Coordination, incorporation and dynamic semantic representation in transfer

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Abstract

Factorized coordinated predicative structures prove to be a problem to transfer whenever the bilingual lexicon suggests a non-isomorphic translation for one of the predicative conjuncts, in particular a solution that requires incorporation of the predicative description into the translation of the source (support) verb. The problem disappears if the factorized structure is 'multiplied out', resulting in a structure where the coordination is raised to VP. Since many languages make use of such factorized coordinations and since, normally, one can translate them into each other, 'multiplying out' is unnecessary in most of the cases and costly.

We suggest a semantics based transfer architecture in this paper which, per default, avoids unfolding the factorized representation and makes it dependent on constraints formulated in the bilingual lexicon whether corresponding structural revision is needed. If so, triggered by such constraints, it is computed on the fly during transfer.

Keywords: MT-methodology, lexicon encoding

1 Introduction

When translating between most Romance and/or Germanic languages, often, factorized predicative coordinations can be kept unchanged structurally, viz. example (1) which illustrates this, using German, English, French and Spanish.

(1) *Johann ist stark und freundlich.*
Johann is strong and friendly.
Johann est fort et aimable.
Johann es fuerte y amable.

Most counterexamples are presented by coordinations where the categories of the conjuncts differ or, if not, where the conjuncts are not adjectives.

(2) *Dorothee war traurig und ohne jeden Freund.*

a) *Dorothee était triste et elle n'avait aucun ami.*
b) *Dorothee était triste et sans aucun ami.*

a) *Dorothee was sad and she had no friend.*
b) *Dorothee was sad and without any friend.*

Provided there are categorially similar translations of the lexical material and homomorphic translations of the non-factorized case, such examples illustrate that languages may differ with respect to whether they **prefer** factorized compact representations or not. (Probably, with respect to (2), a) is a better translation than b)). Also, depending on the grammar, elliptical structures as in (3) may obtain corresponding factorized analyses also (maybe for simplicity only) and the languages may vary with respect to whether they allow or prefer such structures.

(3) *Dorothee ist ohne jeden Freund, glücklich aber auch.*
(?) Dorothee est sans ami, mais aussi (elle est) heureuse.
(?) Dorothee is without a boy friend, however (she is) also happy.

Next to this, it may be for reasons of topicalization, of reinforcement of some complement (the subject), of a variety of (other) stylistic purposes that the factorized presentation may be preferred to the distributive one and the other way round. One might object that Machine Translation which, at so many 'fronts', has to struggle against the reproach of lousy quality could easily abstain from dealing with such ambitious questions of stylistic adequacy. However, there are cases where, beyond stylistic variation, unfolding factorized presentation is a prerequisite in order to avoid really bad translations. The following is an example of this.

(4)

a) *Der Kandidat ist ledig und berufstätig.*
Le candidat est célibataire et excerce un métier.
The candidate is unmarried and working.

b) *Irene ist verzweifelt und süchtig nach Heroin.*
Irene est désespérée et s'adonne à l'héroïne.
Irene is desperate and addicted to heroin.

Assume that German *berufstätig* doesn't have a French adjectival equivalent, then (4.a) must be unfolded in order to provide two instances of *sein/to be* such that one instance can *incorporate* (parts of) the meaning of the adjective *berufstätig* in translation (*exercer* (*un métier*)), whereas the other keeps its character of being copula (*être* (*célibataire*)). A similar argument holds for (4.b) (*s'adonner* versus *être*). One can argue that, provided the languages are of similar type, like the considered languages, thinking about the problem for a while and searching the lexicon, one will find some acceptable solution that allows for keeping the factorized representation anyway, maybe through changing adjectives into prepositional phrases or the like. Thus, at least with respect to (4.b), one would find adjectives, *adonné* or *dépendant*, which are indeed acceptable French translations of the German *süchtig* and which allow to be more conservative with respect to translating the structure. But this misses the point. The scenario is not presented by a human translator, who tries to figuring out a best translation, the scenario is that of an MT engine which must use a bilingual lexicon as is. Therefore, independent of whether there might be isomorphic transfer solutions in principle, the problem is that the MT system is sometimes confronted with factorized representations without having the lexical material at its disposal which could allow to keep the structure unchanged. Therefore, analysing sentences like (4) always and directly into semantic representations which convey different predicative states avoids such translation problems. As this is so, the semantics based transfer of *Personal Translator*, which provide the background of the investigation we present here (cf. (Eberle, 2002)), follows this strategy.

