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Tense and Aspect Information in a FUDR-based German French Machine Translation System

Abstract

Normally, the tense and aspect systems of natural languages do not coincide and the correct translation of the tense forms needs a semantic analysis of the text or sentence which uses these forms. The problem with semantic representations is that, often, ambiguities cannot be resolved, though a remarkable effort of inferencing has been invested to the effect that the analysis of the source text is costly, nevertheless coming up with a large number of alternative representations.

In this paper, we will describe how the German-French Machine Translation, system which is currently been developed at *linguatec*-E & S uses lexical Aktionsart information, tense- and background information in order to determine the parameters of the specific perspective under which the context perceives the new eventuality and incorporates it; we will describe how the system uses these parameters for choosing a suitable target (tense) form.

In order to circumvent the complexity problem, this computation of the relevant semantic decision criteria is not built upon an explicit (deep) semantic representation, but relates to a projection of the syntactic analysis of the source sentence which is called *dependence structure*. This structure defines the level of transfer. It is unique with respect to the underlying syntactic analysis and it can be interpreted as a flat underspecified semantic representation (FUDR).

The tense parameters rely heavily on the investigations of Hans Kamp and Christian Rohrer about the French tense system especially and the formal representation of the meaning of the tenses within discourse representation theory.

1 Introduction

A high quality Machine Translation system should correctly translate tenses. Because different languages may lay stress on different kinds of temporal and aspectual information, often the tense systems of source and target language do not allow a one-to-one correspondance such that the correct translation of the tenses becomes a problem. This is even the case for relatively similar Indoeuropean languages like German and French. Consider the following examples which illustrate the ambiguity of German tense forms with regard to the French tense system and some of the circumstances that can decide about the specific contextual meaning of the tense and, hereby, about the correct transfer alternative to be chosen:

(1) a. Pierre öffnete die Tür. Er begrüsste Marie.
Pierre ouvrit la porte. Il salua Marie.
PIERRE OPENED THE DOOR. HE GREETED MARIE.

b. Pierre öffnete die Tür. Es regnete.
Pierre ouvrit la porte. Il pleuvait.
PIERRE OPENED THE DOOR. IT WAS RAINING.

c. Pierre schrieb Marie einen Brief. Er brachte ihn zur Post.
Pierre écrivit une lettre à Marie. Il la mit à la poste.
PIERRE WROTE MARIE A LETTER. HE TOOK IT TO THE POST OFFICE.

d. Pierre schrieb Marie einen Brief. Zuerst schrieb er, daß er sie liebe und daß er kommen würde. Dann besann er sich und zeriss den Brief.
Pierre écrivait une lettre à Marie. D'abord, il écrivit qu'il l'aimait et qu'il viendrait. Puis il réfléchit et déchira la lettre.
PIERRE WROTE MARIE A LETTER. FIRST, HE WROTE THAT HE LOVED HER AND THAT HE WOULD COME. THEN HE CHANGED HIS MIND AND TORE THE LETTER TO PIECES.

(1.a) – (1.d) demonstrate the notorious ambiguity of German *Präteritum (Praet)* with regard to the French *imparfait (Imp) – passé simple (PS)* contrast. Following the terse summarization of Kamp and Rohrer, this contrast is expressed by the two (default) principles P1 and P2:

(P1) The PS drives the narrative's action forward, the Imp is incapable of this.

(P2) The PS presents an event as punctual, while the Imp presents the state or condition it reports as extended.

Connected to the second principle are the following two further principles, which also express more self-contained than referential semantic-pragmatic properties of the contrasting tenses:

(P3) The PS presents the event it introduces as temporally closed; the Imp presents the state it introduces as temporally open.

(P4) The Imp presents the state it describes from within, whereas the PS presents the event it describes from a distance, and, by implication, from outside.

None of these principles expresses absolute characteristics of Imp and PS. This is discussed in the tense studies of Kamp and Rohrer and, among others, also in our own work that takes up the findings of Kamp and Rohrer (cf. Kamp 1979, Kamp 1981b, Kamp and Rohrer 1983, Kamp and Rohrer 1985, Eberle and Kasper 1991, Eberle and Kasper 1994). Nevertheless, in our opinion, these principles summarize concisely the basic meaning of Imp and PS, as generally (and informally) attributed to these tense forms.

From these principles, of course, guidelines for the translation of Praet can be inferred: Since the recipient of (1.a) understands that an event of Pierre greeting Marie follows an event of Pierre opening the door, knowing the meanings of Imp and PS as expressed by P1-P4, especially by P1 and P3, he would translate both sentences by PS. In contrast, understanding (1.b) in such a way that a state of raining accompanies (surrounds) the event of Pierre opening the door (instead of following this event of opening), on the basis of the same principles, the human translator will choose Imp for the second sentence. Note that the raining event, assuming this reading of the text, in accordance with P2, is clearly felt as extended (it overlaps with the state before the opening, the opening itself and the resultant state of the opening). The contrasting temporal organizations of the described preferred readings of (1.a) and (1.b) conform to a principle which, in a way, generalizes P1-P4 to any presentation of eventualities. In one form or the other one can find this principle in a large number of works treating the temporal organization of texts, like Dowty 1986, Hinrichs 1981, Hinrichs 1986, Lascarides and Asher 1991. We take up our own formulation of Eberle 1991c:

(*) Eventualities which are introduced by *heterogeneous* descriptions continue the story (provided their presentation conforms to the tense level of the story), whereas eventualities which are introduced by *homogeneous* descriptions do not.

Loosely, by a *homogeneous* event description we understand a description whose extension (the set of denotata) is homogeneous in that it shows the following particular closure properties: The elements of the extension, to a certain extent, can be subdivided into subevents which satisfy the same description, this is, which are elements of the same extension. The amalgamation of neighboring elements of the extension also satisfies the same description, that is, it is an element of the same extension. By *heterogeneous* descriptions we mean event descriptions which, in contrast, do not show such closure properties. Informally speaking, homogeneous descriptions denote processes and states, heterogeneous descriptions events in the narrow sense. In Eberle 1995a, we tried a formal working out of this dichotomy on the basis of discourse representation theory (DRT). Its aim was to summarize modeltheoretically the relevant aspects of the different Aktionsart classifications that have been suggested since Vendler's (see Vendler 1967). For the purposes of this paper, there is no need to go into formal details with this. For clarification, we just mention how we use *aspect* and keep it distinct from *Aktionsart*: By *aspect* we mean operations on the description of an eventuality (or the results of such operations) which change the Aktionsart of the description by introducing some particular perspective under which the eventuality should be perceived. Aspects which we consider in this paper are the *progressive* and the *perfective aspect*, also the *inchoative aspect*.

Of course, (*) is a default linguistic principle, as are P1-P4. It is suspended if contradicting information is available. Such information may be provided by linguistic material – by temporal adjuncts for instance. It may also be provided by world knowledge about the organization of the considered event types. It is such information which determines the different temporal structures of (1.c) and (1.d): On the basis of the sentence information, in all sentences of (1.c) and (1.d), just as in (1.a), events are introduced, not states or processes. However, whereas in (1.c) the prediction of principle (*) is confirmed by world knowledge (one normally takes a letter to the post office after having written it), in (1.d) this prediction is overridden by the temporal modifier (and by knowledge about the *writing a letter* frame also): Here, clearly, the reading is prevailing which determines the event of the second sentence as an event which elaborates the first event, thereby presenting this first event as a non-terminated task. We observe that the temporal constellation between the first and the second sentence of (1.d) corresponds to that between the second and the first sentence of (1.b). The presentation issue also seems to be the same: A well delimited event is accompanied by a backgrounding, temporally surrounding eventuality, which from the perspective of this well-delimited event is temporally open and functions like an ongoing process or a (progressive) state providing the thematic background or, maybe, an additional, garnishing background also. These interpretations legitimate the given translations of (1.b) and (1.d), as well as the translations of (1.a) and (1.c), in accordance with P1-P4.

We learn from this that for the correct translation of Praet into French, the semantic-pragmatic analysis of the sentence and its context plays an important role. Note that (1.d) exemplifies that the Aktionsart which can be assigned to the sentence in isolation may be revised by the impact of the surrounding text. Normally this will be triggered by the preceding text. (1.d) shows that this may also be triggered by the following text however, what complicates matters even more.

The following examples (2.a) and (2.b) illustrate how temporal adjuncts are used for clarifying the temporal positioning of the event in question with respect to the contextual temporal structure (in case the principle (*) on the basis of the sentential aspectual knowledge would misdirect the incorporation).

(2) a. Nachdem Pierre das Dachfenster geöffnet hatte, regnete es.
Après que Pierre avait ouvert la lucarne, il plut (il commença à pleuvoir).
PIERRE HAVING OPENED THE DORMER-WINDOW, IT BEGAN RAINING.

b. Nachdem es geregnet hatte, öffnete Pierre das Dachfenster.
Après qu'il avait plu, Pierre ouvrit la lucarne).
AFTER IT HAD STOPPED RAINING, PIERRE OPENED THE DORMER-WINDOW.

Using *nachdem* (and the accompanying perfective tense), the speaker of (2.a) clearly signals that the homogeneous *regnen* must be understood as being located after the opening of the dormer-wndow (in contrast to (1.b)). In the case of (2.b), she invites the recipient to construct just the opposite temporal structure.

Thus, in light of the principles P1-P4 and in order to take advantage of such additional information, a system that simulates the human translator should know how the corresponding lexical items and syntactic phrases (verbs, conjunctions, etc. and its projections) have to be interpreted and how they constrain the Aktionsart on the one hand and the incorporation of the new eventuality into the reported story on the other: The system must know that *nachdem* is meant to relate events by temporal succession – thereby flavoring the eventualitiy of the subclause and that of the matrix sentence by heterogeneity through stressing closedness, and suggesting PS translation in the case of Praet, as in (2.a), therefore. In case, the prerequisites of this meaning do not hold, as in the following (3), where the subclause does not report a (perspectival) past eventuality (signaled by a perfective tense form), Gricean cooperation of the human recipient will result in suitable type coercions such that the descriptions of subclause and matrix clause are event-like. The Machine Translation system must also model this competence.

(3) Nachdem es regnete, schloss Pierre das Dachfenster.
Après qu'il avait commençé à pleuvoir, Pierre ferma la lucarne.
PIERRE CLOSED THE DORMER-WINDOW, AFTER IT HAD BEGUN RAINING.

The translation of (3) reflects the necessary type coercion (see Moens and Steedman 1988 for the notion), which is the inchoative reinterpretation in this case.

(4.a) and (4.b) exemplify the ambiguity of German *Präsens (Praes)*: Homogeneous descriptions normally are understood to hold at the speech time. Heterogeneous descriptions are normally reinterpreted as homogeneous descriptions (via progressivization) and treated accordingly, or the corresponding event is assumed to be located in the (near) future. The translation will be *présent* in the first two cases and *futur* only in the latter futurate case, normally.

(4) a. Es regnet.
Il pleut.
IT IS RAINING.

b. Pierre schreibt einen Brief.
Pierre écrit (est en train d'écrire) une lettre/ Pierre écrira une lettre.
PIERRE WROTES/WILL WRITE A LETTER.

As a rule, in connection with an additional location time from an adjunct (which does not overlap the speech time), Praes gets the futurate interpretation, as in (5) (and therefore the translation *futur*, or, alternatively, *futur proche* also).

(5) Pierre kommt um 4 Uhr.
Pierre arrivera à 4 heures.
PIERRE WILL COME AT 4 O'CLOCK.

In the presence of quantification and in case the additional location time gets narrow scope, this rule is suspended, as (6) makes clear (through its correct translation via présent).

(6) Jeden Tag kommt Pierre um vier.
Chaque jour, Pierre arrive à 4 heures.
EVERY DAY, PETER ARRIVES AT 4 O'CLOCK.

The (5)-case is explained by the fact that the two constraints provided by the tense and the adjunct – (a) the eventuality overlaps the speech time or follows it (tense) and (b) the eventuality is in the past or in the future (adjunct) – are resolved to the one possible disambiguation, which is the futurate interpretation.

In the second case, (6), the time of the embedded event, together with the time of the narrow scope adjunct are bound within the scope of the frequency adverbial. Because the sum event that is provided by this quantificational description (the sum of the different arrival times of Pierre) 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 events. This legitimates the translation via présent.

We postpone a more formal account of these explications in terms of discourse representation structures (DRS) to sections 3 and 5. Here, we take from this pair of examples an argument that says that, at least in certain cases, the correct translation of tenses may presuppose the scopal ordering of the scope bearing elements of the sentence and that the application of the tense information in terms of temporal relations to the speech time (or to other relevant times) must have wide scope with respect to the scope hierarchy of the sentence (at least with respect to the temporal localization of the VP description via temporal adjuncts).

(7.a) and (7.b) illustrate the fact that,besides cases where the tenses show an analytic semantic contribution with regard to compositional semantics, there are more or less idiomatic uses of tenses, that is, cases where the use of a particular tense, as a conventional rule, is bound to a specific linguistic constellation without necessarily contributing its normal semantics.

(7) a. Pierre glaubt nicht, daß sie kommt.
Pierre ne croit pas qu'elle vienne.
PIERRE DOESN'T BELIEVE THAT SHE WILL COME.

b. Wenn Pierre gekommen wäre, hätte er sie gesehen.
Si Pierre était venu, il l'aurait vu.
IF PIERRE WOULD HAVE COME, HE WOULD HAVE SEEN HER.

In French, the sentential complements of (most negated) verbs expressing doubt occur with *subjonctif* (whereas in German they do not occur with a corresponding *Konjunktiv*); and, in hypothetical conditionals, the matrix clause requires *Conditionnel*, not the subclause (which occurs with Imp – whereas, in German, both clauses require *Konditional*). The second sentence of (1.d), by the way, proves akin phenomena with respect to the *consecutio temporum* subject: German and French show different conventional regularities in this respect. (There is also a trend in contemporary French to express the *après que* subclauses, as in (2) and (3), by *subjonctif*, which cannot be semantically motivated, but by analogy only).

Summarizing, these introductory examples should make clear that a complete treatment of the tense translation problem presupposes:

- a (bilingual) lexicon which contains Aktionsart and tense information, this is, verbs are sorted into different Aktionsart classes,
  they inform about the Aktionsart influence of their complements,
  they assign the relevant mood, aspect or tense information to their sentential complements, if any and if necessary (*subjonctif* e.g.),
  the relevant modifiers inform about their constraining the mood, tense, aspect or Aktionsart of their modificandum,

- the construction of a semantic representation from the syntactic sentence analysis which comprises the computation of the Aktionsart of the resulting sentence eventuality,
- the incorporation of the sentence representation into the representation of the preceding text, where the tense information is evaluated into temporal relations to the relevant contextual reference times (where the incorporation itself may effect the application of some further aspectual adjustments),
- a transfer or generation component which can read the correct target tense form for the target string from these temporal and aspectual settings.

It is obvious that this translation strategy is very costly. In addition, and from a practical point of view, it is certainly not the best, provided, applying it, we **always** aspire for unambiguous, deep sentence representations and that we are **always** interested in obtaining the best information about the incorporation of the sentence representation into the context representation. Because then we are faced with massive problems of complexity: The compositional semantics may produce a very high number of readings without providing enough information which could be used to filter out unpromising interpretations (early, or at all).

