text{RIND:} & \text{SORT: empty} \\ \text{REFIND:} & \textcircled{1} \\ \text{LREFIND:} & \textcircled{1} \\ \text{DRS:} & \begin{bmatrix}\text{UNIV:} & \langle\rangle \\ \text{CONDS:} & \langle \textcircled{2} \rangle\end{bmatrix}\end{bmatrix}.$$

$$\text{sat}\left({}^{\text{dpsem\_l}}\begin{bmatrix}\text{REFIND:} & \textcircled{1}\text{REF:}\textcircled{2} \\ \text{PDRS:CONDS:} & \langle \textcircled{3}^{\text{abstrop\_cond}}_{\text{labelvar}} | \ldots \rangle \\ \text{BOT:} & \end{bmatrix}\right) := {}^{\text{sat\_dpsem\_l}}\begin{bmatrix}\text{RIND:} & \text{SORT: empty} \\ \text{REFIND:} & \textcircled{1} \\ \text{LREFIND:} & \textcircled{1} \\ \text{DRS:} & \begin{bmatrix}\text{UNIV:} & \langle \textcircled{2} \rangle \\ \text{CONDS:} & \langle \textcircled{3} \rangle\end{bmatrix}\end{bmatrix}.$$

$$\text{sat}\left({}^{\text{dpsem\_l}}\begin{bmatrix}\text{REFIND:} & \textcircled{1}\text{REF:}\textcircled{2}\text{SORT: nonempty} \\ \text{PDRS:CONDS:} & \langle \textcircled{3}^{\text{quant\_cond}}_{\text{labelvar}} | \ldots \rangle \\ \text{BOT:} & \end{bmatrix}\right) := {}^{\text{sat\_dpsem\_l}}\begin{bmatrix}\text{RIND:} & \text{SORT: empty} \\ \text{REFIND:} & \textcircled{1} \\ \text{LREFIND:} & \textcircled{1} \\ \text{DRS:} & \begin{bmatrix}\text{UNIV:} & \langle \textcircled{2} \rangle \\ \text{CONDS:} & \langle \text{sat}(\textcircled{3}) \rangle\end{bmatrix}\end{bmatrix}.$$

where:

$$\text{sat}\left(\begin{bmatrix}\text{QUANT:} & \textcircled{1} \\ \text{QU\_RES:} & \textcircled{2} \\ \text{QUANT\_VAR:} & \textcircled{3} \\ \text{QUANT\_SUM:} & \textcircled{4}\end{bmatrix}\right) := \begin{bmatrix}\text{QUANT:} & \textcircled{1} \\ \text{QU\_RES:} & \textcircled{2} \\ \text{QU\_SCOPE:} & \begin{bmatrix}\text{RIND:SORT: empty} \\ \text{DRS:} \boxed{?(\textcircled{4})}\end{bmatrix} \\ \text{QUANT\_VAR:} & \textcircled{3} \\ \text{QUANT\_SUM:} & \textcircled{4}\end{bmatrix}.$$

$$\text{sat}\left({}^{\text{dpsem\_l}}\begin{bmatrix}\text{RIND:} & \textcircled{1} \\ \text{REFIND:} & \textcircled{2} \\ \text{LREFIND:} & \textcircled{2} \\ \text{FSET:} & \textcircled{3} \\ \text{SUBS:} & \textcircled{4} \\ \text{BOT:} & \textcircled{5}^{\text{dpsem\_l\&labeldescr}}\end{bmatrix}\right) := {}^{\text{sat\_dpsem\_l}}\begin{bmatrix}\text{RIND:} & \textcircled{1}\text{SORT: empty} \\ \text{REFIND:} & \textcircled{2} \\ \text{LREFIND:} & \textcircled{2} \\ \text{FSET:} & \textcircled{3} \\ \text{SUBS:} & \textcircled{4} \\ \text{BOT:} & \text{sat}(\textcircled{5})\end{bmatrix}.$$

$$\text{sat}\left({}^{\text{dpsem\_l}}\begin{bmatrix}\text{RIND:} & \textcircled{1} \\ \text{REFIND:} & \textcircled{2} \\ \text{LREFIND:} & \textcircled{2} \\ \text{PDRS:} & \textcircled{3} \\ \text{SUBS:} & \textcircled{4} \\ \text{BOT:} & \textcircled{5}^{\text{dpsem\_l\&labeldescr}}\end{bmatrix}\right) := {}^{\text{sat\_dpsem\_l}}\begin{bmatrix}\text{RIND:} & \text{REF:}\textcircled{1}\text{SORT: empty} \\ \text{REFIND:} & \textcircled{2} \\ \text{LREFIND:} & \textcircled{2} \\ \text{PDRS:} & \textcircled{3} \\ \text{SUBS:} & \textcircled{4} \\ \text{BOT:} & \text{sat}(\textcircled{5})\end{bmatrix}.$$

We do not explicate these rules in detail. The outcome is as explained less formally in section 3.5. The copula also accepts Ns:

$${}_{\text{cop\_t}}\begin{bmatrix}\text{LAMBDA:} & \langle \textcircled{1}^{\text{nsem\_l}}[\text{RIND:REF: } \textcircled{2}], [\text{REF: } \textcircled{3}] \rangle \\ \text{RESULT:} & \begin{bmatrix}\text{RIND:} & \begin{bmatrix}\text{BASIC\_AKT:} & \textcircled{4}\text{ stative} \\ \text{AKT:} & \textcircled{4} \\ \text{REF:} & \textcircled{5}\text{SORT: state}\end{bmatrix} \\ \text{DRS:} & \boxed{\begin{array}{l}\textcircled{5} \\ \textcircled{5}\text{:}\boxed{\textcircled{1} \wedge \boxed{\textcircled{2}=\textcircled{3}}}\end{array}}\end{bmatrix}\end{bmatrix}$$

In addition, the copula accepts relational adjectives (and more generally APs):

$$
\text{cop\_t}\left[\begin{array}{ll}
\text{LAMBDA:} & \left\langle {}^{\text{npsem\_l}}\left[\begin{array}{l}\text{RIND:REF: } \textcircled{1}\\ \text{PDRS: } \textcircled{2}\\ \text{SUBS: } \langle(\_ \leq \_)\rangle\\ \text{BOT: } {}^{\text{npsem\_l\&labelvar}}\end{array}\right], \left[\text{REF: } \textcircled{1}\right]\right\rangle\\
\text{RESULT:} & \left[\begin{array}{ll}\text{RIND:} & \left[\begin{array}{ll}\text{BASIC\_AKT:} & \textcircled{3}\ \text{stative}\\ \text{AKT:} & \textcircled{3}\\ \text{REF:} & \textcircled{4}\text{SORT: state}\end{array}\right]\\ \text{DRS:} & \boxed{\begin{array}{l}\textcircled{4}\\ \hline \textcircled{4}:\textcircled{2}\end{array}}\end{array}\right]
\end{array}\right]
$$

There are also some embedding modifiers that have a predicative use, like *sicher, wahrscheinlich*, see example (81). Our modeling of these modifiers introduces a pDRS where the first condition is a modal embedding of a proposition DRF. The second condition describes this DRF (p-description), where the description is the argument of the modifier. Thus, for representing the predicative use, we just have to extract this first condition and identify its propositional DRF with the subject referent:

$$
\text{cop\_t}\left[\begin{array}{ll}
\text{LAMBDA:} & \left\langle {}^{\text{npsem\_l}}\left[\begin{array}{l}\text{PDRS:CONDS } \langle \textcircled{2}^{\text{modal\_cond}}\text{M\_ARG:}\textcircled{1} | \ldots \rangle\\ \text{BOT: } {}^{\text{npsem\_l\&labelvar}}\end{array}\right], \left[\text{REF: } \textcircled{1}\text{SORT: prop}\right]\right\rangle\\
\text{RESULT:} & \left[\begin{array}{ll}\text{RIND:} & \left[\begin{array}{ll}\text{BASIC\_AKT:} & \textcircled{3}\ \text{stative}\\ \text{AKT:} & \textcircled{3}\\ \text{REF:} & \textcircled{4}\text{SORT: state}\end{array}\right]\\ \text{DRS:} & \boxed{\begin{array}{l}\textcircled{4}\\ \hline \textcircled{4}:\boxed{\begin{array}{l}\\ \hline \textcircled{2}\end{array}}\end{array}}\end{array}\right]
\end{array}\right]
$$

One can extend the *saturation* procedure to adjective and noun representations via stipulating that noun representations are unchanged and that the saturation of the adjective is the result of applying the adjective representation to the empty DRS (whose result index is the index of the adjective representation). Using these extensions one can subsume the last four cases under one specification. We omit this here.