A similar problem is posed by the task of incorporating the sentence representation into the context representation. (We call the subtask which is concerned with getting the temporal relations right *temporal resolution*, and *nominal resolution* the subtask of relating definite descriptions and pronouns to contextual antecedents). As demonstrated, in order to obtain reasonable results, one has to rely heavily upon background knowledge, which is voluminous but nevertheless notoriously incomplete. In addition, with respect to resolving the tense information or reading the correct target tense form from source representations, one has to be aware of the fact that there are other tense readings than those considered in this paper; think of *historisches Präsens, présent historique, imparfait de rupture*, or the difference between *passé simple* and *passé composé* under the aspect of the 'relevance to the author's *now*', etc. Note also that the pragmatic factors connected to these readings normally are very difficult to discern. (Often, even the theoretical knowledge about their distribution is lacking). In short, under this deep analysis strategy we have to reckon with time consuming computations which, nevertheless, often will not be very reliable with respect to the suggested resulting semantic representation (or to the target tense suggestion).

Also, again from a practical point of view, the concrete translation scenario is such that the human translator uses the (commercial) Machine Translation system as a tool for providing rough sentence translations, which he modifies in order that they fit with the context. Given this perspective of sentence translation with postprocessing, the correct tense translation is impossible on principle (because of the context dependency of the tense meanings) and commonly no major interest (more important will be all that facilitates the postprocessing). The strategy of Machine Translation must account for the fact, therefore, that the present translation scenario measures the significance of the correct automatic translation of the tenses (and, by the way, of the pronouns also) only little. It must account for this by solutions which are economic in this respect. However, looking ahead, it must try to free itself from the scenario with obligatory postprocessing.

In order to best satisfy the variety of purposes delimited by the extreme positions of expecting extensive postprocessing on the one hand and expecting translations which are always correct on the other and against the background of the above mentioned practical and theoretical problems, the architecture of the German French MT system, which is currently under development at *linguatec*-E&S and which, with regard to the syntactic analyses, is based upon the IBM – *logic programming based Machine Translation* technology (LMT), aims at an economic intermediary strategy which we will describe below.

According to this specification, the system analyses the sentences in syntactical slot grammar structures (typical of LMT) and subsequently maps these onto semantically motivated, so called *dependence structures*, which define the level of transfer. From the target dependence structure, the target string is computed. In the next section (2), we will describe this transfer architecture in a bit more detail. In the succeeding section 3, we will show that the dependence structures can be understood as *flat underspecified discourse representation structures (FUDRs)* in the sense of Eberle 1997b. In section (4), we will sketch the algorithm which defines the recursive transfer, mapping source dependence structures into target dependence structures. In the following section (5), we will describe how the recursive transfer and the subsequent generation component can act as *negotiator* in the sense of Kay et al. 1994 such that requirements for further information, as signaled by these components, effect inspections of the different analysis levels and further refinement of the (semantic) analysis, when needed. This will be exemplified using problems of the translation of tenses as discussed above. Here, we will also sketch the corresponding lexical prerequisites, that is, relevant parts of the sort hierarchy and corresponding classifications of some typical items in the lexicon. In the last section (6), we will summarize the approach and will say something about ongoing work and possible extensions.

2 Architecture

To a certain extent, the architecture of the system is quite similar to the LFG-approach described in Eberle et al. 1992 which is based on the suggestion of Kaplan et al. 1989. There, within the framework of *Lexical functional grammar (LFG)*, it is assumed that the grammar specifies several levels of analysis such as constituent structure (c-structure), functional structure (f-structure), and semantic structure (s-structure). The different levels of analysis are related to each other via *projections*, that is functions mapping the nodes of one structure to nodes in the other structure(s) thus defining *structural correspondences* among the structures. For MT, in addition, *transfer (τ) projections* mapping the structures of the source language to corresponding structures in the target language are used. The following figure 1 depicts the similar setting of our German-French approach which we make as explicit as possible by using the LFG projection names ϕ, σ, τ for our correspondences:

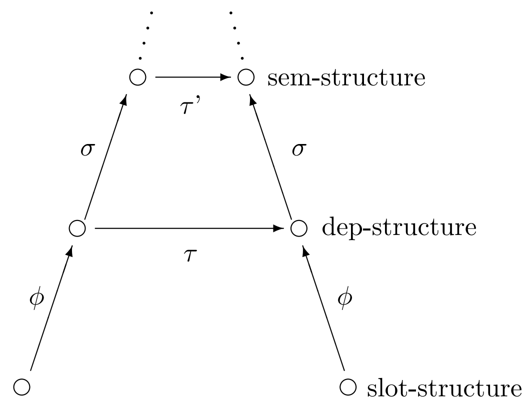


Figure 1: Relations

According to this, the source sentence is analyzed into a slot grammar representation (*slot-structure*), from which ϕ abstracts the corresponding dependence structure (*dep-structure*), which, via σ, can be assigned a semantic representation (*sem-structure*).

The development of slot grammar can be traced back to the late seventies and has been continuously extended and improved, above all by use in translation systems with large grammars and lexicons (that is, in the different versions of LMT; see McCord 1980, McCord 1989a, and McCord 1991 for slot grammar, McCord 1989, and McCord 1989b for LMT). Slot grammar is one of the first lexicalist, head-driven systems in the computational linguistics framework. It uses unification and shows some similarities to unification grammars like LFG (Kaplan and Bresnan 1982) and others. It focusses on *slots*, that is, on the grammatical relations between structures. It is dependency-oriented and, in this respect, similar to suggestions like Hellwig 1986 and corresponding predecessors. It distinguishes between complement and adjunct slot. The grammar modularly distinguishes slot filler rules from slot ordering rules (and other minor types of rules). Correspondingly, the slot grammar analysis of a sentence connects the heads of the substructures (*phrases*) to the sentence head by slots, where the slots are ordered according to the surface ordering. (8) gives an example:

(8) Gestern wartete er auf Maria.
YESTERDAY HE WAITED FOR MARIA.

(8) is analysed in a slot grammar phrase which, according to the representation style which is typical to LMT, we can render by the following (rotated side-inverted) tree:

(8_S)

```
Syntactic analysis no. 1.   Evaluation = 1.31 ...

------------------------------------------------------------------------
,--- vadv              gestern1(1)  adv(X1,X2)
o--- top               wart3(2,3,5) verb(fin([pers3|sg],past,ind:dcl:nwh))
```

```
'--- subj(n)            er1(3)       noun(pron(pers3),[nom,sg,m,kda|X4],nwh)
'--- comp(p([auf|acc])) auf1(4,5)    prep([auf|acc],nwh,5)
  '- objprep(acc)       Maria1(5)    noun(prop,[acc,sg,f,o|X3],nwh)
----------------------------------------------------------------------
```

Note that the vertical positioning reflects linear precedence information. We see that *warten* is the top-node of the structure. It is modified from the left by an adjunct slot *vadv* which is filled by *gestern*, from the right it is modified by the *subj*ect *er*. To the right of this, we find the additional comp(p([auf|acc]))-slot (this is: a prepositional auf-complement), which is filled by *auf*, which, in turn, is modified by the internal argument of the PP from the right.

Hierarchical slot grammar phrase analyses are recorded by the system through equivalent net descriptions, which are like the visualization shown above. The reason for storing the net analysis is that one can navigate through the net in any direction, whereas from a subterm of the recursive phrase structure one cannot get to the higher structure. Thus, at each node of the net, global information is available. As (8_S) makes clear, the nodes store information

- about their position in the surface structure (through the corresponding number; this is only indirectly visible in (8_S), consider the first argument of the sense description of the second column),
- about which slot they fill in the global structure,
- about their meaning through the so called *sense* which, like a pointer, refers to the corresponding entry of the corresponding lemma in the lexicon (*gestern1*, for instance, which internally will be *s(gestern,1)*, to the first entry (reading) of the *gestern* lemma – such senses can be assigned supplementary semantic characteristics through semantic typing),
- about their syntactic feature description (where *gestern* is determined as a not further classified adverb and where *warten* (in the example) comes in its 3rd person singular past form and is used in an *independent* sentence (*ind* versus *dep*) which is *declarative* (*dcl*), not an *imperative* (*imp*) or a *question* (*q*), and which is of type *nwh* (where, with respect to questions, *nwh* signals 'no wh-question', with respect to declaratives, it says 'no relative clause'),
- about their position in the net through the corresponding slot relation items

Note that the representation of the prepositional complement of (8) is redundant: The introduced preposition is used for subclassifying the PP as such: the slot name provides exact information about the preposition used. Therefore, additionally saying that the slot is filled by this preposition is unnecessary; representing the internal argument of the PP as value of the slot would be sufficient. Also, since the auf-PP is subcategorized by *warten*, from a semantic point of view, the preposition is a connector which does not show its meaning proper, that is, the meaning that it would contribute in free modification positions. This is similar in other cases of subcategorized functions where there is a syntactic head combining the argument of the complement to the verb. In all these cases the meaning of this relation comes with the verb and overrides the lexical meaning of this syntactic head.

Often transfer confirms the semantic emptiness of the preposition in subcategorized PPs and makes it explicit by specific translations of the subcategorized preposition, which are determined by the modified verb, in contrast to the normal meaning-preserving translation of the preposition as such. Consider the following example:

(9) Morgen würde der Mann nicht auf der Wiese auf die Frau warten.
TOMORROW, THE MAN WOULD NOT WAIT AT THE MEADOW FOR THE WOMAN.

We obtain (9_S):

```
Syntactic analysis no. 1.   Evaluation = -2.6172 ...

------------------------------------------------------------------------
,------- vadv               morgen483709(1)     adv(X1,X2)
o------- top                fut(2,4,12)         verb(fin([pers3|sg],pastsubj,
                                                          ind:dcl:nwh))
! ,----- ndet               d(3)                det(nMgdFSgP,def)
!------- subj(n)            mann1062123(4,u)    noun(cn,[nom,sg,m,kda|det],nwh)
! ,----- vadv               neg(5)              adv(X4,nwh)
! ,----- vprep              auf51191(6,8)       prep([auf|dat],nwh,8)
! ! ! ,- ndet               d(7)                det(nMgdFSgP,def)
! ! `--- objprep(dat)       wiese791264(8)      noun(cn,[dat,sg,f,w|det],nwh)
! ,----- comp(p([auf|acc])) auf51163(9,11)      prep([auf|acc],nwh,11)
! ! ! ,- ndet               d(10)               det(naFSnaP,def)
! ! `--- objprep(acc)       frau254797(11,u)    noun(cn,[acc,sg,f,w|det],nwh)
`------- auxcomp(binf)      wart777112(12,4,11) verb(inf([bare|X3]))
------------------------------------------------------------------------


,-----------------------------------------------------------------------
,----- vadv         demain   adv(X2,X3)
! ,--- ndet         d        det(nom,pers3-sg-m,X3)
,----- subj(n)      homme    noun(cn,nom,pers3-sg-m,X3)
,----- vadv         ne       adv(X4,X5)
o----- top          attendre verb(ind:dcl:nwh,fin(pers3-sg-m,pres,potc):X1,[potc])
`----- vadv         pas      adv(X6,neg_adv)
! ,--- ndet         d        det(acc,pers3-sg-f,X6)
`----- obj(n)       femme    noun(cn,acc,pers3-sg-f,X6)
`----- vprep        sur      prep([sur|dat],[])
  ! ,- ndet         d        det(dat,pers3-sg-m,X5)
  `--- objprep(dat) pre'     noun(cn,dat,pers3-sg-m,X5)
------------------------------------------------------------------------
```

(9_T) *Demain l'homme n'attendrait pas la femme sur le pré.*

We see that the preposition of the subcategorized PP-argument is dropped, whereas the adjunct-*auf* is translated into the (spatial) *sur* (in English we get *for* and *at* respectively).

The example also illustrates, that, in the presence of a rich analytic tense system of the source (as is the case for German) and possibly of the target also (as is the case for French), doing transfer on the level of syntactic structure results in a lot of cases having to be considered in order to introduce the new verb at the right position in the structure and to get the translation of the auxiliary complex and the different modifications on it right in general. (Note that in the German structure the temporal adverb modifies the auxiliary verb, whereas the negation and the spatial location modify the participle; in French, all three adjuncts modify the unique (finite) verb – in case of an analytic target form, in contrast to German, the negation would modify the finite auxiliary of the auxiliary complex). In short, doing transfer on this level, we will be faced with source and target structures which are far from being homomorphic, in particular when considering the auxiliary complex.

Therefore we aspire at a level of representation which abstracts away from such syntactic details which, with regard to semantics, have no direct local contribution. This level of semantically oriented dependence relations is the range of the projection ϕ. From the source-net of the source analysis, ϕ computes the more abstract dependency structure.

Traversing the source-net, it highlights the relevant nodes by characterizing them as *semnode*s in the workspace. Semantically empty nodes are jumped over and the mother node is connected directly to the relevant node of the structure that fills a specific slot of the mother node. This type of connection is rendered by *semmother(Daughter,Slot,Mother)*. In order to distinguish adjuncts from subcategorized roles, we use the further relation *semslotmarker(Mother,Slot,Daughter)* for the latter roles only. The tense (and mood) information expressed by the auxiliary complex (and punctuation and word order, when considering sentence mood) is compressed into the one *semmtv(Node,MTV)* information, that via MTV assigns a vector style tense analysis to the node which contains the event information. We will come back to this in a minute.

There are no auxiliaries on the dependency layer. Note however, that no information is discarded. In order to get the target surface order right with respect to cases where the order of the source should be considered and with respect to other tasks where the source string as such plays a role, transfer and generation can trigger inspection of both, the dependence structure and of the syntactic analysis, as represented by the source net. The following (9_D) shows the result of the ϕ-mapping applied to the syntactic analysis (9_S) of (9):

(9_D)

```
Dependence tree.

---------------------------------------------------------------------------
,----- vadv                s(morgen,483709) adv(X1,X2)
! ,--- ndet                s(der,d)         det(nMgdFSgP,def)
,----- subj(n)             s(mann,1062123)  noun(cn,[nom,sg,m,kda|det],nwh)
,----- vadv                s(nicht,neg)     adv(X4,nwh)
,-,--- vprep               s(auf,51191)     prep([auf|dat],nwh,8)
! ! ,- ndet                s(der,d)         det(nMgdFSgP,def)
! `--- objprep(dat)        s(wiese,791264)  noun(cn,[dat,sg,f,w|det],nwh)
! ,--- ndet                s(die,d)         det(naFSnaP,def)
,----- comp(p([auf|acc]))  s(frau,254797)   noun(cn,[acc,sg,f,w|det],nwh)
o----- top                 s(wart,777112)   mtv(ind:dcl:nwh,tf(cond,0,X1),a)
---------------------------------------------------------------------------
```

We see that in this structure we do not find the semantically empty preposition as a node. Its entire contribution resides in the specific subclassification of the comp-role. In addition, the information of the auxiliary complex completely resides in the feature description of the unique verb node, where the instantiation of the *mtv*-arguments *Dependency/SentenceMood, TemporalFeatures*, and *Diathesis* expresses that the contribution is 'independent':'declarative':'without wh-element', that, following the temporal features, the contribution is of tense(_attitude) level 'cond', that it is not perfective, and that it is not known to be progressive; finally, that, following the diathesis information, it is 'active' (not passive and no resultative passive). In short **mtv** stands for **m***ood,* **t***ense* and **v***oice* information.