Our fragment considers one more case: predicative PPs. Since PPs introduce labelled structures with a functor set that consists of a (wide scope) DP representation and a representation of the prepositional operation (see section A.3.6), what we have to do is to treat the latter as a modifier of the subject referent, quite similar to the cases considered above, and to give the quantifier scope over the s-description that is introduced by the copula. Without introducing a further *cop_t*, this can be modeled within the composition rules. See the corresponding rule in section A.2.2, which shows that we have chosen the simplest solution for this case. We omit the case of quantifiers that can be used as (predicative) adjectives.

A.3.2 Nouns

Nouns may (optionally) subcategorize for roles, like verbs do. As in 3.2 we consider the case of relational nouns only. The example is *Freund/friend*:

Freund

$$\longrightarrow^{\text{word}}\left[\text{SYNSEM:LOC:}\left[\begin{array}{l}\text{CAT:}\left[\begin{array}{l}\text{HEAD: Ⓝ}\\ \text{SUBCAT: }\langle^{\text{det}}|\text{Ⓛ}\rangle\end{array}\right]\\ \text{CONT:SEM: }^{\text{lexsem(freund)}}\left[\begin{array}{l}\text{LAMBDA: relational(Ⓛ)}\\ \text{RESULT:RIND:CATI: Ⓝ}\end{array}\right]\end{array}\right]\right]$$

where *lexsem(freund)* is defined as follows:

lexsem(freund) := nsem(freund,human,[gsubj0(n,arg1&freund_von,const,human)],rel).

Obviously, we can use *relational* for exactly the same purposes as in the verb case: Relevant syntactic information is transferred to the semantic representation, syntactic and semantic valence are synchronized and, from this, linking is effectuated.

Similarly to the case of verbs, the first argument of the *nsem* macro is the name of the relation that is introduced, the second the sort of the introduced DRF, which, in case of event nominalizations specifies the situation class also and, therefore, takes over the function of the third *vsem* argument (for the Aktionsart). The third argument specifies the subcategorized roles and the fourth argument classifies the type of the noun. Because of the optional role which *Freund* specifies, similar to the *essen* example, the description can be expanded into two feature descriptions:

$$_{\text{nsem\_t}}\left[\begin{array}{l}\text{LAMBDA: }\langle\rangle\\ \text{RESULT: }_{\text{nsem\_l}}\left[\begin{array}{l}\text{RIND: }^{\text{iind}}\left[\begin{array}{l}\text{CATI: noun}\\ \text{REF: ① atom\_ref}\end{array}\right]\\ \text{DRS: }\boxed{\begin{array}{l}\text{①}\\ \text{freund(①)}\end{array}}\end{array}\right]\end{array}\right]$$

$$_{\text{nsem\_t}}\left[\begin{array}{l}\text{LAMBDA: }\left\langle^{\text{iind}}\left[\begin{array}{l}\text{CATI:CASE: gen}\\ \text{REF: ①[SORT: Ⓢhuman]}\end{array}\right]\right\rangle\\ \text{RESULT: }_{\text{nsem\_l}}\left[\begin{array}{l}\text{RIND: }^{\text{iind}}\left[\begin{array}{l}\text{CAT: noun}\\ \text{REF: ② atom\_ref}\end{array}\right]\\ \text{DRS: }\boxed{\begin{array}{l}\text{②}\\ \text{freund(②)}\\ \text{freund\_von(②,①)}\end{array}}\end{array}\right]\end{array}\right]$$

A.3.3 Determiners and quantifiers

We use singular and plural *der* and the universal quantifier *jeder* as examples:

$$\text{der}\longrightarrow^{\text{word}}\left[\text{SYNSEM:LOC:}\left[\begin{array}{l}\text{CAT: }\left[\begin{array}{ll}\text{HEAD:} & \text{NP}\\ \text{SUBCAT:} & \langle \text{N'}_{sg,(masc,nom;fem,dat;fem,gen)}\rangle\end{array}\right]\\ \text{CONT: SEM: }^{\text{detsem(def,sg)}}\end{array}\right]\right]$$

$$\text{der}\longrightarrow^{\text{word}}\left[\text{SYNSEM:LOC:}\left[\begin{array}{l}\text{CAT: }\left[\begin{array}{ll}\text{HEAD:} & \text{NP}\\ \text{SUBCAT:} & \langle \text{N'}_{pl,gen}\rangle\end{array}\right]\\ \text{CONT: SEM: }^{\text{detsem(def,pl)}}\end{array}\right]\right]$$

The arguments of *detsem* specify definiteness and number. For *def(inite) singular*, we obtain:

$$
{}_{\text{detsem\_t}}\left[\begin{array}{ll}
\text{LAMBDA:} & \langle \textcircled{1}^{\text{npsem\_l}}[\text{RIND: } \textcircled{2}\text{REF: } \textcircled{3}]\rangle \\
\text{RESULT:} & {}^{\text{detpsem\_l}}\left[\begin{array}{ll}
\text{NUMB:} & \textcircled{a} \\
\text{RIND:} & \textcircled{4} \\
\text{REFIND:} & \textcircled{2} \\
\text{LREFIND:} & \textcircled{2} \\
\text{PDRS:} & \boxed{\alpha_{def}(\textcircled{3},\textcircled{1})} \\
\text{SUBS:} & \langle \textcircled{b} \leq \textcircled{a}\rangle \\
\text{BOT:} & {}^{\text{labelvar}}\left[\begin{array}{ll}\text{RIND:} & \textcircled{4} \\ \text{NUMB:} & \textcircled{b}\end{array}\right]
\end{array}\right]
\end{array}\right].
$$

We have to consider also the case where the argument of the quantifier is a quantized phrase (*der eine Mann/the one man*). We omit the corresponding rule and show the treatment of the corresponding plural case (*die drei Männer/the three men*), which is quite similar in this respect:

$$
{}_{\text{detsem\_t}}\left[\begin{array}{ll}
\text{LAMBDA:} & \langle \textcircled{1}^{\text{qpsem\_l}}\left[\text{REFIND: } \left[\begin{array}{ll}\text{CATI:} & \textcircled{2} \\ \text{REF:} & \textcircled{3}\end{array}\right]\right]\rangle \\
\text{RESULT:} & {}^{\text{detpsem\_l}}\left[\begin{array}{ll}
\text{NUMB:} & \textcircled{a} \\
\text{RIND:} & \left[\begin{array}{ll}\text{CATI:} & \textcircled{i} \\ \text{REF:} & \text{res}(\langle\langle\textcircled{4},\textcircled{5}\rangle,\langle\textcircled{6},\textcircled{7}\rangle\rangle)\end{array}\right] \\
\text{REFIND:} & \left[\begin{array}{ll}\text{CATI:} & \textcircled{2} \\ \text{REF:} & \textcircled{3}\text{SORT: } \textcircled{8}\end{array}\right] \\
\text{LREFIND:} & \left[\begin{array}{ll}\text{CATI:} & \textcircled{2} \\ \text{REF:} & \text{res}(\langle\langle\textcircled{9},\textcircled{5}\rangle,\langle\textcircled{3},\textcircled{7}\rangle\rangle)\ \&\text{SORT: } \textcircled{8}\end{array}\right] \\
\text{PDRS:} & \boxed{\begin{array}{l}\alpha_{def}(\textcircled{3},\text{sat}(\textcircled{1})) \\ \textcircled{3},\textcircled{4}{::}\left[\begin{array}{ll}\text{RIND:REF:} & \textcircled{9} \\ \text{DRS:} & \boxed{\begin{array}{l}\textcircled{9} \\ \textcircled{9} \in_i \textcircled{3}\end{array}}\end{array}\right] \diamondsuit\!\!\left\langle\begin{array}{c}\text{jed} \\ \text{univ\_qu} \\ \textcircled{9} \\ \text{pl\_qu}\end{array}\right\rangle [\text{NUMB: } \textcircled{b}]\end{array}} \\
\text{SUBS:} & \langle \textcircled{5}(\textcircled{c} \leq \textcircled{b}) \vee \textcircled{7}(\textcircled{c} \leq_n \textcircled{a})\rangle \\
\text{BOT:} & {}^{\text{labelvar}}\left[\begin{array}{ll}\text{RIND:} & \left[\begin{array}{ll}\text{CATI:} & \textcircled{i} \\ \text{REF:} & \textcircled{6}\end{array}\right] \\ \text{NUMB:} & \textcircled{c}\end{array}\right]
\end{array}\right]
\end{array}\right].
$$