With regard to the temporal features, the approach described in this paper is based on the tense analysis, as suggested by Kamp and Rohrer in Kamp and Rohrer 1983, Kamp and Rohrer 1985. There, revising Reichenbach's standard of Reichenbach 1947, a three-dimensional analysis of the tenses is suggested which considers the relations between *speech time, perspective time* and *reference time*, which turn out to be specific to the meaning of the tenses. According to this, a number of tenses are ambiguous and must be assigned different analyses. However, since we want to define the transfer for (semantic) underspecified representations of the sentence which are unique with respect to the chosen syntactic analysis, we abstain from using the analysis system of Kamp and Rohrer directly. Instead the tense information is analysed into a feature description, which relates to the Kamp/Rohrer multi-dimensional analysis only, but which is less informative in that it underspecifies the different meanings of the tenses. This underspecified analysis can be disambiguated into the explicit tense readings however, through semantic evaluation.

The following table lists such analyses (of the French past tenses):

Form	TENSE ATTITUDE LEVEL	PERF	PROG
passé simple	PAST	-	-
imparfait	PAST	-	+
passé antérieur	PAST	+	-
plusqueparfait	PAST	+	+/-
cond. I	COND	-	+/-
cond. II	COND	+	+/-
subjonctif du passé	PAST_SUBJ	-	+/-
subjonctif du plusqueparfait	PAST_SUBJ	+	+/-

PERF informs us whether there is a *perfectivizer*, where, at surface, this operator normally is realized by an analytic structure with auxiliary verb and perfect participle.

PROG informs us whether the eventuality is presented as temporally open, that is, whether there is an aspectual operator on the one hand, which turns descriptions into homogeneous descriptions, like the analytic *dabei sein VP zu tun* in German, or the synthetic, morphological operator of French Imp, or whether the Aktionsart of the VP description is homogeneous, on the other hand (provided there is no explicit aspect operator contradicting this assumption, like the French PS).

TENSE ATTITUDE LEVEL describes the remaining information of the verb about the tense level and about the specific attitude against the eventuality which the tensed verb expresses. To describe this we use the following type system:
TENSE_ATTITUDE =
INDICATIVE | CONJUNCTIVE | CONDITIONAL | IMPERATIVE | INFINITIVE
TENSE_ATTITUDE = PAST_TENSE | NON_PAST_TENSE
PAST ≤INDICATIVE & PAST_TENSE
PAST_SUBJ ≤CONJUNCTIVE & PAST_TENSE
COND ≤CONDITIONAL & PAST_TENSE
PRES, FUT ≤INDICATIVE & NON_PAST_TENSE
PRES_SUBJ ≤CONJUNCTIVE & NON_PAST_TENSE,
where the COND- and _SUBJ- types underspecify the meaning of the (French) conditional and conjunctive mood. Sentential mood information like *declarative sentence, question, embedded question* etc. is not expressed by TENSE_ATTITUDE_LEVEL, but by the first argument of the *mtv*-description.

It is clear that this semi-syntactic classification of the semantic contribution aims at a universal unique description language for the tense systems of more than two languages (with variations at the leaves of the tense-attitude hierarchy only). It is also clear, however, that the corresponding class of languages is a class of relatively similar languages. We think of the Romance and Germanic languages, first of all. The different feature vectors will allow for different disambiguations (where the degree of specification may depend on the considered language). For instance, a feature vector with positive PERF, allows readings of the sentence where, in terms of the Kamp/Rohrer-approach, the mentioned event precedes the contextual perspective time and also for readings where the relevant temporal discourse referent of the sentence is not the event itself, but the corresponding resultative state, which is located at the contextual perspective time. The Imp-constellation <PAST,-,+ >can be read as a present tense, in the sense that the relevant perspective time accompanies the eventuality in question and is past with respect to the speech time, and it can be read as a past time, where the perspective is located at the speech time. The relativizing or modalizing attitudinal tense descriptions COND, PRES_SUBJ etc. subsume the meaning in particular conventional contexts (in conditionals for instance) and the meaning in 'unmarked contexts' (as 'future of the past' or as 'future' under a deontic DESIRE-operator); and so forth for other feature descriptions.

Generating the target description, the temporal features can be refined and revised respectively, as motivated in the introduction (cf. section 5).

With regard to examples like (9), the nodes of the dependence structure are a subset of the nodes of the phrase source net. ϕ only introduces new nodes in case of reentrancies and of syntactic analyses which, from a semantic point of view, are factorized representations, this is, where the compositional semantics suggests some preprocessing unfolding in order to show a homomorphic semantic picture (with respect to the discourse referents introduced). The following coordination example illustrates this unfolding multiplying out:

(10) Der Mann war süchtig nach Heroin und verrückt.
THE MAN WAS ADDICTED TO HEROIN AND CRAZY.

We obtain:

```
Syntactic analysis no. 1.   Evaluation = -0.6789 ...

------------------------------------------------------------------------
  ,----- ndet          d(1)                det(nMgdFSgP,def)
,------ subj(n)       mann1062123(2,u)    noun(cn,[nom,sg,m,kda|det],nwh)
o------- top           sei2(3,2,7,u)       verb(fin([pers3|sg],past,ind:dcl:nwh))
! ,----- lconj         s"uchtig856507(4,6)  adj(unfl,X6)
! ! `--- aobj(p(nach)) nachtemp(5,6)       prep([nach|dat],nwh,6)
! !   `- objprep(dat)  heroin332228(6)     noun(cn,[dat,sg,nt,o|X7],nwh)
`------ pred(a)       und                 adj(unfl,X6)
  `----- rconj         verr"uckt750980(8,u) adj(unfl,X6)
------------------------------------------------------------------------

Dependence tree.

------------------------------------------------------------------------
o----- top           s(sei,2)            mtv(ind:dcl:nwh,tf(past,0,0),a)
! ,--- subj(n)       s(mann,1062123)     noun(cn,[nom,sg,m,kda|det],nwh)
! ! `- ndet          s(der,d)            det(nMgdFSgP,def)
! ,--- pred(a)       s(s"uchtig,856507)   adj(unfl,X6)
! ! `- aobj(p(nach)) s(heroin,332228)    noun(cn,[dat,sg,nt,o|X7],nwh)
`-`--- lconj         s(sei,2)            mtv(ind:dcl:nwh,tf(past,0,0),a)
! ,--- pred(a)       s(verr"uckt,750980) adj(unfl,X6)
`---- rconj         s(sei,2)            mtv(ind:dcl:nwh,tf(past,0,0),a)
  `--- subj(n)       empty               coref(2)
------------------------------------------------------------------------
```

The slot grammar analysis of this sentence has a unique verb node (with sense *s(sei,2)*, which is of type *support_verb*) with a *subj*ect-daughter and a *pred*icate daughter, where the predicative complement is a coordination of adjectives. The sentence provides information about the existence of two states, however, of the *being addicted to heroin* and the *being crazy.* If we assume that it is the compositional semantics which should introduce the corresponding discourse referents (and not some postponed component of semantic evaluation), then, raising the coordination to the verb node level would produce a more homomorphic picture. This is what we mean by 'unfolding'. The projection ϕ distributes such coordinations into verb conjuncts, corresponding in number to the reported events or states.

Since slot grammar, in contrast to grammar theories like HPSG, does not distinguish between the nodes of the *projection line*, we must be more precise here: by distribution into *verb conjuncts*, we mean *raising the coordination to the sentence level*, as the dependence tree shown above makes clear, *through assigning a subject to both verb nodes.* Note that the result of distributing the subject to the verb nodes does not show any reentrancy, that is, coreference information is not expressed by structure sharing, but by an explicit coreference relation between *different* nodes (where the description marks the syntactically empty node).

This representation is better suited for the domain of the transfer than the underlying slot grammar analysis, where we get into serious interference problems in the case of structures with shared parts and transfer equivalents which, nevertheless, show different solutions for these parts. (10) exemplifies this, given the following translation into French:

(10_T) *L'homme s'adonnait à l'héroine et il était fou.*

The problem with this translation is that the translation of *verrückt sein* conserves the predicative structure and, in particular, translates *sein* by the default *être*, whereas the translation of *süchtig sein nach Heroin* changes the structure and, in particular, translates *sein (süchtig sein)* by *s'adonner*. The dependence representation allows for disentangling the corresponding translation tasks by separating the shared structures. The following target dependence structure is nearly homomorphic to the above depicted source dependence structure:

(10_{TD})

```
Target dependence tree.

------------------------------------------------------------------------
,----- lconj            adonner   mtv(ind:dcl:nwh,tf(past,0,0),a)
! `--- subj(n)          homme     noun(cn,nom,pers3-sg-m,X2)
! ! `- ndet             d         det(nom,pers3-sg-m,X2)
! `--- obj(n)           empty     coref(2)
! `--- iobj(p([`a|dat])) he'roine   noun(cn,dat,pers3-sg-f,X4)
o----- top              coord(et) coord(mtv(ind:dcl:nwh,tf(past,0,0),a),9,10)
`-_--- rconj            e^tre      mtv(ind:dcl:nwh,tf(past,0,0),a)
  `--- subj(n)          empty     coref(2)
  `--- pred(a)          fou       adj(X1,nom,pers3-sg-m,X3)
------------------------------------------------------------------------
```

Therefore, the level of dependence structure is the (main) level of transfer. The source dependency structure, using the lexicon information, is recursively translated into a dependency structure of the target, via τ. The target dependency structure is the input of the inversion of the (target) projection ϕ, which is designed as a general French generation grammar that potentially can be used by other translation variants with the same target language (language X to French). For the above target dependence tree, it computes the following slot grammar structure:

(10_{TS})

```
Restructured tree.

------------------------------------------------------------------------
    ,--- ndet          d         det(nom,pers3-sg-m,X2)
  ,-'--- subj(n)       homme     noun(cn,nom,pers3-sg-m,X2)
  ,----- obj(n)        se        noun(pron(reflprn),acc,pers3-sg-m,[coref(2)])
,------- lconj         adonner   verb(ind:dcl:nwh,fin(pers3-sg-m,imp,ind:dcl:nwh):X1,[]
!
! `----- iobj(p([`a|dat]))         prep(`a,X2)
!   ! ,- ndet          d         det(dat,pers3-sg-f,X4)
!   `--- objprep(dat)  he'rone   noun(cn,dat,pers3-sg-f,X4)
o------- top           coord(et) coord(mtv(ind:dcl:nwh,tf(past,0,0),a),9,10)
! ,----- subj(n)       il        noun(pron(def),nom,pers3-sg-m,[coref(2)])
`------- rconj         e^tre      verb(ind:dcl:nwh,fin(pers3-sg-m,imp,ind:dcl:nwh):X3,[]
!
  `----- pred(a)       fou       adj(X4,nom,pers3-sg-m,X3)
------------------------------------------------------------------------
```

We call the slot grammar level result of the generation *restructured tree* for historical reasons [1] and because it emphasizes that generation subsumes structural changes needed for passivization or topicalization or participle constructions and the like. From the depicted restructured tree, the target morphology computes the target string (10_T).

ϕ^{-1} is not a pure generation grammar, because it can inspect the source representations, mainly in order to translate the stylistic and ordering pecularities of the source correctly.

Like τ it may need further information which is not explicitly represented in the source representations. In this case, it can trigger further semantic evaluation of the source, via σ, and the computation of the corresponding consequences for the target representations, via τ', which is the transfer relation of the level of semantics.

To be precise, describing σ and τ' this way interpretes fig. (1) according to the LFG approach already mentioned. There is a difference however. In the next section, we will show that dependence representations of sentences can be understood as flat underspecified discourse representations, modulo the specific notational convenience of which it is made use. In the light of this, σ is not a function from structures of a functional type say into semantic structures, but an evaluation procedure from semantic representations into semantic representations. For this reason, it can be thought of as consisting of different evaluation routines controlled by different specifications about the desired degree or depth of the resulting inferences. In short, the domain and the range of σ are not completely different levels, they mark the one realm of semantic representation which shows different levels of granularity, corresponding to different degrees of semantic evaluation. τ', therefore, is not a more abstract transfer relation, it subsumes the basic τ and refines or constrains the output of this in case of missing unique transfer equivalences. It does this by making the source representation more explicit in the considered respect. In section 5, we will show what this means for the problem of translating the tenses.

3 Dependence Structure and Semantic Representations

In Eberle 1997b, starting from Reyle's *underspecified discourse representation theory* (UDRT, cf. Reyle 1993a, Reyle 1994, Reyle 1995a), a formalism for *flat underspecified discourse representation* has been developed, and a semantics for interpreting the corresponding FUDRSs. FUDRSs are designed to allow for compact semantic representations of a broad semantic fragment, including the compact, 'flat' representation of lexical ambiguity. Because of this latter property, above all, dependence structures obtain unique FUDRS-interpretations and can be seen as a subset of the FUDR language, as we will show in the following. [2]

Consider the following example (11), its dependence structure (11_D) and its FUDRS (11_{FUDRS}):

[1] This is the name of this type of result in the predecessors of the system, that is, the LMT systems.

[2] A quite similar result that says that (a subset of the) LFG f-structures are interpretable as UDRSs is reported in Genabith and Crouch 1996.

(11) Stundenlang arbeitete der junge Mann nicht.

A) It is not true that the young man was working for hours.

B) There is a stretch of time t lasting hours such that, within t, the young man didn't work.

(11_D)

```
---------------------------------------------------------------------
,--- vadv    s(stundenlanglang,423619)   adv(X7,adv)
o--- top     s(arbeit,41999)  mtv(ind:dcl:nwh,tf(past,0,X1),a)
! ,- ndet    s(der,d)         det(nMgdFSgP,def)
! ,- nadj    s(jung,367349)   adj(nMnaFNSnaP,X15)
`--- subj(n) s(mann,1062123)  noun(cn,[nom,sg,m,kda|det],nwh)
`--- vadv    s(nicht,neg)     adv(X12,nwh)
---------------------------------------------------------------------
```

(11_{FUDRS}) l: $\boxed{}$ $\{l1_{\varepsilon\ ,x,x}$:$\underline{\text{der}}(\underline{\text{junge}}(\underline{\text{mann}}(x)))$, $l2_t$:$\underline{\text{nicht}}(t)$, $l3'_e$:$\underline{\text{stundenlang}}(e'),\}$
$\{\}$
$l0_e$:$\underline{\text{arbeiten}}(e,x)$

According to the notational conventions of Eberle 1997b, underlining means that the corresponding expression is a functional term whose evaluation depends on some particular triggering conditions -constraints- which are formulated for the function. Depending on the definition of the function, the term may obtain more than one evaluation (this is, the function may be multi-valued). Evaluations are DRSs or partial DRSs, depending on the type of the representation. Underlined expressions mark what we call *flat* representations i.e. representations which can be analyzed into (different) (partial) DRSs. The functional terms of (11_{FUDRS}) are described as follows:

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

$\underline{\text{mann}}(x) := l_x$: [x | mann1(x)]

$\underline{\text{mann}}(x) := l_x$: [x (y) | mann2(x,y)]

This means that $\underline{\text{mann}}$ is a function from *ref*erents (individuals) into labelled discourse representation structures of type noun semantics (one-place predicates applied to the argument individual), where the label of the DRS is decorated by the *distinguished* referent (the argument). This function has different evaluations corresponding to the *man-* and *husband*-meaning of *Mann* (we have skipped annotating the different evaluations by some triggering contextual constraints – which are rather difficult to spell out).