Next to the illustration of how the quantized argument is saturated and used as restriction of the definite α-condition, we can see the modeling of the optional distribution here. Of course, as in the paper, *res* models a function with delayed evaluation. For a realization of this (and other types of) postponed evaluation, see A.4. We skip, spelling out the plural case with *npsem_l* argument (where the NP semantics is the argument of a summation *abstrop* condition which specifies the restriction of the introduced α-condition, see section A.4) and turn to the sample quantifier entry:

$$
\text{jeder} \longrightarrow^{\text{word}}\left[\text{SYNSEM:LOC: } \left[\begin{array}{ll}\text{CAT:} & \left[\begin{array}{ll}\text{HEAD:} & \text{NP} \\ \text{SUBCAT:} & \langle \text{N'}_{sg,masc,nom}\rangle\end{array}\right] \\ \text{CONT: SEM:} & {}^{\text{quantop(jed,univ\_qu\&sg\_qu).}}\end{array}\right]\right]
$$

The first argument of *quantop* is the name of the quantifier, the second the type. As explained in the paper, it depends of the type, whether the collective reading is allowed or whether there is a non-empty (upper) referential index. The quantifier *jeder* is always distributive and never introduces a referent for DP modification (indicated by the empty upper index), therefore:

quantop($\textcircled{N}$jed,$\textcircled{T}$univ_qu& sg_qu) :=

$$
{}^{\text{quantop\_t}}\left[\begin{array}{ll}
\text{LAMBDA: } \langle \textcircled{1}^{\text{npsem\_l}}\text{RIND: } \left[\begin{array}{ll}\text{CATI: } \textcircled{2} \\ \text{REF: } \textcircled{3}\end{array}\right]\rangle & \\
\text{RESULT: } {}^{\text{detpsem\_l}}\left[\begin{array}{ll}
\text{RIND: } & \text{REF: } \textcircled{4} \\
\text{REFIND: } & \left[\begin{array}{ll}\text{CATI: } \textcircled{2} \\ \text{REF: } \text{SORT: empty}\end{array}\right] \\
\text{LREFIND: } & \left[\begin{array}{ll}\text{CATI: } \textcircled{2} \\ \text{REF: } \textcircled{3}\end{array}\right] \\
\text{PDRS: } & \boxed{\begin{array}{l}\textcircled{4},\ \textcircled{5} \\ \textcircled{5},\ \textcircled{4}{::}\ \textcircled{1} \Diamond\!\left(\textcircled{N}\ \textcircled{T}\ \textcircled{3}\right) [\text{NUMB: } \textcircled{a}]\end{array}} \\
\text{SUBS: } & \langle \textcircled{b} \leq \textcircled{a} \rangle \\
\text{BOT: } & {}^{\text{labelvar}}[\text{NUMB: } \textcircled{b}]
\end{array}\right]
\end{array}\right].
$$

Note that a number of coreferences need not to be stipulated by the quantifier description, they are inherited from the percolation principle, such as the CATI correspondences for instance. We have made explicit such correspondences and do it also in others for the sake of transparence.

Interpreting the abbreviations as defined, we easily obtain the other values of *quantop* from the stipulations of section 3.4. Note that with respect to *pl_qu* quantifiers like *wenige (few), alle (all)*, which allow for the collective reading and DP modification, the only difference is that the value of REFIND:REF is coindexed with $\textcircled{5}$ and SUBS introduces the disjunction ($\textcircled{b} \leq \textcircled{a} \vee \textcircled{b} \leq {}_{n}\textcircled{c}$), where $\textcircled{c}$ is the NUMB value of the RESULT structure. (In case of disambiguation to the collective reading, $\textcircled{4}$ will be identified with the 'dummy' DRF via SORT: ${}^{\text{empty}}$).

A.3.4 Adverbs and adjectives

The contributions of adverbs and adjectives are very similar. Therefore we present a relational adverb (and omit the corresponding adjective example), and an embedding adjective (skipping the adverbial analogue).

$$
\text{schnell} \longrightarrow^{\text{word}} \left[\text{SYNSEM:LOC: } \left[\begin{array}{ll}\text{CAT: } & \left[\begin{array}{ll}\text{HEAD: } & {}^{\text{adv}}[\text{MOD:V'}] \\ \text{SUBCAT: } & \langle\rangle\end{array}\right] \\ \text{CONT: SEM: } & {}^{\text{advsem(schnell,velocity,rel\_facet)}}\end{array}\right]\right]
$$

$$\text{möglich} \longrightarrow^{\text{word}} \left[\text{SYNSEM:LOC:} \left[\begin{array}{ll} \text{CAT:} & \left[\begin{array}{ll} \text{HEAD:} & ^{\text{adj}}[\text{MOD:N'}] \\ \text{SUBCAT:} & \langle\rangle \end{array} \right] \\ \text{CONT: SEM:} & ^{\text{adjsem(moeglich,\_,modop).}} \end{array} \right] \right]$$

The first argument of the 3-place modifier macros is the name of the relation or the operator, the second is the type of the relation or operation, and the third argument classifies the modifier. The definitions are as follows:

advsem(Ⓝ,Ⓣ,rel_facet) :=

$$_{\text{rel\_mod\_t}} \left[\begin{array}{ll} \text{LAMBDA:} & \left\langle \textcircled{1}^{\text{vpsem\_l}} \left[\begin{array}{ll} \text{RIND:REF:} & \textcircled{2} \\ \text{NUMB:} & \textcircled{a} \end{array} \right] \right\rangle \\ \text{RESULT:} & ^{\text{vpsem\_l}} \left[\begin{array}{ll} \text{NUMB:} & \textcircled{b} \\ \text{PDRS:} & \boxed{\textcircled{N}_{\textcircled{T}}(\textcircled{2},^{\text{facet}})} \\ \text{SUBS:} & \langle \textcircled{a} \leq \textcircled{b} \rangle \\ \text{BOT:} & \textcircled{1} \end{array} \right] \end{array} \right].$$

adjsem(Ⓝ,Ⓣ,modop) :=

$$_{\text{modop\_t}} \left[\begin{array}{ll} \text{LAMBDA:} & \left\langle \textcircled{1}^{\text{npsem\_l}} \left[\begin{array}{ll} \text{RIND:REF:} & \textcircled{2} \\ \text{NUMB:} & \textcircled{a} \end{array} \right] \right\rangle \\ \text{RESULT:} & ^{\text{npsem\_l}} \left[\begin{array}{ll} \text{RIND:REF:} & \textcircled{3} \\ \text{NUMB:} & \textcircled{b} \\ \text{PDRS:} & \boxed{\begin{array}{l} \textcircled{4}\text{@prop},\ \textcircled{3} \\ \Diamond\!\left(\begin{array}{c}\textcircled{N} \\ \textcircled{T}\end{array}\right) \textcircled{4} \\ \textcircled{4}:\boxed{\textcircled{1} \wedge \boxed{\textcircled{2}=\textcircled{3}}} \end{array}} \\ \text{SUBS:} & \langle \textcircled{a} < \textcircled{b} \rangle \\ \text{BOT:} & \textcircled{1} \end{array} \right] \end{array} \right].$$

The adverb *schnell* is an example of the *rel-facet* class of relational modifiers (the second argument of the introduced relation is a 'facet', i.e., a predicate). There is also the *rel* class that introduces one place relations (and that, for instance, contains the colour adjectives).

A.3.5 Conjunctions

The fundamental HPSG presentation in [Pollard/Sag(1994)] is not very explicit with respect to conjunctions. Coordinations are treated as tripartite structures consisting of the two conjuncts and the conjunction word which is classified as a marker. Subordinating conjunctions are not dealt with. In 3.7.1, we have understood the semantic contribution of subordinating conjunctions to be very similar to that of prepositions: Both subcategorize for an internal argument (a DP in the preposition case, a sentence in the other) and, after consumption of this argument result in a modifier of the external argument (a VP or NP in the preposition case and a VP in the subordination case). In the following, we stick to this similarity and assume a corresponding syntactic characterization. What is said about prepositions in [Pollard/Sag(1994)] is also little . For the purpose of this appendix, which is to demonstrate that the developed semantics easily can be incorporated into the HPSG framework, we want to be as neutral as possible however and thus, instead of relating to ongoing developments, content ourselves with a canonical extrapolation of the indications of [Pollard/Sag(1994)].

• subordinating conjunctions

We stipulate that subordinating conjunctions subcategorize for a saturated VP and modify a VP. We use *weil* for an example:

$$\text{weil} \longrightarrow^{\text{word}} \left[\text{SYNSEM:LOC:} \left[\begin{array}{ll} \text{CAT:} & \left[\begin{array}{ll} \text{HEAD:} & {}^{\text{adv}}[\text{MOD:V'}] \\ \text{SUBCAT:} & \langle \text{S}_{fin} \rangle \end{array} \right] \\ \text{CONT: SEM:} & {}^{\text{lexsem(weil)}} \end{array} \right] \right].$$

It holds:

lexsem(weil) := subordsem(weil,explicrel).

The first argument of the *subordsem* macro is the name of the relation introduced, as nearly always. The second argument defines the type of this relation. There are *subordsem* relations that relate the distinguished DRFs of internal and external argument, like *temp_rel*, and there are others. *explic_rel* is a *discourse relation* and, as such, relates the situations that are described by internal and external argument. subordsem(Ⓝweil,Ⓣexplic_rel) builds up the following structure:

$$^{\text{subord\_t}}\left[\begin{array}{ll} \text{LAMBDA:} & \langle \textcircled{1}^{\text{satvpsem\_l}}[\text{RIND:REF:}\textcircled{2}], \textcircled{3}^{\text{vpsem\_l}}[\text{RIND: } \textcircled{4}\text{REF:}\textcircled{5}] \rangle \\ \text{RESULT:} & ^{\text{vpsem\_l}}\left[\begin{array}{ll} \text{RIND:} & \textcircled{4} \\ \text{NUMB:} & \textcircled{a} \\ \text{PDRS:} & \boxed{\begin{array}{l} \textcircled{6}\ \textcircled{7} \\ \textcircled{N}\text{weil}_{\textcircled{T}}(\textcircled{6},\textcircled{7}) \\ \textcircled{6}\text{:sat\_tense}(\textcircled{1}) \\ \textcircled{7}\text{:}(\begin{array}{|l|} \hline \text{t} \\ \textcircled{2} \text{ meets t} \\ \text{res}(\langle (\textcircled{5} = \text{t})_{\textcircled{5}@^{\text{int}}_{akt(hom)}}, (\textcircled{5} \subseteq \text{t})_{akt(het);@^{(\text{state;process})}} \rangle) \\ \hline \end{array} \wedge \textcircled{3}) \end{array}} \\ \text{SUBS:} & \langle \textcircled{b} < \textcircled{a} \rangle \\ \text{BOT:} & \textcircled{3}\text{NUMB:}\textcircled{b} \end{array} \right] \end{array} \right].$$

We obtain similar results for other discourse relations. Notice that discourse relations, in addition to relating the situational DRFs of the representation, may (as an entailment) introduce a second relation that connects the distinguished (event) DRFs of the representations to each other. Normally, this is a temporal relation, as with *explic_rel*. Also as here, it may be that, depending on the Aktionsart of the arguments, different cases must be distinguished. However, we do not assume that every temporal relation from a subordinating conjunction is (directly) connected to a discourse relation, see the modeling of *nachdem* in section 3.7.1. We skip spelling out *sat_tense* here. This is just a reformulation of the algorithm sketched in section 3.11.

• coordinating conjunctions

We omit specifying the coordinating sentential adverbs. (An example is *deshalb (therefore)*). Very similarly to the above described subordinating conjunctions they introduce a discourse relation with the very difference that the first argument is not asserted by the modificandum, but is presupposed. Syntactically, they conform to the adverb description treated further above.

We present the coordination *und*:

und

$$\longrightarrow^{\text{word}} \left[\text{SYNSEM:LOC:} \begin{bmatrix} \text{CAT:} & \begin{bmatrix} \text{HEAD:} & {}^{\text{mark}}[\text{SPEC: XP}] \\ \text{MARKING:} & \text{conj} \end{bmatrix} \\ \text{CONT: SEM:} & {}^{\text{lexsem(und)}}[\text{LAMBDA: } \langle \text{trans\_cati(XP), trans\_cati(XP)} \rangle] \end{bmatrix} \right]$$

trans_cati determines the correct categorial information about the items of the lambda prefix of coordinating conjunctions:

$$\begin{array}{lll} \text{trans\_cati(LOC:CAT: NP[CASE: ⓒ])} & := & {}^{\text{dpsem\_l}}[\text{LREFIND:CATI:CASE: ⓒ}] \\ \text{trans\_cati(LOC:CAT: N'[CASE: ⓒ])} & := & {}^{\text{npsem\_l}}[\text{RIND:CATI:CASE: ⓒ}] \\ \text{trans\_cati(LOC:CAT: VP[VFORM: ⓒ])} & := & {}^{\text{vpsem\_l}}[\text{RIND:CATI:VFORM: ⓒ}] \end{array}$$

(As in section 3.7.2, we consider DP, NP and VP coordination only). We stipulate:

lexsem(und) := coordsem(und,flat).
where coordsem(Name,flat) is defined as in 3.7.2, namely as follows:

$${}_{\text{coord\_t}} \begin{bmatrix} \text{LAMBDA:} & \langle ①,② \rangle \\ \text{RESULT:} & \underline{\text{Name}}(①,②) \end{bmatrix}$$

We come back to the semantics of *und* below in A.4 as an example of flat semantics and its expansion. With coordinating conjunctions as part of the fragment, we have to extend the Semantics Principle by the following constraint:

$$\text{DTRS: coord-struc} \;\; < \begin{bmatrix} \text{SYNSEM:LOC:CONT:SEM: m\_apply\_rec(Ⓛ,Ⓕ)} \\ \text{DTRS:} \begin{bmatrix} \text{CONJUNCTION-DTR: SYNSEM:LOC:CONT:SEM: Ⓕ} \\ \text{CONJ-DTRS: Ⓛ} \end{bmatrix} \end{bmatrix}$$

We define the procedure *m_apply_rec* as follows:

m_apply_rec(⟨[SYNSEM:LOC:CONT:SEM: Ⓐ], [SYNSEM:LOC:CONT:SEM: Ⓑ]⟩,Ⓕ)
:= compose(compose(Ⓑ,Ⓕ),Ⓐ)

$$\text{m\_apply\_rec}(\langle[\textsc{synsem:loc:cont:sem:}\ \textcircled{A}],\ [\textsc{synsem:loc:cont:sem:}\ \textcircled{B}]|\ \textcircled{R}^{\text{nelist}}\rangle,\textcircled{F})$$
$$:= \text{m\_apply\_rec}(\langle\text{compose}(\text{compose}(\textcircled{B},\ \text{copy}(\textcircled{F})),\textcircled{A})|\ \textcircled{R}\rangle,\textcircled{F}).$$

Of course, we assume that, w.r.t. coordinated structures, inheritance of slashes, indices etc. remains as specified in the particular HPSG formulation that is at the basis of the semantics incorporation.

A.3.6 Prepositions

Prepositions are treated as follows (the example is *mit*):

$$\text{mit} \longrightarrow$$
$$_{\text{word}}\begin{bmatrix} \textsc{synsem:loc:} & \begin{bmatrix} \textsc{cat:} & \begin{bmatrix} \textsc{head:} & {}^{\text{prep}}\begin{bmatrix} \text{PFORM:} & \text{mit} \\ \text{MOD:} & \text{XP} \end{bmatrix} \\ \textsc{subcat:} & \langle \text{NP}[\textsc{case:}\ \textcircled{c}] \rangle \end{bmatrix} \\ \textsc{cont:}\ \textsc{sem:} & {}^{\text{lexsem(mit)}}\textsc{lambda:}\ \langle \textsc{lrefind:cati:case:}\textcircled{c}, \text{trans\_cati(XP)} \rangle \end{bmatrix} \end{bmatrix}$$