$\underline{\text{arbeiten}}(\text{ref,ref}) \Rightarrow$vsem_l

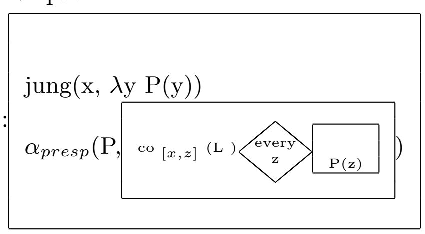
$\underline{\text{arbeiten}}(e,\chi) := l_{e_{t,akt(hom),MTV}}$: [e @ process | arbeiten(e), $\text{agent}_{cons}(e)=\chi$, $e \subseteq t$]

$\underline{\text{arbeiten}}$ is a function from pairs of referents into labelled DRSs of type verb semantics, where the one argument is the event variable and the other the agent of the event which, by the compositional semantics, will be identified to the distinguished referent of the subject. We note that there is some Aktionsart typing of the event variable (which is the distinguished referent of the verb representation) and of the structure as such (seen as an event predicate), and in connection with this of the thematic role, where *hom* means *homogeneous* and *cons* means *constant*. We come back to this in the section after next. Note also that the event introduced is bound to some time t, which we call the *focus time* and which will be determined by the context as an available, presently focussed reference time of the context. The decoration of the distinguished event referent, besides the Aktionsart information, will contain tense information also, by MTV.

The evaluations of the flat noun- and verb-representations are so called *basic* representations (i.e. conventional, but decorated DRSs).

jung(npsem_l) ⇒npsem_l

jung(L) := $l1_x$:



$\{l \leq l1\}$
L_x

jung is a function from labelled structures of type NP semantics into structures of the same type. It percolates the distinguished referent of the argument by determining it as its own distinguished referent. The evaluation is structurally different from the evaluations of the noun- and verb-representations. It puts its (NPsem-type) argument L at a distinguished position and stipulates this argument to be dominated by the adjective contribution proper in the UDRT-sense. We call such structures *pDRS* structures. They are typical for modifiers like adjectives and adverbs. In disambiguations of FUDRSs the chosen argument of the modifier will be unified to this argument-L (and with this the argument referent to the percolated referent). In case, the argument is ≤-ordered with respect to the modifier contribution proper it will be merged to this contribution (*jung* is an example of this), otherwise, in the case of <, L will be mentioned within the modifier contribution (at an embedded position) such that there won't be any merging in the disambiguation (and there cannot be for the sake of acyclic structures). Modal adjectives like *möglich/possible* exemplify this embedding type of modification.

We see that the evaluation interprets the adjective as a relative modifier, that is, as a modifier which relativizes the property that it contributes (i.e. *jung*) to some (contextually inferrable) aspect: We render this by presupposing a (contextually familiar) predicate P which, as an argument of the *jung*-predicate, relativizes the *jung*-predication. This P is stipulated to be satisfied by the individuals of the modificandum (by *men* in the case at hand), thus, with this modelling, we obtain something like *'jung' for a man* or *'jung' for a human being* with respect to the context given, but not *'jung' for a planet*.

nicht(vpsem_l) ⇒vpsem_l

$\underline{\text{nicht}}(L_{\varepsilon_t}) := l1_{t_{akt(hom)}}: \boxed{\neg\text{: } L}\ \begin{array}{l}\{l < l1\ \} \\ L\end{array}$

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

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

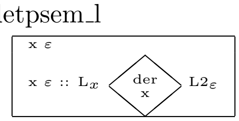
$\underline{\text{stundenlang}}(L_{\varepsilon_{akt(het)}}) := l1_{E_{akt(het)}}: \boxed{\begin{array}{l} \text{stundenlang(E)} \\ \text{E} \in \text{iter } \varepsilon \text{ L} \\ \text{E} \in \max \text{E' co}_{[E,E']}(\boxed{\begin{array}{l}\text{E'} \\ \text{E'} \in \text{iter } \varepsilon \text{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

nicht and stundenlang are quite similar to the adjective representations, in the sense that they are modifiers, functions of type X/X, except that, with them, X is not NPsem but VPsem. Note that nicht is stipulated to turn event descriptions into homogeneous event descriptions, where the resulting distinguished DRF is not the argument event, but the (focus) time for which the realization of an event of the argument type is excluded. stundenlang, applied to homogeneous descriptions, stipulates the modified instance to be a maximal representative of the argument event description. When applied to heterogeneous descriptions, it does some type coercion (we have rendered the case of iteration) to the argument, before qualifying it in accordance to the first case. We come back to this type of Aktionsart information in the section after next.

$\underline{\text{der}}(\text{npsem\_l;qpsem\_l}) \Rightarrow \text{detpsem\_l}$
$\underline{\text{der}}(L) := \underline{\text{det}_{def,sg}}(L).$
$\underline{\text{der}}(^{\text{npsem\_l}}L) := \underline{\text{q\_der}}(L).$

where:

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

$\underline{\text{q\_der}}(L) := l1_{\varepsilon,x,x}:$  $\begin{array}{l}\{l3 \leq l2\} \\ L3\end{array}$

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

$\underline{\text{det}_{def,sg}}(^{\text{npsem\_l}}L_x) := l1_{\varepsilon,x,x}: \boxed{\alpha_{def}(\text{x,L})}\ \begin{array}{l}\{l2 \leq l1\} \\ L2_{\varepsilon}\end{array}\ .$

$\underline{\text{det}_{def,sg}}(^{\text{qpsem\_l}}L_{\_,x,x}) := l1_{\varepsilon,x,x}: \boxed{\alpha_{def}(\text{x,sat(L)})}\ \begin{array}{l}\{l2 \leq l1\} \\ L2_{\varepsilon}\end{array}\ .$

der is a function from NPsem labelled structures and QPsem labelled structures into

DetPsem labelled structures, where QPsem labelled structures are representations of (**q**uantized) **p**hrases like *viele Männer* which allow for a (further) determiner and where DetPsem labelled structures are **det**erminer **p**hrases which don't accept a further determiner or quantifier. The result is a pDRS-representation whose argument is a VP-representation and whose label is annotated by three distinguished referents, where the first is the percolated (or modified) event variable, where the second is the referential argument of the DP as accessible from outside the DP representation (in case of summation, as with *viele*, it is the sum referent), and where the third is the referent which is accessible from the argument VP-position (the referent which, by the syntax-semantics interface, is identified as (one of) the complement argument(s) of the VP). The evaluations of der render the referential determiner use and the attributive use as in *derjenige welcher/the one who.* The sentence representation itself, (11_{FUDRS}), structurally is of a third (and last) type of representation: it is a so called *functor set* representation, consisting of a set of functors – the structures labelled by l1, l2 and l3, of a set of ordering conditions (which constrain the order of application of the functors to the argument in a disambiguation of the representation), and, finally, of the argument, that is, the minimum of the partial order described. For more details about this represesentation formalism and a discussion about the similarities and differences between FUDRSs and UDRSs refer to Eberle 1997b, also refer to this study for the disambiguation algorithm that turns such structures into classical DRSs and for the FUDR-model theory. Adopting the referential reading of der (the attributive reading is not supported by the context), and accommodating the DRF of the corresponding description at the main DRS-universe, (11_{FUDRS}) can be disambiguated to the following two DRSs:

x t now mann(x) jung(x, λy. mensch(y)) t $\prec$ now $\neg$: [e arbeiten(e) agent(e)=x stundenlang(e) e $\subseteq$ t]	x t now mann(x) jung(x, λy. mensch(y)) t $\prec$ now stundenlang(t) $\neg$: [e arbeiten(e) agent(e)=x e $\subseteq$ t]

Now, what is the relation between the dependence analyses, as depicted by the dependence trees, and FUDRSs?

The leaves of the dependence structures are easily identifable as lexical FUDRs with evaluations of the basic type and of the pDRS-type respectively. With regard to (11_D), we identify as follows (remember that the nodes of the dependence structures carry names (position numbers), which are not rendered in the visualization, but which, nevertheless, we can use as labels of the corresponding FUDRSs):

1 - s(stundenlang,423619) adv(_,adv) $\longrightarrow$ l1$_{\varepsilon}$:<u>stundenlang</u>(L1')
2 - s(arbeit,41999) mtv(ind:dcl:nwh,tf(past,0,_),a) $\longrightarrow$ l2$_{e,\mathrm{mtv(ind:dcl:nwh,tf(past,0,_),a)}}$: <u>arbeiten</u>(e,$\chi$)
3 - s(der,d) det(nMgdFSgP,def) $\longrightarrow$ l3$_{\varepsilon',y,y}$:<u>der</u>(L3')
4 - s(jung,367349) adj(nMnaFNSnaP,_) $\longrightarrow$ l4$_z$:<u>jung</u>(L4')
5 - s(mann,1062123) noun(cn,[nom,sg,m,kda| det],nwh) $\longrightarrow$ l5$_x$:<u>mann</u>(x)
6 - s(nicht,neg) adv(_,nwh) $\longrightarrow$ l6$_t$:<u>nicht</u>(L6')

It should be clear, that, up to renaming of variables, and more generally, up to isomorphism, of course, for each leaf node of the dependence structure there is exactly one FUDRS describing the node. This is so because lexical ambiguity is passed to the evaluations of the flat representations. For further illustration: the article *der* not only is ambiguous between the referential and the attributive meaning (as shown by the representation above), it also accepts plural referents (case genitive plural) and its set of evaluations will therefore also contain the corresponding collective and distributive reading. The further constraint of case nominative singular, which is provided by the sentential agreement information, effects the respective constraining of the evaluations of <u>der</u> (to the treated <u>det$_{def,sg}$</u>-cases – by requiring the identity and atomicity of the referential indices). However, there is no parallel decrease of the set of interpreting FUDRSs. The different meanings are summarized by the one initial 'der'-representation <u>der</u>. The difference completely resides in additional constraints (which, in the case at hand, are about the decoration of <u>der</u>) and the corresponding impact on the admissible kinds of evaluation. We already have mentioned that slot grammar analyses don't really make a difference between verbs and their projections (and nouns and their projections etc.). However, FUDRSs do. The verb is represented as a FUDRS of the basic type, whereas the VP is represented as a FUDRS of type *functor set*, consisting of a basic FUDRS, for the verb, at its bottom, of a set of functor representations and of a set of specifications about the order of applying the functors to the argument. We solve this problem by considering the dependence structure as a set of nodes, a set of two place relations (which are the slot relations), and inferrable from these, a set of (sub)trees:

<u>Definition</u> (preliminary): **Dependence structure**
A dependence structure DS is a structure:

<Nodes, Edges, Subj-Edges, Obj-Edges, ..., Trees >

where Edges are pairs of nodes, Subj-Edges etc. are these subsets of Edges which are *subj*-, *obj*- relations etc., and where the trees are either the singleton sets over the set of nodes or these sets of nodes which are dominated by exactly one node, w.r.t. Edges, and which are maximal in this respect.
1 $\{\mathrm{T}_{FUDRS}(\mathrm{DN1}_{[...]}), \ldots, \mathrm{T}_{FUDRS}(\mathrm{DNn}_{[...]})\}$
According to this, for each DS, there is a one-to-one-mapping M_{max} which, to a node N, assigns the maximal tree which is dominated by N, and there is a second one-to-one-mapping M_{min} which assigns the set consisting of N to N. We can use these mappings in order to get our projection problem right: we do not map the nodes of a DS into FUDRSs, but the corresponding trees: The singleton set trees (meaning nodes as such)

of a DS are interpreted by basic FUDRSs or pDRS-FUDRSs as illustrated above. In case a node N of a DS is modified, M_{max}(N) is different from {N} (=M_{min}(N)). We map M_{max}(N) onto a functor set FUDRS which uses the FUDRS of {N} as its bottom element, and the FUDRS-interpretations of the maximal subtrees of M_{max}(N) as the functors. Calling this mapping T_{FUDRS} (translation into FUDRSs), the relevant recursion step easily is rendered as follows:

$$T_{FUDRS}(\mathrm{MN}\ [\mathrm{DN1}_{[...]}, \ldots, \mathrm{DNn}_{[...]}\ ]) :=$$

$$l_{MN}: \boxed{} \begin{array}{l} \{T_{FUDRS}(\mathrm{DN1}_{[...]}), \ldots, T_{FUDRS}(\mathrm{DNn}_{[...]})\} \\ \{\} \\ T_{FUDRS}(\{\mathrm{MN}\}) \end{array}$$

where MN [DN1,..., DNn] stands for the tree dominated by MN with maximal subtrees dominated by DN1, ..., DNn, and $T_{FUDRS}(\mathrm{DNx}_{[...]})$ for the translation of the tree dominated by DNx.

Considering this recursive translation of dependence structures into FUDRSs, the specific edge-information is often redundant. For instance, *vadv* says that the daughter applies adverbial modification to the (syntactic) verbal mother. This, however, is clear already, knowing that the daughter is an *adv(_,_)* and the mother a verb (*mtv(_,_,_)*). The edge-information is relevant to distinguish adjunct modification from subcategorized roles however, and, with regard to the latter, the naming of the edges represents the linking information of the syntax semantics interface. (Since the case-roles of the dependence structures are deep cases in the Chomskian sense, there is no risk, however, that the syntax style naming of the roles conflicts with the assumption that this naming represents an underspecified thematic classification of the roles of the considered verb). With subcategorized roles, therefore, the naming of the edges causes the distinguished referent of the role to be correctly identifed to the corresponding verb argument. We skip formally working out the translation function T_{FUDRS} in this respect. We also skip extending T_{FUDRS} to all types of dependence descriptions as can be generated from the German slot grammar (or the grammar of some other language). It should be clear how this working out proceeds with regard of other parts of speech (conjunctions etc.) and corresponding syntactic structures. What is more relevant to our subject here is to have shown how lexical Aktionsart-information and tense information is available as decorations of the FUDRSs, where the percolation of the information from decorations follows the (HPSG-like) principles formulated in Eberle 1997b.

As it stands, the dependence structures are identifiable as FUDRSs, as shown. However, they always represent maximally weak information with respect to the partial ordering statements that can come with the FUDRSs. The only ordering constraints stem from the dependence hierarchy as such and from type information: The functors of a relative clause, for example, are bound within the local domain of the modified NP (note that FUDRSs treat wide scope readings of embedded definites as a matter of presuppositional projection and not as a matter of quantifier scope, for this, again, see Eberle 1997b). (11) presents an example of how type information can constrain the partial order of the functor representations. der and jung are modifiers of mann. Since both modify NPs and since only jung outputs structures of the same type, in each disambiguation, jung must be applied before der. Therefore, it holds:

$$\mathrm{l}{:}\boxed{}\begin{array}{l}\{\mathrm{l3}_{\varepsilon\ ,y,y}{:}\underline{\mathrm{der}},\mathrm{l4}_{\chi}{:}\underline{\mathrm{jung}}(\mathrm{L4'})\}\\ \{\}\\ \mathrm{l5}_{x}{:}\underline{\mathrm{mann}}(\mathrm{x})\end{array} \Longrightarrow \mathrm{l}{:}\boxed{}\begin{array}{l}\{\mathrm{l3}_{\varepsilon\ ,y,y}{:}\underline{\mathrm{der}},\mathrm{l4}_{\chi}{:}\underline{\mathrm{jung}}(\mathrm{L4'})\}\\ \{\mathrm{l4}\ \leq \mathrm{l3}\}\\ \mathrm{l5}_{x}{:}\underline{\mathrm{mann}}(\mathrm{x})\end{array}$$

Since the latter FUDRS entails complete ordering knowledge, (abstracting away from lexical ambiguities) it is equivalent to the (partial) DRS:

$$\lambda.(\ \lambda \mathrm{x.DRS})\ \langle \mathrm{x}, \boxed{\alpha_{def}(\mathrm{x}, \boxed{\begin{array}{l}\mathrm{x}\\ \mathrm{jung}(\mathrm{x},\ \lambda.\mathrm{y\ P(y)})\\ \mathrm{mann}(\mathrm{x})\end{array}})} \cup \mathrm{DRS}\rangle$$

which is the FUDRS $\mathrm{l}_{\varepsilon\ ,x,x}{:}\boxed{\alpha_{def}(\mathrm{x}, \boxed{\begin{array}{l}\mathrm{x}\\ \mathrm{jung}(\mathrm{x},\ \lambda.\mathrm{y\ P(y)})\\ \mathrm{mann}(\mathrm{x})\end{array}})}\ \begin{array}{l}\{\mathrm{l'} \leq \mathrm{l}\}\\ \mathrm{L'}_{\varepsilon}\end{array}$

In case we want to express scope information also which is not already implicitly given by the dependence structure as such – and we want to have this possibility, because, often, the good translation needs scope information – we must extend the dependence structure language by the corresponding type of statements:
In order to bring out scope ordering knowledge, and knowledge about information structure, we augment the DS-structure by two types of relations *semscope(A,B)*, expressing scope ordering items (A $\geq$ B), and *semfocus(A,B)*, expressing modifier-focus-items (where B is the focus of A within the scope of A):

Definition: **Dependence structure**
A dependence structure DS is a structure:

<Nodes, Edges, Subj-Edges, Obj-Edges, ..., Trees, semscope, semfocus >

where *Edges* , ..., *Trees* is as above, and where *semscope* and *semnode* list scope and focus relations as described. With this, we easily see that it is not only that for a sentence S, with DS(S) (the dependence structure of S), we obtain the corresponding (unique) FUDRS T_{FUDRS}(DS(S)). Conversely, we also obtain a dependence structure T^{-1}_{FUDRS}(FUDRS(S)) for a FUDRS FUDRS(S) of the sentence (given the assumption that there is a word sense hierarchy – over the s(_,_)-terms - which reflects the lexical ambiguities satisfactorily). In short, we can understand dependence structures as FUDRSs written according to a convenient abbreviating notation format. Since FUDRSs can be augmented continuously by scope- (and other disambiguating) information to an informational density which makes them equivalent to a (non-disjunctive) DRS, the σ of our approach, as said in the last section, is not a projection from a functional representation into a semantic representation, as in the LFG architecture already mentioned. It is a semantic evaluation procedure which translates semantic expressions into more informative semantic expressions (using contextual and background knowledge).

4 Transfer

The backbone of the German-French transfer is a top-down construction algorithm that builds a target dependency structure from the source dependency structure. This algorithm defines a translation function τ which, schematically (and preliminarily), can be characterized by:

$$\tau(\text{Mother}\left\{\begin{matrix}\text{slot}_1\text{: Daughter}_1,\\ \vdots \\ \text{slot}_n\text{: Daughter}_n\end{matrix}\right\}\text{\& OC}) := \tau_n(\text{Mother})\left\{\begin{matrix}\tau_s(\text{slot}_1)\text{:}\tau(\text{Daughter}_1),\\ \vdots \\ \tau_s(\text{slot}_n)\text{: }\tau(\text{Daughter}_n)\end{matrix}\right\}\text{\& OC}$$

This recursive strategy is inspired by similar approaches that have been suggested, for instance, with respect to typed feature structures, by Zajac 1989 (meant to be used for translating HPSG-like source representations into corresponding target representations), and by Dorna et al. 1994 for the *Verbmobil* (HPSG-)scenario. The transfer function (which often is multi-valued, thus, more precisely, the transfer *relation*) is based on the translation of the nodes (that is, the translation of the corresponding word and its feature description), τ_n, and the (default) translation of the slots, τ_s. In addition, the assumption of the basic routine is that the ordering conditions of the source structure (OC) remain unchanged.

The (bilingual) lexicon defines the word equivalences, which, together with some default knowledge about the translation of the categorial feature descriptions, define τ_n. τ_s is the default slot translation. It stipulates, for instance, that *subj(n)* is translated into *subj(n)*, that *obj(ob)* (which points to a subclause headed by *ob* (*whether*)) is translated into *obj(si)*, that *iobj(n)* or *iobj(p(an))* are translated into *iobj(p(à))*, or, for short, *iobj(n | p(an))* into *iobj(p(à))*. For illustration, consider example (12):

(12) Er schreibt dem Mann.
HE WRITES TO THE MAN.

On the basis of the lexical entry (12_L) for *schreiben (write)* (where (12_L) renders the part of the existing database-entry that is relevant to our subject), from the dependence tree (12_D), we obtain the target dependence structure (12_{TD}):

(12_L) *schreib*
>verb [obj(n | fin | ob),iobj(n | p([an|acc]))]
>τ_n: écrire
.

(12_D)

```
Dependence tree.
------------------------------------------------------------------------
'--- subj(n) s(er,206261)      noun(pron(pers3),[nom,sg,m,kda|X3],nwh)
o--- top     s(schreib,615154) mtv(ind:dcl:nwh,tf(pres,0,0),a)
! '- ndet    s(dem,d)          det(dMNS,def)
`---- iobj(n) s(mann,1062123)   noun(cn,[dat,sg,m,kda|det],nwh)
------------------------------------------------------------------------
```

(12_{TD})

```
Target dependence tree.
------------------------------------------------------------------------
o--- top               e'crire mtv(ind:dcl:nwh,tf(pres,0,0),a)
`--- subj(n)           il     noun(pron(pers3),nom,pers3-sg-m,X2)
`--- iobj(p([`a|dat])) homme  noun(cn,dat,pers3-sg-m,X3)
  `- ndet              d      det(dat,pers3-sg-m,X3)
------------------------------------------------------------------------
```

Since the lexical entry of *schreiben* does not provide particular constraints for the transfer, the structure is preserved and the naming of the nodes and edges follows τ_n and τ_s. Note that each structure that is computed at intermediate levels of the recursive process is a well defined target dependency structure (in the sense of the target grammar) that renders a substructure of the final complete target dependency structure. Next to formal exactness, this means that at each level of processing, inference mechanisms which are defined for the expressions generated by source and target grammar respectively are applicable to the actual input and output structures. Translation cannot always output target structures which are homomorphic pictures of the source. With regard to the mother node and its daughters, renaming slots, exchanging slots for each other, deleting and adding slots (and fillers), and more generally, renaming, deleting and adding paths (and path values), in this order, increases the structural difference between source and target. Dorr 1992, Kuhn and Heid 1994 present examples and classifications of (such structural) translation problems. Similar to suggestions like Kaplan et al. 1989 (for the LFG framework), we assume that the lexical item can stipulate specific transfer correspondences about the arguments which will be assigned to it in the sentence, or, more generally, about the substructure which it is the head of in the sentence. These particular transfer statements override the general translation routine with respect to the node in question. Consider the following example and its French translation:

(13) Er gedenkt des Mannes.
Il évoque le souvenir de l'homme.

Here, the German genitive object must be deleted and a new obj-role must be introduced that incorporates the source genitive at an embedded level. We provide the following lexicon entry that handles this case:

(13 $_L$) *gedenk*
>*verb* [*gobj1*]
>*τ:évoquer* [item(obj(n), [souvenir|m] .det(def,sg), [comp(p(de)):τ(d(gobj))]),e]
.

The item introduces an instruction for the recursive transfer which says the following: The translation of the slots which are less oblique than the genitive slot follow the general recursive translation routine using τ_s (this is the information of not mentioning them, as in (12_L) –here, this only relates to *subj*). The target does not know a genitive slot, however, (the *e* refers to *gobj* and means *empty*, the '1' of *gobj* requires the slot to be obligatory). In addition, there is a new slot that has no counterpart in the source (designated by (new) *item*) and which is an obj(n)-slot with head word *souvenir* realized in the definite singular variant. In addition, this obj-role comes with a complement which is a *de*-PP and whose content is the translation of the source genitive object. Note that further embeddings would be allowed by assigning item-literals as values of the slot-list of target-items, if necessary. With this, we obtain (13_{TD}) as τ-correspondence of the dependence structure (13_D) of the sentence (13):

(13_D)

```
------------------------------------------------------------------------
,--- subj(n) s(er,1)     noun(pron(pers3),[nom,sg,m,kda|X1],nwh)
o--- top     s(gedenk,1) mtv(ind:dcl:nwh,tf(pres,0,0),a)
! ,- ndet    s(des,d)    det(gMNS,def)
'--- gobj(n) s(mann,1)   noun(cn,[gen,sg,m,w|det],nwh)
------------------------------------------------------------------------
```

(13_{TD})

```
------------------------------------------------------------------------
o----- top         e'voquer  mtv(ind:dcl:nwh,tf(pres,0,0),a)
'----- subj(n)     il        noun(pron(pers3),nom,pers3-sg-m,X2)
! ,--- ndet        d         det(acc,pers3-sg-X1,X2)
'-+--- obj(n)      souvenir  noun(cn,acc,pers3-sg-X1,X2)
  ! ,- ndet        d         det(dat,pers3-sg-m,X3)
  '--- comp(p(de)) homme     noun(cn,dat,pers3-sg-m,X3)
------------------------------------------------------------------------
```

We will not go into the details of the lexicon formalism here. The example should make clear however, that the so-called *τ-slots*-statements which, as illustrated by (13_L), describe path equivalences of the source- and target-structures which are dominated by the considered item and its translation respectively, certainly are expressive enough to solve the transfer problems already mentioned. Also, it should be clear how such statements fit with the recursive translation strategy and how they direct the general transfer algorithm by presenting specific translations for particular nodes (or, more precisely, for the trees dominated by such nodes). However, there are structurally more complex translation mismatches, which cannot be dealt with by the transfer algorithm as it is defined at present. These problems are posed by the so called *head switching* phenomena, where functor and argument exchange their positions for each other. The following (14) presents an example of this type of structural change:

(14) Er schwimmt gerne.
Il aime nager.
HE LIKES TO SWIM.

In the lexicon, we treat this by a (type changing) τ-slots statement within the entry of *gerne*:

(14_L) *gerne*
>*adv* []
>τ*:*
(u-cat(verb) → aimer [item(subj(X'),τ(u-d(subj(X)))),item(obj(binf),τ(u$^{\not\succeq id}$)))]
.

Here, u and d stand for *up* and *down* respectively, where the corresponding path statements relate to the edge structure of the dependence tree. $u^{\not\succeq id}$ is like u , except that besides *id* (that is, the lexical structure itself) it does not contain the modifiers which are assumed or known to be outside the scope of *id.* (14_L) states that provided *gerne* modifies a verb, it is translated into *aimer*, where the subject of *aimer* will be the translation of the subject of the modified verb (where the subclassification of the target subject, X', is identical to the subclassification of the source subject, X – modulo the τ_s default correspondences, that is, τ_s(subj(X))=subj(X')), and where the object of *aimer* will be the bare infinitive variant of what τ(u$^{\not\succeq id}$) designates. Here, τ(u$^{\not\succeq id}$) designates the translation of the verb together with the (subcategorized and free) modifiers of the verbal complex that are analysed as being in the scope of *gerne*. For (14) we obtain the following:

(14_D)

```
-----------------------------------------------------------------------
,- subj(n) s(er,1)      noun(pron(pers3),[nom,sg,m,kda|X5],nwh)
o- top     s(schreib,1) mtv(ind:dcl:nwh,tf(pres,0,0),a)
'- vadv    s(gerne,1)   adv(X6,X7)
-----------------------------------------------------------------------
```

(14_{TD})

```
-----------------------------------------------------------------------
o--- top        aimer  mtv(ind:dcl:nwh,tf(pres,0,0),a)
'--- subj(n)    il     noun(pron(pers3),nom,pers3-sg-m,X2)
'--- obj(binf) e'crire mtv(inf,tf(pres,0,0),a)
  '- subj(n)    empty  coref(1)
-----------------------------------------------------------------------
```

Note that, here, in order to avoid cyclic structures, we exploit the fact that our source structures are (unresolved) semantic structures and, therefore, allow for scopal ordering of the functors of an argument such that, in the transfer definition of *gerne*, the structure u can be restricted to $u^{\not\succeq id}$, which otherwise would contain *id* itself such that the recursive formulation of the translation would trigger an infinite regression. It remains to reformulate the transfer routine such that it accounts for the order of the transfer steps as prescribed by the scopal interpretation. As a prerequisite, we assume the input to be rewritten as a sequence of application steps in accordance with the condition set OC. With this, we obtain the following basic routine:

$$\tau(\text{Mother}\left\{\begin{array}{l}\text{mod}_1\text{: Mod}_1,\\ \vdots \\ \text{mod}_n\text{: Mod}_n\end{array}\right\} \&\ \text{OC}) = \tau(\text{mod}_1(\text{Mod}_1,\ldots \text{mod}_n(\text{Mod}_n,\text{Mother})\ldots)\ )$$

$$:= \tau_s(\text{mod}_1)(\tau_n(\text{Mod}_1),\ldots \tau_s(\text{mod}_n)(\tau_n(\text{Mod}_n),\tau_n(\text{Mother}))\ldots)\ \&\ \text{OC}$$

As before, specific τ's from lexicl entries may stipulate specific conditions about the (syntactically or semantically) subcategorized complex.

Often it is argued that head switching is a syntactic phenomenon that disappears if transfer is formulated for the semantic level. There, *gerne*, for instance, takes the VP-semantics as argument and applies some modal relativization to it just like *aimer faire qc* or *to like to do s.th.* do. Most elegant in this respect is the interlingua approach to translation, which always assumes identical representations of source and target sentence at the level of universal semantic description (cf. Kuhn and Heid 1994 for a modern HPSG-based example of this approach). Here, translation is just a matter of semantic construction and generation from semantic representations. Until now, nobody has discovered the broad coverage interlingua however. It is not so clear, whether the more modest approach to translation, of which our suggestion is a representative and also others like Dorna et al. 1998 and which assumes semantic representations that may be language dependent in certain respects, can truly assume that there is no head switching on the semantic level. We will not go into detail with this question here, we just want to emphasize that our approach can deal with head switching phenomena, independently on whether they are purely syntactic or semantic in nature. (For a discussion of this question and details of our lexicon formalism compare Eberle 2000a). It can do this, we repeat it, because the representations to be processed are structured into argument and functor semantics related by the scopal constraints of the dependence structure. It depends on the nature of the modification whether the argument is characterized relationally –adjuncts of temporal location do this for instance– or whether the argument falls in the scope of an embedding operator –as is the case with *gerne*. In the presence of the latter true scope bearing modifiers, meaning preserving translation necessitates a procedure which decides the scopal relations in these cases which are not predicted by the syntactic constraints of the source sentence and which, nevertheless, are relevant to get the target dependence structure (and word order) right. Still adhering to the underspecification philosophy, the computation of this information is postponed to the time, however, where, within transfer or generation, this information is needed. (Head switching slots or adjuncts will trigger scoping such that the transfer can correctly evaluate the '$u^{\not\geq id}$' of the $\tau(u^{\not\geq id})$-statements as referring to appropriate structures consisting of the representation of the syntactic head together with a number of modifiers). This also follows the lazy expansion strategy, as stipulated in Kay et al. 1994 and elsewhere.