Notice that here, as in a number of other lexical entries that we have specified so far, there is no exhaustive transfer of the information about the subcategorized functions or the modified or specified object to the lambda prefix of the lexical item considered. This regards on the one hand syntactic information. (The type specifications that result from DPs, NPs, VPs, in turn, are also satisfied by DP-, NP-, VP-modifiers, since there is no constraint about the internal shape of the corresponding labelled structure). Here, in order to rule out incorrect semantic composition, the categorial requirements of the composition rules do the necessary filtering: Note that the *sem_t*-information that is introduced with the description of the lexical items is much more fine grained than the type information that can be entailed from the categorial information that is connected to the labelled structures or indices that make up the LAMBDA prefix and the RESULT of the considered specific *sem_t* description. It is exactly this further information that, without risk of losing relevant constraints, allows for the relatively abstract typology of the labelled structures. This setting ensures a reasonable restriction of the stand alone version of the compositional semantics and, of course, incorporating the semantics into a grammar theory, we obtain additional, syntactically motivated constraints about licensed semantic structures. The HPSG setting, on the other hand, also would allow for a more exhaustive transfer of information about the semantic content from the subcategorized functions or the objects that are to be modified or specified to what in HPSG is called the semantic head. That is, with regard to this potentially available information, one could spell out the semantic composition directly at the semantic head and percolate the result upwards along the semantic projection line. This is what the Semantics Principle of [Pollard/Sag(1994)], which we have formalized further above in A.2.1, suggests at first glance. However, a closer look makes clear that this relates to the percolation of *nom-object* information and to the *nucleus semantics* of a *psoa* content only, and, in the latter case, depending on the decisions about the scope of quantifiers, to the retrieved quantifiers. And notice that the retrieval of a quantifier is possible only at ancestor nodes of the node that introduces the quantifier. Let as consider the *psoa* case first. On the basis of our (redefined) UDRT framework, which is more expressive with regard to scope constraints than the quantifier storage mechanism of [Pollard/Sag(1994)] and which allows for adding the quantifier representation to the nucleus semantics at the mother node of the quantifier node without any anticipation about the final scopal outcome and which, therefore, allows for a simple uniform application of quantifiers that avoids postponed retrieval, our Semantics Principle of A.2.1 satisfies to the HPSG philosophy about the distribution of semantic information over the nodes of a nucleus projection line: Because of the rich structure that our semantic representations show, the nucleus semantics that is percolated upwards can be identified as the BOT-semantics of the complex representation that is built up, where the application of quantifiers (and other embedding operators) consists of adding corresponding functors to the FSET of this complex representation. Thus, our approach is compatible with the original HPSG picture in this respect. It deviates from it, however, with respect to the percolation of *nom-obj* information. In [Pollard/Sag(1994)] the content of a (relational) adjective is a nom-obj structure that subsumes the (say, bare) adjective semantics and the semantics of the modified N'. It is this information that is percolated from the adjective node to the modified N' node. We abstain from this setting, however, because then there is no longer a Montagovian style (homomorphic) correspondence between syntactic and semantic representation and, in order to reinstall the basics of this picture, i.e., in order to determine the 'true' semantic contribution of a node from the asserted complex representation—a faculty that is desirable in many respects, for a recursively defined machine translation component that operates over semantic structures for instance (see [Zajac(1989), Eberle(1995)])—there have to be defined specific retrieval mechanisms. Also there is the problem of uninstantiated parts of the semantic representation. With the setting that we suggest here, though through the clustering of information it would be even more suited for dealing with these kinds of problems than the original HPSG framework we nevertheless have tried to reduce such difficulties to a minimum. Summarizing this short excursion, we can say that under the Semantics Principle of A.2.1, we obtain a semantic composition that parallels the syntactic composition, where the means of λ-conversion ensures that the items of λ- prefixes are constrained and finally instantiated in the correct way.

For *lexsem(mit)*, we require:
lexsem(mit) := prepsem(mit,_,rel).

As discussed in 3.8, prepositions can build up *rel(ational)* modifiers or *emb(edding)* modifying *op(erations)* (within the scope of the internal DP argument). Here, for illustration of the macro, we introduce the relation case only. For the specifications of other cases, see the indications of 3.8 and the section about flat semantics below.

prepsem(Ⓝmit,Ⓣ,rel) :=

$$
{}_{\text{prepsem\_t}}\begin{bmatrix}
\text{LAMBDA:} & \langle \textcircled{1}^{\text{dpsem\_l}}, \textcircled{2}^{\text{vnpsem\_l}} \rangle \\
\text{RESULT:} & {}_{\text{vnpsem\_l}}\begin{bmatrix}
\text{RIND:} & \textcircled{7} \\
\text{REFIND:} & \begin{bmatrix} \text{CATI:} & \begin{bmatrix} \text{PPFORM:} & \textcircled{N} \\ \text{PPCASE:} & \textcircled{3} \end{bmatrix} \\ \text{REF:} & \textcircled{4} \end{bmatrix} \\
\text{FSET:} & \Big\langle \textcircled{1} \begin{bmatrix} \text{RIND:} & \textcircled{7} \\ \text{REFIND:} & \begin{bmatrix} \text{CATI: CASE:} \textcircled{3} \\ \text{REF:} \ \textcircled{4} \end{bmatrix} \\ \text{LREFIND: REF:} & \textcircled{5} \\ \text{NUMB:} & \textcircled{a} \end{bmatrix}, {}_{\text{vnpsem\_l}}\begin{bmatrix} \text{NUMB:} & \textcircled{b} \\ \text{PDRS:} & \boxed{\textcircled{N}\text{mit}_{\textcircled{T}}(\textcircled{6},\textcircled{5})} \\ \text{SUBS:} & \langle \textcircled{c} \leq \textcircled{b} \rangle \\ \text{BOT:} & {}_{\text{vnpsem\_l}}\begin{bmatrix} \text{NUMB:} & \textcircled{c} \\ \text{RIND:} & \text{REF:} \ \textcircled{6} \end{bmatrix} \end{bmatrix} \Big\rangle \\
\text{SUBS:} & \langle \textcircled{b} \leq \textcircled{a} \rangle \\
\text{BOT:} & \textcircled{2}
\end{bmatrix}
\end{bmatrix}
$$

Certain PPs allow DP modification also (not *mit*, but, for instance, the provenience specifying *aus*). For this DP-modification case, we stipulate the following evaluation of the prepsem-macro:

prepsem(Ⓝ,Ⓣ,rel) :=

$$
{}_{\text{prepsem\_t}}\begin{bmatrix}
\text{LAMBDA:} & \langle \textcircled{1}^{\text{dpsem\_l}}, \textcircled{2}^{\text{dpsem\_l}} \rangle \\
\text{RESULT:} & {}_{\text{dpsem\_l}}\begin{bmatrix}
\text{RIND:} & \textcircled{7} \\
\text{REFIND:} & \begin{bmatrix} \text{CATI:} & \begin{bmatrix} \text{CASE:} & \textcircled{3} \\ \text{REF:} & \text{empty} \end{bmatrix} \\ \text{REF:} & \textcircled{4} \end{bmatrix} \\
\text{FSET:} & \Big\langle \textcircled{1} \begin{bmatrix} \text{RIND:} & \textcircled{7} \\ \text{REFIND:} & \begin{bmatrix} \text{CATI: CASE:} \textcircled{3} \\ \text{REF:} \ \textcircled{4} \end{bmatrix} \\ \text{LREFIND: REF:} & \textcircled{5} \\ \text{NUMB:} & \textcircled{a} \end{bmatrix}, {}_{\text{dpsem\_l}}\begin{bmatrix} \text{REFIND:} & \textcircled{8} \\ \text{NUMB:} & \textcircled{b} \\ \text{PDRS:} & \boxed{\textcircled{N}_{\textcircled{T}}(\textcircled{6},\textcircled{5})} \\ \text{SUBS:} & \langle \textcircled{c} \leq \textcircled{b} \rangle \\ \text{BOT:} & {}_{\text{dpsem\_l}}\begin{bmatrix} \text{NUMB:} & \textcircled{c} \\ \text{REFIND:} & \textcircled{8}\big[\text{REF:} \ \textcircled{6}\big] \end{bmatrix} \end{bmatrix} \Big\rangle \\
\text{SUBS:} & \langle \textcircled{b} \leq \textcircled{a} \rangle \\
\text{BOT:} & \textcircled{2}\big[\text{REFIND:CATI:CASE:} \ \textcircled{3}\big]
\end{bmatrix}
\end{bmatrix}
$$

Note that the outermost referential index does not specify a referent. This is no problem if we assume that nested quantification is not recursive. In case, we allow for recursive nested quantification, we have to revise the embedded DP semantics (the first item of the FSET-list) in such a way that, in addition, it introduces a DRF which sums up the DRFs specified by ⑥. This DRF is the referent of the outermost referential index then. We omit this here.

A.3.7 Complementizers

The lexical entry for the complementizer *daß* reads as follows:

daß $\longrightarrow$

$$\text{word}\left[\text{SYNSEM:LOC: }\left[\begin{array}{l}\text{CAT: }\left[\begin{array}{l}\text{HEAD: }^{\text{mark}}[\text{SPEC: S}[\tilde{}\text{comp,LOC:CONT.SEM: satvpsem\_t}]]\\ \text{MARKING: comp}\end{array}\right]\\ \text{CONT: SEM: }^{\text{lexsem(daß)}}\end{array}\right]\right]$$

where lexsem(daß) := complsem(dass) and:
complsem(dass;ob) :=

$$\text{complementizer\_t}\left[\begin{array}{l}\text{LAMBDA: }\langle ①^{\text{satvpsem\_l}}, ②^{\text{vnpsem\_l}}[\text{RIND: } ③]\rangle\\ \text{RESULT: }^{\text{ssem\_l}}\left[\begin{array}{ll}\text{RIND: incirc3} & \\ \text{REFIND:} & \text{REF: } ④\text{SORT:}^{\text{prop}}\\ \text{NUMB: } ⓐ & \\ \text{PDRS:} & \boxed{\begin{array}{l}④\\ ④\text{:sat\_tense}(①)\end{array}}\\ \text{SUBS: }\langle ⓑ \leq ⓐ\rangle & \\ \text{BOT: } ②[\text{NUMB: } ⓑ] & \end{array}\right]\end{array}\right].$$

Notice that, in contrast to [Pollard/Sag(1994)], the semantics of the complementizer is not empty. As explicated in 3.10, it is convenient to understand it as introducing a semantic 'marker' for the complement sentence, i.e., a propositional DRF that is described by the sentence representation.