The "→"-prefixes in the lexical transfer statements, like "u - cat(verb) →" of the τ-value of (14_L), are lexical examples of *contextual constraints* (in the sense of Eberle et al. 1992). They have to be evaluated to get the target dependence structure right.

Others will be formulated at later stages of processing and/or will be evaluated later like those that are relevant for target word order and those that are relevant for the task of determining the target surface tense, to which we will turn now.

5 Evaluation

Besides the use of the contextual constraints that the lexical entries stipulate for particular disambiguations and/or translations respectively, which we have mentioned in the last section and which are mainly syntactic and semantic type tests applied to the slots of the considered item or to nodes that are reachable via some particular path, we make use of another type of contextual filtering: the antecedent information about pronoun anaphora. The corresponding module, the nominal resolver (that is taken over from the LMT-implementation), makes weighted suggestions about the identity of antecedents, mainly by exploiting information structural knowledge (parallelism etc.) and type information. It does this on the basis of accessibility constraints as provided by the syntactic structure, see Lappin and McCord 1990, Leass and Schwall 1991. This device is optional. Depending on the translation mode, it can be switched on or off. Currently, the algorithm is extended in order to make better use of semantic constraints – like the semantic accessibility relation as provided by the semantic representations of the sentence and the preceding text. Note that semantic accessibility and scope relational setting are interdependent (pronouns must be in the scope of their antecedents). Since the determination of the target tense can depend on the Aktionsart and the temporal localization of the considered event, which, as we tried to motivate in the introduction, in turn also depend on the scope ordering, the different types of resolutions should be interleaved. This is work in progress. At present, when it is switched on, nominal resolution in fact precedes tense and aspect evaluation, which is sensitive to the scopal consequences of the antecedence decisions in this case. Consider the following example:

(15) Seinen Lehrer lernt jedes Mädchen bei dessen Amtseinführung kennen.
EVERY GIRL BECOMES (/WILL BECOME) ACQUAINTED WITH HER (/HIS) TEACHER AT HIS INITIATION.

In case the possessive pronoun *seinen* is resolved to the different girls (solution with *her*) the representation of the accusative NP must be in the scope of the representation of the subject NP, otherwise, because of the necessary distributive reading of the quantifier *jed*, there could not be the corresponding anaphoric link. Now, in this case, the PP-representation must be in the scope of the subject NP also, provided *dessen* is correctly related to the teacher. From this, we obtain that the temporal modification *bei dessen Amtseinführung* relates to the single situations of becoming acquainted. In contrast, resolving *seinen* to some other (wide scope) accessible DRF of the preceding text the wide scope accommodation of the initiation event becomes available and is preferred. In accordance to what has been said in the introduction (when considering example (5)), this wide scope modification would trigger the futurate translation of the German Präsens, whereas, in the first case of narrow scope modification, the quantificational statement as such is not bound to some specific time from an adverbial and allows for the *présent* translation also. Whether this translation is preferred to the futurate translation will depend on whether the sentence is interpreted as describing a (homogeneous) situation rather than a (heterogeneous) event (also in accordance with the motivation of the introduction). This decision, in turn, heavily depends on whether the recipient assumes the quantifying *jedes Mädchen* to be bound to some implicitly given contextual reference set or not. In the latter case, the sentence will obtain a reading of generic quantification and, with this, it will be attributed homogeneous Aktionsart. In the first case, it will obtain the existential interpretation, and will be attributed heterogeneous Aktionsart. Note that this decision is also a matter of exploiting the results of the nominal resolution (of nominal descriptions in this case). The results of the nominal resolution are maintained in the dependence structures of the text via coreference statements similar to those of the representation of (10) in section 2 for syntactically empty reentrancies. Depending on the different results of the resolution, we obtain different dependence structures from which the tense/aspect heuristics computes the different target tense suggestions, as used in the corresponding translations:

(15_{D1})

```
Dependence tree.
-------------------------------------------------------------------------
  ,--- ndet               s(sein,629234)         det(gMNaMS,poss)
,----- obj(n)             s(lehrer,432015)       noun(cn,[acc,sg,m,kda|det],nwh)
o----- top                s(lern,436861)         mtv(ind:dcl:nwh,tf(pres,0,X1),a)
! ,--- ndet               s(jed,365112)          det(naNS,indef)
`----- subj(n)            s(m"adchen,452507)      noun(cn,[nom,sg,nt,na|det],nwh)
`----- vprep              s(bei,81024)           prep([bei|dat],nwh,8)
! ! ,- ndetgen            s(dessen,d)            det(relpgenMNS,def)
! `--- objprep(dat)       s(amtseinf"uhrung,25989) noun(cn,[dat,sg,f,o|det],nwh)
`----- comp(ptcl(kennen)) kennen                 ptcl(kennen)
-------------------------------------------------------------------------
semscope(5,2)    semref(1,5)
```

(15_{T1}) *Chaque fille fait la connaissance de son professeur (à elle) au cours de*
l'initation de celui-ci.

(15_{D2})

```
Dependence tree.
-------------------------------------------------------------------------
  ,--- ndet               s(sein,629234)         det(gMNaMS,poss)
,----- obj(n)             s(lehrer,432015)       noun(cn,[acc,sg,m,kda|det],nwh)
o----- top                s(lern,436861)         mtv(ind:dcl:nwh,tf(pres,0,X1),a)
! ,--- ndet               s(jed,365112)          det(naNS,indef)
`----- subj(n)            s(m"adchen,452507)      noun(cn,[nom,sg,nt,na|det],nwh)
`----- vprep              s(bei,81024)           prep([bei|dat],nwh,8)
! ! ,- ndetgen            s(dessen,d)            det(relpgenMNS,def)
! `--- objprep(dat)       s(amtseinf"uhrung,25989) noun(cn,[dat,sg,f,o|det],nwh)
`----- comp(ptcl(kennen)) kennen                 ptcl(kennen)
-------------------------------------------------------------------------
semscope(2,5)
```

(15_{T2}) *Chaque fille fera la connaissance de son professeur au cours de l'initation de celui-ci.* [3]

As a kind of intermediate summary, we can take from this, that the tense/aspect heuristics can assume that the input dependency structures provide antecedent information for pronouns, and, if inferrable from this, corresponding scope information. We repeat what has been said in the introduction that the choice of the correct tense form doesn't always presuppose such (and other) contextual disambiguations. Under many circumstances the correct tense form is directly inferrable from the source representation, from bilingual lexical information and/or general source- and target-tense correspondences. For instance, in French the sentence complements of a number of attitude verbs show subjunctive mood (always or under some additional easily testable conditions). The class of epistemic attitude verbs conform to this, at least when negated, except *savoir/know* (which, in contrast to the other items of this class presupposes the truth of its scopal proposition). The corresponding consecutio temporum says that the tense level of the subclause is inherited from the matrix clause. Since, modulo perfectivity +/-, there are two subjunctive tenses only (subjonctif du passé and subjonctif du présent), it suffices to spell this out at the granularity level PAST/NON-PAST. We obtain the following rules therefore:

- ∀ LM, LD (semmtv(LM,mtv(_,tf(TL,Perf,_),_)) &
  LM-obj(fin)-LD & semmtv(LD,mtv(_,tf(CONJUNCTIVE,_),_),_))
  ⇒(non-past(TL,Perf) ⇒
  semmtv(LD,mtv(_,tf(pres_subj,_,_),_)) ; semmtv(LD,mtv(_,tf(past_subj,_,_),_))))

  This is a rule of French consecutio temporum which, as such, is part of the French (analysis and generation) grammar. (Here non-past(TL,Perf) means (TL ≤NON-PAST & (TL=pres →Perf=-))

- ∀ LM, LD
  (LM ≤EPISTEMIC_VERB & LM - obj(fin) - LD & LM - vadv - NEG_MOD
  ⇒semmtv(LD,mtv(_,tf(CONJUNCTIVE,_,_),_))

  This is a rule expressing knowledge about French epistemic verbs and, as such, also part of the French (analysis and generation) grammar.

[3] Since the LMT-resolver does not compute context sets, the tense/aspect heuristics decides the alternative between generic and contextually bound universal quantification, which, as seen, is relevant to the determination of the Aktionsart, by text type specific defaults. Remember, by the way, that the translation of (15) into English is an instance of the problem of correct pronoun translation which legitimates nominal resolution independently of the problem of translating the tenses: under the first interpretation, the critical possessive of (15) is translated by *her*, under the second, assuming another antecedent (not the *girl* discourse referent), where (per default) natural and grammatical gender coincide, the translation will be *his*. Since in French the possessive agrees with its modificandum in number and gender (w.r.t. morphology), this type of translation alternative doesn't play a role in (15), but there are other similar problems of pronoun translation, of course: Exchanging *jed* for a plural quantifier like *die meisten/most* in (15), under otherwise identical interpretation assumptions, will lead to the translation *leur* in the distributive case and to *son* in the other.

- ∀ LD, SLD (tau(SLD,LD) & semmtv(SLD,mtv(_,tf(TL,Perf,Prog),_)) &
  semmtv(LD,mtv(_,tf(CONJUNCTIVE,_,_),_))
  ⇒semmtv(LD,mtv(_,tf(_,Perf,Prog),_)))

  This is a general transfer rule which, as such, controls the recursive transfer.

- *glaub*
  >*verb* [*obj(n | fin)*]
  >τ*: croire* ≤EPISTEMIC_VERB

  This is (part of) a lexical item which says that *glauben/believe* has a direct object which can be realized by a NP or by a finite subclause. Its translation is *croire* which shows the same subcategorized slots. In addition, *croire* is of type EPISTEMIC_VERB. Alternatively, (and more precisely) we could have stipulated the source verb to be of this type already. In this case the translation would inherit this (semantic) type property.

On the basis of this knowledge, we infer the mtv-value:
mtv(dep:dcl:nwh,tf(past_subj,+,_),a)
for the target dependence structure of (16_G), which allows to generate the target sentence (16_F):

(16) G: Er glaubte, daß sie gekommen war.
F: *Il croyait qu'elle fût venue.*

Similar to this, the German-French system translates a number of tense features without further going into the details of how the tense form controls the relating of the introduced eventuality to the temporal parameters of the context. For instance, the features of *Plusquamperfekt* are transferred to the target representation (such that the target is realized by *plusqueparfait*), if there is no specific information available which could object to this assumption, where this information could be provided by one ore more lexical rules, transfer rules or generation rules (of the type *consecutio temporum* and the like). Note that there are some style parameters which can decide about the surface realization of a tense description (such that in (16_F), for instance, we can obtain the more familiar style result *Il croyait qu'elle soit venue*). We come back to this in section 5.3.

In contrast, mainly with respect to the Präteritum-features or the Präsens-features, the system does some further (economic, un-exhaustive) semantic evaluation, in particular it evaluates the Aktionsart information, and if necessary, it does some restricted temporal resolution. Let us turn to the Aktionsart calculus first.

5.1 Aktionsart Calculus

In the introduction we showed how the Aktionsart or the aspect respectively of the maximal VP (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, where the relation chosen in turn controls the choice of the correct target tense. We have mentioned the relevant principles P1-P4 of interpreting Imp and PS. In the case of single sentences without explicit temporal anchors, it is the Aktionsart or the aspect as such, which will be relevant for the aspectual marking of the target (more precisely, its presenting the introduced eventuality relative to some suitably accommodated temporal clue). As mentioned, the corresponding Aktionsart evaluation of the German-French MT-system bases upon the suggestion of Eberle 1995a. It makes use of the following lexical prerequisites:

The lexical entries, more precisely the different *senses* of the lexical entries are classified by the types of a semantic hierarchy. In particular, the verbs are sorted according to the following partition of SITUATIONs (verb senses):

SITUATION = EVENT | PROCESS | STATE, where

- a verb sense is classified as EVENT, if the event type which is described by the verb and its obligatory roles is of *heterogeneous* Aktionsart,
- it is classified as PROCESS or STATE, if the described event type is of *homogeneous* Aktionsart (the finer distinction into STATE and PROCESS follows the conventional criteria and tests, where processes show some internal structure and states do not etc.).

This classification assumes that the bearers of the subcategorized thematic roles are neither mass terms, nor sum descriptions, but atomic objects. Without this restriction, the assignment of an Aktionsart could not be unique. Consider *öffnen/open* and suppose that its direct object is obligatory, then it depends on whether we say *a man opens a door* or *a man opens doors* whether the corresponding event type is homogeneous or not. Note that the notion of *discourse homogeneity* that we use calls an event type homogeneous iff it is cumulative to a certain exent (two neighboring instances can be amalgamated to an eventuality of the same type), and divisive to a certain extent (parts of an instance are instances of the same event), where *to a certain extent* means 'adapted or relativized to the granularity level which is determined by the interest of the discourse'. According to this, the event type with direct object *a door* will not be homogeneous (that is, it will be heterogeneous), whereas the other one, using the bare plural, will be. Because of the atomic object assumption, the lexical entry will be classified on the basis of the *a door*-use as EVENT. If one or more obligatory roles are instantiated contrary to the assumption of the lexical entry, the Aktionsart calculus has to take into account this revision of the basic event type, which may change the Aktionsart. Also, of course, it has to take into account the other thematic roles from the instantiated optional slots of the subcategorization frame and the impact of the free modifiers. Thus, *essen / to eat* will be classified as process. Therefore, the basic value of the Aktionsart calculus will be *hom.* With respect to DRS-construction, this Aktionsart is the value that is assigned to the verb representation within the sentence DRS, i.e., to the innermost DRS that contains the verb predicate (precisely speaking, it describes the Aktionsart of the predicate that develops through lambda abstraction of the event DRF from this DRS). In our dependence structure it characterizes the verb node or, with respect to the equivalent FUDRS, it is part of the decoration of the corresponding label. *Essen* has an optional obj-slot. In case it is instantiated according to the default, and assuming that the subject is instantiated similarly, the Aktionsart-value of the corresponding VP must be *het*, since it describes something like *someone eats a particular edible object*. In order to evaluate the contribution of a thematic role, it is relevant to know of what type the role is. 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), where *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 *spatial_goal* is a characteristic role (because the corresponding bearer of the role is completely different in subevents). Now, for example, adding a gradual role whose bearer is described by a heterogeneous predicate changes a homogeneous description into a heterogeneous one, like the transition *someone eats* to *someone eats (an edible thing)*, X, since the same object X cannot be the bearer of the role with respect to subevents, otherwise the role would not be gradual. The same is true for characteristic roles, not for constant roles. Conversely, in case the bearer of an obligatory gradual or characteristic role, contrary to the default assumption, is described by a homogeneous predicate (a bare plural or a mass term), the event type will lose heterogeneity, provided there is no other gradual or characteristic role with heterogeneous description which, through this, prevents subevents of an event of the new type from being describable by this same type also. An example which requires such revision is the above mentioned *a man opened doors*. What we need, then, in order to be able to take into account such revisions of the basic lexical Aktionsart assumption, is knowledge about the type of the subcategorized slots. Since the default linking of the syntax-semantics interface will assume *agent*, or some equally *constant* abstraction of this role for *subj*, and, similarly, a *constant* role for *iobj* also (*beneficiary* or some abstraction of this), mostly, in the verbal entry we need to specify the role characteristics of *obj* only, as in the following:

- *ess*
  >*verb* $[obj(n)_{grad}]$
  >τ: *manger*

- *öffn*
  >*verb* $[obj(n)_{char}]$
  >τ: *ouvrir*

- *seh*
  >*verb* $[obj(n)_{const}]$
  >τ: *voir*

Of course, we must also classify the more oblique slots, if there are any. Note however, that most of these additional slots in slot grammar analyses are (optional) PP-complements, which in other grammar theories would be treated as adjuncts, mainly certain (collocational) temporal and spatial localizations. In such cases the relevant slot-type can be inferred from the type of the preposition and of the argument (such that the lexical entry is discharged and can do without corresponding explicit statements). Similarly, as sketched further above in section 3, the free modifiers themselves carry the information about their potential for changing the Aktionsart. In Eberle 1995a, we have spelled out an Aktionsart-calculus which, on the basis of this, can compute the Aktionsart for the classical case of disambiguated (DRT-) sentence readings (DRSs). The advantage of the DRS case is that the scope relations are known and the reading of the different roles and modifiers. How about the underspecification case with which we are faced in our translation scenario? First, plural roles can be read collectively or distributively. We represent distributive readings via DRS-duplex conditions. Duplex conditions from quantified verb roles change event descriptions into more complex descriptions (into descriptions of the event sums that are abstractable from the duplex condition). Such changes can be accompanied by Aktionsart changes. Typically, for instance, bare plurals bring about homogeneous event types, as in (17.a). However, they don't always do this, compare (17.b).