A.3.8 Relative pronouns

In [Pollard/Sag(1994)] relative clauses are analyzed into a headed structure whose head is a so called (null) relativizer and whose complements are the constituent that contains the relative pronoun and either a sentence with a slashed complement or a VP (in the sense of HPSG). In the first case, the slashed complement is bound by the LOC-value of the relative pronoun constituent, in the second case the missing subject complement is identified to this constituent. The relative pronoun is analyzed as a DP which puts an item onto the INHER:REL-store. We adopt this analysis and therefore revise our analysis of relative pronouns in 3.12 accordingly. For the slashed category variant, we stipulate:

null relativizer $\longrightarrow$

$$\text{SYNSEM: }\left[\begin{array}{l}\text{LOC: }\left[\begin{array}{l}\text{CAT: }\left[\begin{array}{l}\text{HEAD: }^{\text{rltvzr}}[\text{MOD: N'}[\text{TO-BIND:REL: }\{①\}]\text{: }[\text{INDEX: } ①]]\\ \text{SUBCAT: }\left\langle\begin{array}{l}[\text{LOC: } ②\text{, INHER:REL: }\{①\}]\text{: }[\text{SEM:RESULT:}③],\\ \text{S}[\text{fin,unmarked,INHER:SLASH: }\{②\}]\text{: }[\text{SEM:RESULT:}④]\end{array}\right\rangle\end{array}\right]\\ \text{CONT: }^{\text{rltvzrsem(satvp)}}[\text{LAMBDA: }\langle ④,③\rangle]\end{array}\right]\\ \text{NONLOC:TO-BIND:SLASH: }\{②\}\end{array}\right]$$

In case the relativizer undergoes the Subject Extraction Lexical Rule, we obtain the VP complement case, for which we stipulate the following (compare also [Pollard/Sag(1994)]:218ff.)

null relativizer $\longrightarrow$

$$\begin{bmatrix} \text{SYNSEM: } \begin{bmatrix} \text{LOC: } \begin{bmatrix} \text{CAT: } \begin{bmatrix} \text{HEAD: } {}^{\text{rltvzr}}\left[\text{MOD: N'[TO-BIND:REL: } \{\textcircled{1}\}]\text{: } [\text{INDEX: } \textcircled{1}]\right] \\ \text{SUBCAT: } \left\langle \begin{matrix} \textcircled{2}\text{NP[INHER:REL: } \{\textcircled{1}\}]\text{:[SEM:RESULT:}\textcircled{3}], \\ \text{VP[fin,SUBCAT: } \langle \textcircled{2}\text{LOC:}\textcircled{4}\rangle]\text{:[SEM:RESULT:}\textcircled{5}] \end{matrix} \right\rangle \end{bmatrix} \\ \text{CONT: } {}^{\text{rltvzrsem(nsatvp)}}[\text{LAMBDA: } \langle \textcircled{5},\textcircled{3}\rangle] \end{bmatrix} \\ \text{NONLOC: } \begin{bmatrix} \text{TO-BIND:SLASH: } \{\textcircled{4}\} \\ \text{INHER:SLASH: } \{\textcircled{4}\} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

In 3.12, we have argued that relative clauses should be allowed to modify DPs also. We easily obtain this extension, if we accept relativizer descriptions also that develop from the presented requirements by exchanging N' for NP. As an example of the relative pronoun characterization, we render the relevant parts of the representation of *den (whom)*:

$$\text{den} \longrightarrow^{\text{word}} \begin{bmatrix} \text{SYNSEM: } \begin{bmatrix} \text{LOC: } \begin{bmatrix} \text{CAT: } \begin{bmatrix} \text{HEAD: } {}^{\text{noun}}[\text{akk}] \\ \text{SUBCAT: } \langle\rangle \end{bmatrix} \\ \text{CONT: } \begin{bmatrix} \text{IND: } \textcircled{1} \\ \text{SEM: } {}^{\text{relprosem(sg)}} \end{bmatrix} \end{bmatrix} \\ \text{NONLOC: } \begin{bmatrix} \text{INHER: } \begin{bmatrix} \text{QUE: } \{\} \\ \text{REL: } \{\textcircled{1}\} \\ \text{SLASH: } \{\} \end{bmatrix} \\ \text{TO-BIND: } \begin{bmatrix} \text{QUE: } \{\} \\ \text{REL: } \{\} \\ \text{SLASH: } \{\} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The macro *relprosem* takes *sg* or *pl* as argument. It is defined as follows:

relprosem(_) :=

$${}^{\text{relpro\_t}} \begin{bmatrix} \text{LAMBDA: } \langle\rangle \\ \text{RESULT: } {}^{\text{dpsem\_l}} \begin{bmatrix} \text{RIND: } \textcircled{1} \\ \text{REFIND: } \textcircled{2} \begin{bmatrix} \text{CATI: noun} \\ \text{REF: atom\_ref} \end{bmatrix} \\ \text{LREFIND: } \textcircled{2} \\ \text{NUMB: } \textcircled{a} \\ \text{PDRS: } [\,] \\ \text{SUBS: } \langle \textcircled{b} \leq \textcircled{a} \rangle \\ \text{BOT: } {}^{\text{vpsem\_l}} \begin{bmatrix} \text{RIND: } \textcircled{1} \\ \text{NUMB: } \textcircled{b} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

relprosem(pl) :=

$$
{}_{\text{relpro\_t}}\left[\begin{array}{l}
\text{LAMBDA: } \langle\rangle \\
\text{RESULT: } {}^{\text{dpsem\_l}}\left[\begin{array}{l}
\text{RIND:REF: } \text{res}(\langle\langle \textcircled{5},\textcircled{3}\rangle,\langle\textcircled{6},\textcircled{4}\rangle\rangle) \\
\text{REFIND: } \left[\begin{array}{l}\text{CATI: noun}\\ \text{REF: } \textcircled{1}^{\text{sum\_ref}}\end{array}\right] \\
\text{LREFIND:REF: } \text{res}(\langle\langle \textcircled{2},\textcircled{3}\rangle,\langle\textcircled{1},\textcircled{4}\rangle\rangle) \\
\text{NUMB: } \textcircled{a} \\
\text{PDRS: } \boxed{\begin{array}{l}\textcircled{5}\\ \textcircled{1},\textcircled{5}: \boxed{\begin{array}{l}\textcircled{2}\\ \textcircled{2} \in_i \textcircled{1}\end{array}} \Diamond^{\text{jed}}_{\textcircled{2}} [\text{NUMB: } \textcircled{b}]\end{array}} \\
\text{SUBS: } \langle \textcircled{3}(\textcircled{c} \leq \textcircled{b}) \vee \textcircled{4}(\textcircled{c} \leq_n \textcircled{a})\rangle \\
\text{BOT: } {}^{\text{vpsem\_l}}\left[\begin{array}{l}\text{RIND:REF: } \textcircled{6}\\ \text{NUMB: } \textcircled{c}\end{array}\right]
\end{array}\right]
\end{array}\right]
$$