(17) 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 (17.a) and of (17.b). However, whereas, in (17.a), the event sum gets the (more or less default) reading, where the atoms of the sum are ordered successively (according to what a control modifier like *nacheinander/successively* makes explicit), in (17.b), background knowledge (about the considered event type and the related scenario) says, that the reading with simultaneous subevents should be preferred. We obtain:

(17.a$_{rep}$)

u v W e1 t1 t2
rocky(u)
tür(v)
öffnen(e1)
agent(e1) = u
object(e1) = v
e1 $\subseteq$ t1
t1 $\prec$ n
E2 W :: [w | frau(w), w $\in$W] ⟨jed w⟩ [e2 c | vorübergehen(e2), agent(e2) = w, kind(c), mit(w,c), e2 $\subseteq$ t2]
successive(E2)
t2 $\prec$ n
e1 $\subseteq$ E2
E2 $\subseteq$ t2

(17.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 m
                                      zuschiessen(e2)
           r                          agent(e2) = r
E2 R ::    reporter(r)   <jed r>      micro(m)
           r ∈R                       mit(r,m)
                                      spat_goal(e2) = u
                                      e2 ⊆ t2
simultaneous(E2)
t2 ≺ n
e1 ≺ t2
E2 ⊆ t2
```

(17.a) and (17.b) should exemplify what, here, we can only informally motivate: Simultaneous quantification percolates the Aktionsart of the argument event type to the result (*het* →*het*, in (17.b)). This corresponds to the impact of the collective reading of a plural role on the Aktionsart. In the case of temporally distributed quantification, bare plural roles will generate homogeneous event types (→*hom*, in (17.a)), 'quantized' roles (definite descriptions and most quantifier expressions) will generate heterogeneous event types however (exchange *die Frauen* for *Frauen* in (17.a)). We account for these data as follows:
The quantifiers are classified into:

- always distributive quantifiers,
  DISTR_QU,

- quantifiers which prefer the distributive reading,
  D_DISTR_QU (*distributive per default*),

- quantifiers which prefer the collective reading,
  D_COLL_QU (*collective per default*),

- always collective quantifiers,
  COLL_QU
  where:

- DISTR_QU encompasses the singular universal quantifier (*jeder/every*) and its variants (*fast jeder/ almost every* etc.):
  UNIV_QU & SG_QU < DISTR_QU,

- D_DISTR_QU includes most plural quantifiers, among others also the quantifiers which describe their denotata via comparision to similar situations, like *viele/*

many, wenige/few, mehr/more, weniger/fewer:
COMP_DEF_QU < D_DISTR_QU, (COMP_DEF_QU < PL_QU)

- D_COLL_QU includes the numeral quantifiers *zwei, drei, vier,.../two, three, four,...*, but not the threshold-quantifiers which are defined from numbers like *wenigstens drei, höchstens vier/ at least three, at most four*:
  NUMB_QU < D_COLL_QU
  NUMB_DEF_QU < D_DISTR_QU,

- COLL_QU encompasses the singular determiners *ein, der/a, the*, but not the plural definite determiner (which is collective by default only), this is:
  SG_QU & DET < COLL_QU
  PL_QU & DET < D_COLL_QU

Note that assigning the relevant class to a quantifier phrase is compositional: Modification of a quantifier may change the class of the quantifier. We will treat negative quantifiers as composed of the corresponding positive quantifier and the negation modifier. We will say something more on this below, when considering adverbial modification. What complicates matters is that the verb often prescribes or recommends a particular reading of (one of) its roles also. We keep track of this kind of information as a subscript to the considered role, similarly to the representation of the other role properties considered further above. Because of the well known difficulties one is faced with when trying to classify the verbs into different distribution patterns w.r.t. their roles (one of these difficulties is that verb roles do not always constrain the members of a plural argument to partake in the same way in the described event, compare Link 1983, Link 1984a) we classify only as follows:

- the role R of a verb (type) V (preferrably) gets distributive reading:
  $V_{R_{distr}}$, for instance, *sterben/to die* < $\text{verb}_{subj_{distr}}$,

- the role R of a verb (type) V (preferrably) gets collective reading:
  $V_{R_{coll}}$, for instance, *versammeln/to meet* < $\text{verb}_{subj_{coll}}$,
  where we assume the following order constraint:
  $R_{grad} < R_{distr}$

Mostly, the roles will be unclassified. In cases where the quantifier prediction contradicts the corresponding verbal prediction, the heuristics about the reading of the role is as follows:

- when a distributive role ($V_{R_{distr}}$) comes with a (plural) D_COLL_QU-quantified argument:
  the heuristics assumes distribution,
  (*Hans baute vier Häuser / Hans built four houses*)

- when a distributive role ($V_{R_{distr}}$) comes with a (plural) COLL_QU-quantified argument:
  the heuristics assumes collective reading,

(*Die vier Freunde starben zusammen / The four friends died jointly* – where *zusammen* is interpreted as a floated quantifier)

- when a collective role ($V_{R_{coll}}$) comes with a (plural) D_DISTR_QU-quantified argument:
  the heuristics assumes collective reading,
  (*Viele Mitarbeiter versammelten sich am Empfang / Many employees gathered at the entrance*)

- when a collective role ($V_{R_{coll}}$) comes with a DISTR_QU-quantified argument:
  the heuristics assumes distributive reading,
  (*Jeder Mitarbeiter versammelte sich am Empfang / Every employee gathered at the entrance* – where it is assumed that for each item quantified over there is an implicit, contextually salient group which is the true argument of the respective single predication).

Generally, a (further) criterion that limits distributive interpretations is the uniqueness of a verb argument: the distributive reading of a role is out, if the verbal predicate contains an argument that cannot partake in more than one event of the described type, like the food in an eating event, and that is bound by a quantifier which has wide scope w.r.t. the considered role (*(?) das Schnitzel aß jeder Angestellte / Every employee ate the cutlet*). Because of the fact that metonymy is fairly productive and almost impossible to predict, and because of the fact that through such metonymic reinterpretations nearly all such constraints can be weakened or even discarded, we abstain from using this criterion (and others that refer to world knowledge). However, we accept another restriction to distributive readings: a bare plural NP cannot take another quantifier in its scope. This position is in line with what has been noticed at various places in the literature, with various results of formal accounts. To be precise, our account assumes the existential, non-generic reading for bare plural phrases per default, and it assumes that the introduced sum obtains the distributed interpretation per default, provided that the event description which is distributed over the elements of this sum does not contain another quantifier, except for definite descriptions, whose denotata can be assumed to obtain wide scope interpretations via presupposition resolution (and marginally indefinites under the same presuppositional (de re) assumption). With this, we are faced with the question of scoping. Following the account of Frey 1993a, and adopting it to the slot grammar framework, we assume that, in German, independent of the surface structure, the scope order which corresponds to the obliqueness hierarchy of the verb roles is always possible (and that others develop only when the surface structure deviates from the canonical order as defined by the obliqueness hierarchy). In addition, we assume that this order is the preferred one (and that the different surface presentations, above all, signal different information structural purposes). On the basis of these assumptions, the heuristics which assigns an Aktionsart value to the sentence radical (without considering adjuncts) is as follows:

- Start with the Aktionsart value as provided by the lexical entry of the verb.

- Determine the impact of the instantiated optional roles on the Aktionsart of the basic event predicate as introduced by the verb entry, using the *const*-, *grad*- or *char*-assumptions of this entry under the further assumption that the role values are atomic objects.

- Determine the impact of non-quantized mass terms on the Aktionsart of the basic event predicate which is extended by the instantiated optional role relations: We assume that gradual verb roles which come with non-quantized mass term descriptions (which is contrary to the default assumption of the lexical Aktionsart assignment), change heterogeneous event types into homogeneous types (as shown above - *einen Holzscheit verfeuern/to use up a piece of wood* →*Holz verfeuern/to use up wood*). If there is no such role or no such role description contradicting the default assumptions, the Aktionsart remains unchanged.

- Determine the impact of applying the most oblique verb role description to the basic event type:
  a) the description is singular: the Aktionsart value is percolated;
  b) the description is plural: according to the heuristics above, decide whether it will be considered under the collective (α) or distributive (β) reading;
  (α) the Aktionsart is percolated;
  (β) decide whether the description will be considered under the temporally simultaneous reading (i) or under the temporally distributive reading (ii); for this, use the findings about temporal text structure as reported in the introduction, especially the principle (*), and apply it to the intrasentential data. This means, in the case of the actual Aktionsart of Pe being homogeneous (where Pe is the event predicate, as it is before applying the role considered), by default, we assume that the situations e_i of the different stative predications Pe_i, as attributed to the different members i of the role value, all characterize the same contextual reference time, i.e. that these situations e_i are cotemporal. The role obtains the simultaneous reading. In the case of Pe being heterogeneous, (*) applied to the intrasentential data results in the default temporally distributed reading. In short:

  (i) where the actual event predicate is homogeneous, consider the simultaneous reading of the role,
  (ii) where the actual event predicate is heterogeneous, consider the temporally distributed reading.

  (i) signifies that the Aktionsart is percolated and
  (ii) signifies that the Aktionsart depends on the Aktionsart changing potential of the quantifier,

  in accordance to the assumptions of Eberle 1995a. There, it is shown that most plural quantifiers turn event predicates into heterogeneous predicates (under the described specific distributive reading): A subsum E' of a complex *many/ most/at least twenty X doing Y* sum of events E occurring at a subinterval of the time of E is not necessarily a sum of the same type (it is not necessarily a sum of *many, most X* which is involved in E'). The quantifier introduces a kind of *measure* in this case. Others do not, in our opinion: We assume, that event descriptions from generic quantifications via *every* satisfy to the subinterval property and also descriptions which develop from the temporally distributive application of the empty plural quantifier. That the truth of distributive bare plural predications is inherited by subintervals (and by amalgamations of truth intervals) is clear, since the quantifer doesn't make any assumption about the number of the bearers of the role at particular times (as a consequence, such predications are homogeneous). What is the argument in case of generic quantification, however? When we understand *every X* as referring to the set of all instances of the noun description X which are available for the considerd time span t (or, in other words, to the prototypical X of the focussed t), the sentence will report a (generic) law holding for t, which, in order to be true, must be true for (the Xs/the X-prototype of) subintervals of t also. This reading, note, is not available for restrictions of *every* like *every except one* etc. which explicitly prohibit the generic reading by presupposing a specific context set, an absolute measure so to speak. Therefore, we distinguish two cases of (ii):

(ii.a) the resulting Aktionsart is *heterogeneous*, in the case of a 'measuring' quantifier,
(ii.b) the resulting Aktionsart is *homogeneous*, in the case of other quantifiers.

- Determine the impact of applying the next less oblique verb role description to the actual event type:
  This is like the step before, except for the above mentioned restrictions about the scope of the distributive reading of bare plural and the interplay with wide scope presupposition accommodation and resolution of definites (and indefinites) respectively.
- Iterate the last step, till there is no subcategorized role left.
- The last Aktionsart value of this process is the default value assigned to the complex event predicate which is built from the basic predicate and the subcategorized roles.

Notice that this algorithm assigns a specific Aktionsart default to the saturated VP only. Thereby it constrains the semantic interpretation of this structure, but it doesn't determine it completely: Every reading is accepted that is assigned the same Aktionsart. What about the impact of the adjuncts? In our GF-MT-system,, for a number of reasons, where the Aktionsart assignment is only one, we classify adjunct verb modifiers into the following (not necessarily disjoint) groups:

- DISCREL_MOD
  the modifiers which introduce a discourse relation to the context,
  like *nevertheless, though* etc., including the temporal relations like *later* etc.
- ATT_MOD
  the modifiers which introduce an attitude towards the propositional argument,
  like *fortunately, hopefully* etc., including
  - MODAL_MOD
    the modal modifiers
    like *possibly, necessarily, likely*, including

  - NEG_MOD
    the negative modifiers
    like *not at all, not*

- FOC_MOD
  the focus modifiers
  like *only, even* etc.

- TEMP_MOD
  including modifiers of temporal localization (*at noon, later, then*), duration and frame adverbials (*for/in an hour*)

- SPAT_MOD
  including modifiers of spatial localization (*here*), also source-, path- and goal-descriptions

- QUANT_MOD
  including frequency adverbials (often, seldom) – next to other non-temporally quantifying modifiers like *at many places*

- MANNER_MOD
  like *quickly, slowly.*

As said further above, we assume that the free modifiers come with information about their impact on the Aktionsart (which, in case of complex modifiers, might be computed compositionally). That is, the application of such a modifier doesn't present a problem to our algorithm. (Flat descriptions of modifiers will be constrained thus far, however, that the Aktionsart assumption about the argument is satisfied and that the resulting Aktionsart is unique - see the example of *stundenlang* in section 3). The relevant thing to know is: What is the order of the applications? Before sketching the corresponding heuristics of our GF-system, note that the translation data show that some modifications, though changing the reported situation and possibly the Aktionsart, have no influence on the choice of the target tense. As it seems, these are the modifications of type DISCREL_MOD, ATT_MOD and FOC_MOD, that is: the relating of the sentential (propositional) information to some contextual information, the relativization of the sentence information to some attitude (which includes the relativization of the truth of the propositional content), and the structuring of the sentence information into focussed and background parts. Since determining the correct target tense is our interest, we must distinguish the Aktionsart of the sentence situation as a whole, therefore, from the Aktionsart of the eventuality which develops from the sentence description by stripping off the mentioned propositional operators. Loosely, and in short, we must concentrate not on the sentence situation itself, but on the eventuality which the author presents as the subject of this situation. Therefore, we restrict ourselves to the remaining event modifiers. Note that some of the modifiers of the excluded types still have to be considered. It is these modifiers which, besides the contribution in terms of the considered (excluded) type, show contributions of the remaining (accepted) types, like these discourse relations which entail temporal relations. [4] We assume, that the computation of the preferred reading of a sentence is guided by the following three principles:

- 1) There is a surface independent ordering of modifiers which results from semantic incompatibilities between the domain and the range of particular modifiers:
  For instance, it does not make sense to provide an event type with spatial source-, goal- or path-descriptions which focusses on the duration of some event ([[*running for three hours*] *to the top of the mountain*]).
  From restrictions like this, we take the following dominance relation (its transitive closure, to be precise):
  Spatial descriptions informing about the source, the goal, the path or the direction of an event are dominated by manner adverbials,
  manner adverbials are dominated by frame- and duration adverbials,
  frame and duration adverbials are dominated by localization adverbials,
  further constraints can be contributed by specific lexical information assigned to the modifiers,
  (such that it is guaranteed, for instance, that duration assignments fit with the frequency rate associated with a wide scope quantifying adverbial and vice versa),

- 2) The default scoping of the remaining undecided cases follows the surface order,

- 3) The scope relation over the free modifiers is incorporated into the scope relation of the subcategorized roles according to surface order (and the trace positions, in the case of moved constituents);
  also we assume that source-, goal-, path- and direction-descriptions do not apply to sum-events.

On the basis of these principles, the algorithm is as follows:

- Revise the sentence structure by deleting the free modifiers which are not of type TEMP_MOD, LOC_MOD, QUANT_MOD, MANNER_MOD.

- Revise the resulting structure by extracting moved subcategorized roles and by identifying them to their trace positions.
  In the case of alternative orderings which may develop from this, through the presence of free modifiers, prefer to put the subcategorized roles to the right of the free modifiers – for instance:
  Die Frau betrachtete er aufmerksam →*Er betrachtete aufmerksam die Frau*, not →*Er betrachtete die Frau aufmerksam.*

[4]It complicates matters with respect to scoping as such, that one cannot say that 'propositional' modifiers always have scope over 'predicative' (i.e. event) modifiers. This, in part, is due to this multi-functionality. Think of cases like *often they did not come* (where the preferred reading takes the 'propositional' negation into the scope of the 'predicative' 'event'-quantifier. With regard to our subject, we would say that, irrespective of the position of the negation, the theme of the sentence is the *often coming.*

- If there are modifiers to the left of a free modifier FM which, according to principle 1) above, must be dominated by FM:
  Revise the present sentence structure by extracting these modifiers and by placing them to the right of FM, where the order of the moved modifiers corresponds to the dominance order– for instance:
  Aufmerksam betrachtete er stundenlang die Frau →Er betrachtete stundenlang aufmerksam die Frau.

- In case there are source-, goal-. path-, direction-descriptions to the left of subcategorized roles R which will be read distributively:
  Revise the present structure by extracting these descriptions and by adjoining them to the right of the rightmost of these roles R – for instance:
  Nach Paris flog in dieser Woche Air France wenigstens fünfzehn VIPs →Air France flog in dieser Woche wenigstens fünfzehn VIPs nach Paris.
  Compute the Aktionsart of the new structure:

- Start with the verb predicate and its Aktionsart as determined by the routine described further above.

- Consider the rightmost sentential element REF:
  a) REF is a subcategorized role:
  Determine the Aktionsart of the event predicate which develops from the application of REF as described further above.
  b) REF is a free modifier:
  Determine the Aktionsart of the resulting event predicate,
  α) by exploiting general type information – for instance:
  spatial goals are characteristic roles and must be accounted for correspondingly,
  β) by exploiting specific lexical information – this is, the lexicon determines under which circumstances the modifier influences the Aktionsart in which way.

- Consider the element to the left of REF and so forth.

Again we emphasize that the assignment of an Aktionsart to the *sentence radical* restricts the sentence readings only in so far as those readings that do not conform to this Aktionsart are excluded. It is seldom that this corresponds to prescribing a unique reading of the sentence (if there are different readings at all). This holds for the case of sentences with free modifiers also.

5.2 Contextual Resolution

At present, in order to determine the aspect of the events and, with this, the target tense, we use *temporal resolution* (this means *relating the events of the text to one another* in a very restricted way only: We consider intrasentential relations only. However, intersentential relations are not completely skipped, they are considered in so far, at least, as they are reflected in the sentence by temporal locations and discourse relations. For instance, the temporal location *dann* relates to a contextual event. We don't try to get hold of this event. Instead of this, we take from this adverbial what is most important with respect to aspect: the fact that *dann* presupposes that the eventuality modified thus did not hold before. A consequence of this is that homogeneous descriptions get a heterogeneous, mostly inchoative reinterpretation. Since such anaphoric relators are (free) modifiers, their aspectual contribution is taken into account by the algorithm sketched in the last section and we have nothing more specific to say to them here, except that this algorithm allows for a postprocessing routine, which investigates whether some or all of the disambiguations which satisfy to the given representation constraints show a wide scope temporal location or not. Remember that such information can decide about tense alternatives: The examples (5) and (6) of the introduction illustrate the alternatives with respect to the translation of German Präsens. As said, we abstain from trying to reconstruct the temporal structure of the text, via text organization principles like (*) or P1-P4. In addition to exploiting the localization information of anaphoric temporal modifiers as described, we evaluate the intrasentential relations under the same perspective only. Mainly this means, that we use the information of subordinating conjunctions, in order to get the aspect and the tense of subclause and matrix clause right. The example which we will consider in the following is *nachdem/after*. Note that such conjunctions are 2-place representatives of the class of functors which, in contrast to the subcategorized verb roles, themselves provide information about the influence on the Aktionsart or aspect (and the target tense) of the modified argument(s). This means that besides the postprocessing routine mentioned above, there is no further extension of the evaluation algorithm needed, in order to compute the information needed for determining the target tense.

(18) Nachdem es geregnet hatte, schien die Sonne.
AFTER IT HAD RAINED, THE SUN WAS SHINING.

We obtain:

```
Target dependence tree.
-----------------------------------------------------------------------
o----- top          briller  mtv(ind:dcl:nwh,tf(past,0,X1),a)
‘----- vsubconj     apr‘es    subconj(dep)
!  ‘--- sccomp(fin) pleuvoir mtv(dep:dcl:nwh,tf(past,1,X2),a)
!    ‘- subj(il)    il       noun(pron(pers3),nom,pers3-sg-m,X5)
‘----- subj(n)      soleil   noun(cn,nom,pers3-sg-m,X7)
  ‘--- ndet         d        det(nom,pers3-sg-m,X7)
-----------------------------------------------------------------------

Target dependence tree (evaluated).
-----------------------------------------------------------------------
o----- top          briller  mtv(ind:dcl:nwh,tf(past,0,0),a)
‘----- vsubconj     apr‘es    subconj(dep)
!  ‘--- sccomp(fin) pleuvoir mtv(dep:dcl:nwh,tf(past,1,X2),a)
!    ‘- subj(il)    il       noun(pron(pers3),nom,pers3-sg-m,X5)
‘----- subj(n)      soleil   noun(cn,nom,pers3-sg-m,X7)
  ‘--- ndet         d        det(nom,pers3-sg-m,X7)
-----------------------------------------------------------------------
```

(18_T) *Après qu'il avait plu, le soleil brilla.*

According to the algorithm of the last section, the matrix clause of (18) alone would be translated by Imp (*le soleil brillait*), given that *scheinen* is classified as STATE in the lexicon. *Nachdem* will be classified as a AFTER_TEMPLOC-conjunction. According to investigations as reported in Herweg 1990 and others, we assume that such subordinating conjunctions introduce a reference time for the main clause eventuality e which precedes this e and therefore triggers the presupposition (just like *dann* does), that there is no eventuality e' of the considered type which starts to hold before the matrix e holds. On the basis of the principles P1-P4, this signals that e has to be presented under the non-progressive aspect; that is, that PS has to be chosen, not Imp. This reasoning underlies the corresponding instantiation of the Prog-value of the evaluated transfer tree in (18_T) and legitimates it. AFTER_TEMPLOC-conjunctions do not constrain the presentation of the main clause eventuality only. There is also an impact on the subclause eventuality: Homogeneous event descriptions obtain a perfective aspect, even if they are introduced by a non-perfective tense form, as possible in German. This implicit aspect has to be made explicit, when translating into French. Consider the following example:

(19) Nachdem die Sonne schien, ging er aus.
AFTER THE SUN HAD BEGUN TO SHINE, THE MAN WENT OUT.

We obtain:

```
Target dependence tree.
----------------------------------------------------------------------
o------- top         sortir  mtv(ind:dcl:nwh,tf(past,0,X1),a)
`------- vsubconj    apr`es   subconj(dep)
!  `----- sccomp(fin) briller mtv(dep:dcl:nwh,tf(past,0,X2),a)
!   `--- subj(n)     soleil  noun(cn,nom,pers3-sg-m,X4)
!     `- ndet        d       det(nom,pers3-sg-m,X4)
`------- subj(n)     il      noun(pron(pers3),nom,pers3-sg-m,X5)
----------------------------------------------------------------------

Target dependence tree (evaluated).
----------------------------------------------------------------------
o------- top             sortir    mtv(ind:dcl:nwh,tf(past,0,0),a)
` ,----- vsubconj        apr`es     subconj(dep)
! !  ,--- subj(n)         soleil    noun(cn,nom,pers3-sg-m,X4)
! ! !  `- ndet            d         det(nom,pers3-sg-m,X4)
! `----- sccomp(fin)     commencer mtv(dep:dcl:nwh,tf(past,1,0),a)
!   `--- obj(p([|inf])) briller   mtv(inf,tf(pres,0,0),a)
!     `- subj(n)         empty     coref(3)
`------- subj(n)         il        noun(pron(pers3),nom,pers3-sg-m,X5)
----------------------------------------------------------------------
```

(19_T) *Après que le soleil avait commencé à briller, il sortit.*

Clearly, (19) says that the man went out after the sun had begun to shine, not after some period of shining was terminated or something else. Why is this so? As said above, we think, *nachdem*, like the other AFTER_TEMPLOC-conjunctions are used for anchoring the matrix eventuality at the reference time which comes form the subclause. To be precise, the matrix eventuality should be located in the resultative state of the subclause eventuality (i.e. after this eventuality). When the subclause eventuality is homogeneous and not closed by an explicit perfective operator, there is no such resultative state (at least none with a clear cut beginning). However, we get one when we apply the fairly regular process of type coercion to the state or process of the subclause which is called *inchoative reinterpretation.* Another such process would be *termination*, but this reinterpretation seems to be excluded in the presence of AFTER_TEMPLOC-subordinations, probably because of the fact that it normally is expressed by a perfective tense form. Thus, omitting this default tense form of *termination* which is also the default tense of these subordinations seems to signal that exactly this terminative interpretation is not meant. Our French generation grammar uses the knowledge about the temporal relation between subclause and matrix eventuality in the context of *after_temploc*-conjunctions (and also in the context of other temporal conjunctions), decides whether some aspectual revision has to be applied and carries it out when needed. The evaluated target tree of (19) and (19_T) respectively show the result for the case at hand.

5.3 Stylistic Variation

The system makes use of a number of style parameters. For instance, a more colloquial style can be chosen such that questions are rendered by *est-ce que* paraphrases. Part of this overall colloquial setting is the more specific choice to use passé composé instead of passé simple. There are parameters also which cause the modelling of specific output in the presence of marked source structures (different forms of) topicalization for instance. In this section, we restrict ourselves to sketching the effect of just one of these style parameters. In order to illustrate the influence of the components of semantic evaluation that we have considered in this paper, we choose a parameter which is sensitive to the results of the contextual resolution. Under the so called INFPREF_STYLE, we try to reduce explicit subclauses into more elegant, shorter infinitival constructions (partciple constructions, small clauses). The subordinating conjunctions of the last section, in particular *nachdem*, provide examples for this.

(20) Nachdem der Mann den Brief geschrieben hatte, las er.
AFTER HE HAD WRITTEN THE LETTER, THE MAN WAS READING.

For (20), we obtain the following translation under the default style setting:

(20_{Td}) *Après que l'homme avait écrit la lettre, il lut.*

In case, INFPREF_STYLE is set and in case the nominal resolution is switched on, the system will assume that *er* refers to *der Mann* (through the nominal resolution), and, on the basis of this, it will accept and then prefer infinitival style for the target subclause (through INFPREF_STYLE). We obtain:

```
Target dependence tree.
-----------------------------------------------------------------------
o------- top         lire   mtv(ind:dcl:nwh,tf(past,0,X1),a)
`------- vsubconj    apr`es  subconj(dep)
! `----- sccomp(fin) e'crire mtv(dep:dcl:nwh,tf(past,1,X2),a)
!   `--- subj(n)     homme  noun(cn,nom,pers3-sg-m,X5)
!   ! `- ndet        d      det(nom,pers3-sg-m,X5)
!   `--- obj(n)      lettre noun(cn,acc,pers3-sg-f,X7)
!     `- ndet        d      det(acc,pers3-sg-f,X7)
`------- subj(n)     il     noun(pron(pers3),nom,pers3-sg-m,X8)
-----------------------------------------------------------------------

-----------------------------------------------------------------------
,------- vprep        apr`es  prep([apr`es|inf],[])
! `----- objprep(inf) e'crire mtv(inf,tf(pres,1,0),a)
!   `--- subj(n)      empty  coref(3)
!   `--- obj(n)       lettre noun(cn,acc,pers3-sg-f,X7)
!     `- ndet         d      det(acc,pers3-sg-f,X7)
o------- top          lire   mtv(ind:dcl:nwh,tf(past,0,0),a)
`------- subj(n)      homme  noun(cn,nom,pers3-sg-m,X5)
  `----- ndet         d      det(nom,pers3-sg-m,X5)
-----------------------------------------------------------------------
```

(20_T) *Après avoir écrit la lettre, l'homme lut.*

Of course, when nominal resolution cannot compute coreference between the subjects of main clause and subordinate clause, a necessary condition for the infinitival presentation of the subclause cannot be obtained and it will be blocked, as in *Nachdem sie den Brief geschrieben hatte, las er./After she had written the letter, he was reading./Après qu'elle avait écrit la lettre, il lut*). The overall strategy of the system is to compute unmarked target structures under the default style setting, in order to obtain acceptable translations for all kinds of sentences and texts, and to try to come up with more elegant, more subtle translations only if the user explicitly desires this and makes the corresponding adjustments to the system, including the switching on of the relevant evaluation components.

6 Résumé

In this paper, we have described a German-French translation system which analyses sentences into slot grammar analyses and more abstract dependence structures. These structures can be understood as flat underspecified discourse representation structures (FUDRSs). As such they allow semantic evaluations in different respects. The scope order can be refined, focus and background of focussing modifers can be determined, lexical disambiguations can be carried out and pronouns and descriptions can be resolved. The dependence structures define the level of recursive transfer. This component, as well as the following target generation, can trigger particular semantic evaluations of the mentioned types. We have shown, how this system treats the problem of translating the German tenses into French:

When needed, the Aktionsart of an eventuality and relevant location parameters are computed on the basis of a preferred disambiguation. We have sketched the corresponding algorithm. Where the translation can do without further information, there is no evaluation of the dependence structure and the target dependence structure respectively. We have also illustrated how the results of this economic setting can be fine-tuned by the use of style parameters which are specific to particular texts or tasks. It is work in progress to design an interleaved architecture for the different evaluation tasks whose results guide the translation of tense and aspect.

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