The first specification, which is available for *sg* and *pl* encompasses the cases of NP modifying relative clauses and singular DP modifying relative clauses. In this case, the referent that is passed to the relative clause is an atomic referent. In case that a plural DP is modified, the referent that is passed over to the relative clause is a sum referent. We then obtain optional distribution. We see that, except for the typing as *relpro_t*, the semantic contribution parallels that of other DPs. With regard to *rltvzrsem*, we stipulate the following:

rltvzrsem(satvp) :=

$$
{}_{\text{rltvzr\_t}}\left[\begin{array}{l}
\text{LAMBDA: } \langle \textcircled{1}^{\text{satvpsem\_l}}, {}^{\text{dpsem\_l}}[\text{REFIND:REF:}\textcircled{2}]\rangle \\
\text{RESULT: } {}^{\text{npsem\_l}}\left[\begin{array}{l}
\text{RIND: } \textcircled{3}[\text{REF: } \textcircled{2}^{\text{atom\_ref}}] \\
\text{NUMB: } \textcircled{a} \\
\text{PDRS: } \boxed{\text{sat\_tense}(\textcircled{1})} \\
\text{SUBS: } \langle \textcircled{b} \leq \textcircled{a}\rangle \\
\text{BOT: } {}^{\text{npsem\_l}}\left[\begin{array}{l}\text{NUMB: } \textcircled{b}\\ \text{RIND: } \textcircled{3}\end{array}\right]
\end{array}\right]
\end{array}\right]
$$

rltvzrsem(satvp) :=

$$
{}_{\text{rltvzr\_t}}\left[\begin{array}{l}
\text{LAMBDA: } \langle \textcircled{1}^{\text{satvpsem\_l}}, {}^{\text{dpsem\_l}}[\text{REFIND:REF:}\textcircled{2}]\rangle \\
\text{RESULT: } {}^{\text{dpsem\_l}}\left[\begin{array}{l}
\text{RIND: } \textcircled{3} \\
\text{REFIND: } \textcircled{4}[\text{REF: } \textcircled{2}] \\
\text{LREFIND: } \textcircled{5} \\
\text{NUMB: } \textcircled{a} \\
\text{PDRS: } \boxed{\text{sat\_tense}(\textcircled{1})} \\
\text{SUBS: } \langle \textcircled{b} \leq \textcircled{a}\rangle \\
\text{BOT: } {}^{\text{dpsem\_l}}\left[\begin{array}{l}\text{NUMB: } \textcircled{b}\\ \text{RIND: } \textcircled{3}\\ \text{REFIND: } \textcircled{4}\\ \text{LREFIND: } \textcircled{5}\end{array}\right]
\end{array}\right]
\end{array}\right]
$$

rltvzrsem(nsatvp) :=

$$\text{rltvzr\_t}\begin{bmatrix} \text{LAMBDA: } \langle \textcircled{1}^{\text{nsatvpsem\_l}}, \textcircled{2}^{\text{dpsem\_l}}[\text{REFIND:REF:}\textcircled{3}]\rangle \\ \text{RESULT: }^{\text{npsem\_l}}\begin{bmatrix} \text{RIND: } \textcircled{4}[\text{REF:}\textcircled{3}] \\ \text{NUMB: } \textcircled{a} \\ \text{PDRS: } \boxed{\text{sat\_tense(l\_apply(}\textcircled{2},\textcircled{1}\text{))}} \\ \text{SUBS: } \langle \textcircled{b} \leq \textcircled{a}\rangle \\ \text{BOT: }^{\text{npsem\_l}}\begin{bmatrix}\text{NUMB: }\textcircled{b}\\ \text{RIND: }\textcircled{4}\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

rltvzrsem(nsatvp) :=

$$\text{rltvzr\_t}\begin{bmatrix} \text{LAMBDA: } \langle \textcircled{1}^{\text{nsatvpsem\_l}}, \textcircled{2}^{\text{dpsem\_l}}[\text{REFIND:REF:}\textcircled{3}]\rangle \\ \text{RESULT: }^{\text{dpsem\_l}}\begin{bmatrix} \text{RIND: } \textcircled{4} \\ \text{REFIND: } \textcircled{5}[\text{REF: }\textcircled{3}] \\ \text{LREFIND: } \textcircled{6} \\ \text{NUMB: } \textcircled{a} \\ \text{PDRS: } \boxed{\text{sat\_tense(l\_apply(}\textcircled{2},\textcircled{1}\text{))}} \\ \text{SUBS: } \langle \textcircled{b} \leq \textcircled{a}\rangle \\ \text{BOT: }^{\text{dpsem\_l}}\begin{bmatrix}\text{NUMB: }\textcircled{b}\\ \text{RIND: }\textcircled{4}\\ \text{REFIND: }\textcircled{5}\\ \text{LREFIND: }\textcircled{6}\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

These stipulations mean that the relativizer applies the second argument (the DP from the relative pronoun) to the first, in case this first argument is *nsatvpsem_l*. In case that the first argument already is a saturated VP this step is omitted. Then the result (in each case a saturated VP structure) is *tense_saturated*; i.e., temporal conditions relating the event to contextual anchors are introduced. The corresponding DRS then is used as the contribution of a NP- or DP-modifier, where the modificandum's REFIND- or RIND referent (depending on the type of the modificandum structure) is the same as the REFIND referent of the relative pronoun DP. With this, we terminate the specification of lexical entries. Instead of working out feature descriptions of the few remaining lexical classes that we have considered in the paper and not yet treated here (or of the omitted cases of the classes which we have accounted for in this appendix)—this should be an easy, though boring exercise on the basis of the indications in the paper and the setting of the macros, we turn to a possible modeling of the flat semantics, in fact to the one that is used in the CUF-implementation of the presented semantics.

A.4 Realization of flat semantics

In the CUF implementation that this appendix documents we have deviated from the suggestion of 2.9, where we have said that the (multi-valued) functional terms which we use for the representation of ambiguous, non further analyzed (flat) information—and which are marked as such through the underlining of the function symbol—best would be interpreted in the implementation as goals with delayed evaluation. In the CUF framework therefore, they would be interpreted as delayed CUF-sorts with (partly) instantiated internal arguments. The particular circumstances that should trigger evaluation and direct the choice of a possible result would function as specific wait conditions connected to the definition of the considered CUF-sort. Because there are a number of technical problems connected to this architecture which we do not want to go into detail here (mainly it is because one cannot completely suppress evaluation in processing states with insufficient information, so that, as a consequence, we would obtain unfounded disambiguations) we have implemented a cruder, but simpler and more tractable alternative. This alternative consists of interpreting the functional term simply as a relational condition that is marked as a flat description of what it stands for. This can be a labelled structure, an index, a referent, an Aktionsart specification, a DRS condition and possibly other things. 'Marking' means that the considered structure type is subdivided into a *resolved* and a *unresolved* subtype:

unres_l	<	labeldescr.
unres_ind	<	ind.
unres_akt	<	akt.
unres_cond	<	cond.

unres_l	::	[FLAT: rel_cond].
unres_ind	::	[ALT: list(⟨ref,top⟩)].
unres_akt	::	[AKT_ALT: list(⟨akt,top⟩)].
unres_cond	::	[COND_ALT: list(⟨cond,top⟩)].

Thus, an unresolved representation structure is specified by a *flat* semantic description only, an unresolved index introduces a list of *alt(ernative)* referents, which are connected to specific choice conditions. The value of the AKT feature can present a number of alternative Aktionsarten, and there might be alternative conditions in the partial DRSs. There is a second semantic lexicon which specifies the possible resolutions of the flat lexical semantics. We use the macro *expand* in order to relate the flat semantics to more explicit representations (which, of course, may contain flat semantics parts also). In order to illustrate the macro and the information of the deep semantics lexicon, we use the coordination *und (and)* and parts of the specifications of the preposition *für (for)*:

expand(fuer(①$^{\text{dpsem_l}}$,②$^{\text{xtype_l}}$),_)

:= result($^{\text{prepsem(fuer,beneficiary,rel)}}$[LAMBDA: ⟨①,②⟩])
:= result($^{\text{prepsem(fuer,causa\_finalis,pdescrop)}}$[LAMBDA: ⟨①,②⟩])
:= result($^{\text{prepsem(fuer,\_,perspop)}}$[LAMBDA: ⟨①,②⟩])
:= result($^{\text{prepsem(fuer,\_,facetop)}}$[LAMBDA: ⟨①,②⟩])

where we still have to define the *prepsem* dimensions *pdescrop* (which embeds the external argument via *p-description*), *perspop* (which embeds (part of) the internal and the external argument via *perspectival relativization*), and *facetop* (which embeds internal and external argument via *facet relativization*). Of course, *result* is the access function which is defined over *sem_t* and which returns the value of the RESULT-feature. Via the second argument of *expand*, context information can be used. In the following, we do not take into account this facility.

prepsem($\textcircled{N}$,$\textcircled{T}$,pdescrop) :=

$$\text{prepsem\_t}\begin{bmatrix} \text{LAMBDA: } \langle \textcircled{1}^{\text{dpsem\_l}}, \textcircled{2}^{\text{vnpsem\_l}} \rangle \\ \text{RESULT: } {}^{\text{vnpsem\_l}}\begin{bmatrix} \text{NUMB: } \textcircled{a} \\ \text{RIND: } \textcircled{3}\,[\text{REF: } \textcircled{4}] \\ \text{PDRS: } \boxed{\begin{array}{l} \textcircled{5}\,@^{\text{prop}} \\ \textcircled{N}_{\textcircled{T}}(\textcircled{4},\textcircled{5}) \\ \textcircled{5}{:}\boxed{\text{sat}(\textcircled{1}) \wedge \boxed{?}} \end{array}} \\ \text{SUBS: } \langle \textcircled{b} \leq \textcircled{a} \rangle \\ \text{BOT: } \textcircled{2}\begin{bmatrix} \text{RIND: } \textcircled{3} \\ \text{NUMB: } \textcircled{b} \end{bmatrix} \end{bmatrix} \end{bmatrix}.$$

prepsem($\textcircled{N}$,$\textcircled{T}$,perspop) :=

$$\text{prepsem\_t}\begin{bmatrix} \text{LAMBDA: } \langle \textcircled{1}^{\text{dpsem\_l}}, \textcircled{2}^{\text{vnpsem\_l}} \rangle \\ \text{RESULT: } {}^{\text{vnpsem\_l}}\begin{bmatrix} \text{RIND: } \textcircled{7} \\ \text{FSET: } \langle \textcircled{1}\begin{bmatrix} \text{RIND: } \textcircled{7} \\ \text{NUMB: } \textcircled{a} \\ \text{LREFIND:REF: } \textcircled{3} \end{bmatrix}, {}^{\text{vnpsem\_l}}\begin{bmatrix} \text{NUMB: } \textcircled{b} \\ \text{RIND: res}(\langle \begin{array}{l} \langle \textcircled{4}, \textcircled{i} \leq \text{noun} \rangle, \\ \langle [\text{REF:SORT: }^{\text{empty}}], \textcircled{i} \leq \text{verb} \rangle \end{array} \rangle) \\ \text{PDRS: } \boxed{\begin{array}{l} \textcircled{5}\,@^{\text{prop}} \\ \Diamond(\textcircled{N}, \textcircled{T}, \textcircled{3})\ \textcircled{5} \\ \textcircled{5}{:}\text{sat\_tense}(\textcircled{6}) \end{array}} \\ \text{SUBS: } \langle \textcircled{c} < \textcircled{b} \rangle \\ \text{BOT: } \textcircled{6}^{\text{labelvar\&vnpsem\_l}}\begin{bmatrix} \text{NUMB:} \textcircled{c} \\ \text{RIND:} \textcircled{4} \end{bmatrix} \end{bmatrix} \rangle \\ \text{SUBS: } \langle \textcircled{b} \leq \textcircled{a} \rangle \\ \text{BOT: } \textcircled{2}\,[\text{RIND:CATI: } \textcircled{i}] \end{bmatrix} \end{bmatrix}$$

prepsem($\textcircled{N}$,$\textcircled{T}$,facetop) :=

$$
{}^{\text{prepsem\_t}}\begin{bmatrix}
\text{LAMBDA: } \langle ①^{\text{dpsem\_l}}[\text{REFIND:REF: } ②], ③^{\text{vnpsem\_l}}\rangle \\
\text{RESULT: } {}^{\text{vnpsem\_l}}\begin{bmatrix}
\text{NUMB: } ⓐ \\
\text{RIND: res}(\langle\langle ④, ⓘ \leq \text{noun}\rangle, \langle[\text{REF:SORT: }{}^{\text{empty}}], ⓘ \leq \text{verb}\rangle\rangle) \\
\text{PDRS: } \boxed{\begin{array}{l} ⑤@^{\text{prop}} \\ \quad Ⓝ \\ \quad Ⓣ \quad ⑤ \\ \lambda②.\text{sat}(①) \\ ⑤\text{:sat\_tense}(⑥) \end{array}} \\
\text{SUBS: } \langle ⓑ < ⓐ \rangle \\
\text{BOT: } ③\begin{bmatrix} \text{RIND: } ④[\text{CATI: } ⓘ] \\ \text{NUMB: } ⓑ \end{bmatrix}
\end{bmatrix}
\end{bmatrix}.
$$

The definitions encompass VP modification but also, since adjectives are modifiers from NPs to NPs, cases like *[das [für einen Richter schwierige] Problem]*. (Of course, *sat_tense*, when applied to structures that are not *sit_ind* indexed, corresponds to the identity function). We skip DP modification that via nested quantification seems possible also.

Using the example *und*, we illustrate the impact of categorial information on the evaluation. We consider NP and DP coordination only.

$$
\text{expand}(\text{und}(①^{\text{npsem\_l}}\begin{bmatrix} \text{RIND: } ② \\ \text{NUMB: } ⓐ \end{bmatrix}, ③^{\text{npsem\_l}}[\text{RIND: } ②]),\_)
$$

$$
:= {}^{\text{npsem\_l}}\begin{bmatrix} \text{RIND: } ② \\ \text{NUMB: } ⓑ \\ \text{PDRS: } \boxed{① \wedge ②} \\ \text{SUBS: } \langle ⓐ < ⓑ \rangle \\ \text{BOT: } ① \end{bmatrix}.
$$

$$
\text{expand}(\text{und}(①^{\text{dpsem\_l}}\begin{bmatrix} \text{REFIND:REF: } ② \\ \text{CATI: } ⓘ \end{bmatrix}, ③^{\text{dpsem\_l}}\begin{bmatrix} \text{REFIND:REF } ④ \\ \text{CATI: } ⓘ \end{bmatrix}),\_)
$$

$$
:= {}^{\text{dpsem\_l}}\begin{bmatrix}
\text{RIND: res}(\langle\langle \textcircled{5},\textcircled{x}\rangle, \langle \textcircled{6},\textcircled{y}\rangle, \langle \textcircled{7},\textcircled{z}\rangle\rangle) \\
\text{REFIND: } \begin{bmatrix} \text{REF: } \textcircled{8} \\ \text{CAT: } \textcircled{i} \end{bmatrix} \\
\text{LREFIND: res}(\langle\langle \textcircled{9},\textcircled{x}\rangle, \langle \textcircled{10},\textcircled{y}\rangle, \langle \textcircled{8},\textcircled{z}\rangle\rangle) \\
\text{NUMB: } \textcircled{a} \\
\text{PDRS: } \boxed{\begin{array}{l}
\textcircled{8} \\
\text{sat}(\textcircled{1}) \wedge \text{sat}(\textcircled{3}) \\
\textcircled{8} = \Sigma\ \text{x} \boxed{\begin{array}{l} \text{x} \\ \text{x} \in \{\textcircled{2},\textcircled{4}\} \end{array}} \\
\textcircled{5}{::} \begin{bmatrix} \text{RIND:REF: } \textcircled{9} \\ \text{DRS: } \boxed{\begin{array}{l} \textcircled{9} \\ \textcircled{9} \in_i \textcircled{8} \end{array}} \end{bmatrix} \Big\langle \text{jed } \textcircled{9} \Big\rangle \begin{bmatrix}\text{NUMB: } \textcircled{b}\end{bmatrix} \\
\textcircled{6}{::} \begin{bmatrix} \text{RIND:REF: } \textcircled{10} \\ \text{DRS: } \boxed{\begin{array}{l} \textcircled{10} \\ \textcircled{10} \in \{\textcircled{2},\textcircled{4}\} \end{array}} \end{bmatrix} \Big\langle \text{jed } \textcircled{10} \Big\rangle \begin{bmatrix}\text{NUMB: } \textcircled{c}\end{bmatrix}
\end{array}} \\
\text{SUBS: } \langle \textcircled{x}(\textcircled{d} \leq \textcircled{b}) \vee \textcircled{y}(\textcircled{d} \leq \textcircled{c}) \vee \textcircled{z}(\textcircled{d} \leq_n \textcircled{a})\rangle \\
\text{BOT: } \begin{bmatrix} \text{NUMB: } \textcircled{d} \\ \text{RIND:REF: } \textcircled{7} \end{bmatrix}
\end{bmatrix}.
$$

The expansion of a flat semantic representation is identified to the labelled structure that the flat semantics describes. Therefore, the direction that the expansion takes easily can be controlled from the outside of the labelled structure considered by formulating constraints over this structure. Consider for instance the example of *der eine* (as in *der eine Mann der im Zimmer war (the one man who was in the room*). *ein*, is assigned the following flat semantic description:

$$
\text{ein} \longrightarrow \text{SYNSEM:LOC:CONT:SEM: } {}^{\text{detorquant\_t}}\begin{bmatrix} \text{LAMBDA: } \langle \textcircled{1}^{\text{npsem\_l}} \rangle \\ \text{RESULT: } \textcircled{2}\text{FLAT: ein(numb\_qu,} \textcircled{1}) \end{bmatrix}
$$

where ein(numb_qu,①) is a flat representation of the labelled structure ② that subsums the DP semantics reading where an indefinite α-condition is introduced and the quantized NP reading where *ein* is interpreted as a quantifier. Now, since the determiner *der* requires that its argument be a NPsem labelled structure, as described further above, the constraint that the determiner *der* puts onto ② is such that the expansion of the *ein* relation must result in the quantifier reading.

We stop the presentation of deeper analyzed semantics here and, with that, terminate specifying AVM constraints for the semantic classes that we have considered in 3. The lexicon easily can be enriched by extrapolation from the examples presented.

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