However, a disadvantage of this strategy is, as has been said in the beginning, that in a large number of cases, the factorized representation could be kept and would even be better. Therefore, in order to avoid heaviness of translation, generation will generally try to factorize if possible and if suggested by the source representation to the consequence that in such cases a lot of unnecessary and time consuming work is wasted (with regard to system design and and with regard to run time). Also, one has to realize that the phenomenon is not restricted to the predicative case. There are examples of attributive constructions that need some multiplying out in order to provide enough material for enabling correct and principle-based transfer to apply, instead of requiring messing around with some singular solution. The same is true for adverb coordinations. (5) lists some cases.

(5)

a) *Maria schwimmt gerne und gut.*
Maria aime nager et elle nage bien.
Maria likes to swim and she swims well.

b) *Er sieht wenige, aber wichtige Probleme*
Il voit peu de problèmes, mais des problèmes importants.
He sees few, but important problems.

Summarizing, the data suggest to stick with the unresolved compact form as long as possible, instead of unfolding factorized coordinations in each and every case, and to make it dependent on the translational needs whether they should be unfolded and raised to VP (or to NP, viz (5.b)) or not and if the answer is yes, to do it on the fly. This strategy fits well with the underspecified semantics based transfer approach as underlying recent versions of *Personal Translator*. In sections 3 and 4 we will show how it can be incorporated in such an approach. We will restrict ourselves to treat the predicative case, for reasons of simplicity – not without emphasizing that the method can be easily generalized to the other cases mentioned.

Before going into detail with this, however, we will say a few words about the architecture of the system as is.

2 Transfer architecture

The system is a representative of the transfer approach: Sentences are analyzed into syntactic structures from which more abstract representations are constructed which define the level of transfer and whose transfer equivalents are at the basis of the generation of the target string. [1] The system is lexically driven in the sense that the recursive transfer routine is guided and specified by transfer statements which are 'co-described' in the source entries of the bilingual lexicon. In this respect the system is similar to the transfer architecture of (Kaplan et al., 1989), where, on the basis of LFG, a projection τ is suggested which, via co-description in the lexicon, defines a mapping from lexical source structures into corresponding structures of the target representation. However, in contrast to this approach, where τ relates to the layer of *functional description*, here, it is defined for the layer of semantic representation. This semantic layer assumes underspecified representations which allow further specification with respect to different kinds of semantic ambiguity, namely lexical ambiguity (homography and polysemy), structural ambiguity (scope and attachment ambiguities) and pragmatic ambiguity (pronouns and definite descriptions). This is important because it enables transfer to trigger evaluation in this respect without that the result of evaluation be outside the domain of transfer. Also, in contrast to the LFG approach, lexical co-description is reserved for the definition of the transfer relation τ. The construction of the semantic representation isn't done by co-description in the lexicon, but more modularly and rather classically, by a seperate construction algorithm. In this respect the system is more similar to approaches of transfer like (Allegranza et al, 1991), also with regard to the dependency-oriented type of representation. However, in contrast to both of these well-known and influential transfer types, transfer, here, can investigate both semantic and underlying syntactic structure of the context, i.e. constraints of lexical transfer statements can relate to semantic structure (of varying depth of evaluation) and to syntactic structure, where 'context' is **not** restricted to the structure headed by the lexical item. (This means that constraints can relate to other phrases of the sentence and even to the representation of the preceding text). Also, in accordance with this, there are not several levels of abstraction (functional and semantic – the LFG-case – or relational and interlingua-type interface structure – the Eurotra-case – or the like), but just one. We can exploit this for solving our problem, as we will show further below.

The system parses sentences into *Slot Grammar* analyses. Slot Grammar is a dependence based unification grammar (cf. (McCord, 1989a)). Basically, in slot grammar, a sentence is analyzed into a head (the verb node), to which is assigned a number of (subcategorized) *slots* (the verb complements) and, possibly, one or more adjunct modifiers (like subordinated clauses, adverbials, etc.). (6.syn) below renders the corresponding analysis of the sentence (6).

(6) *Hier, M. Chirac a fait passer les dossiers à trois ministres.*
Yesterday Mr. Chirac has passed the files to three ministers.

In (6.syn), top-down ordering reflects left-to-right surface order. The first column characterizes the functional dependencies, the second column the senses of the terminal nodes and the third their categorial feature description (where the numbers following the citation of the words of the second column are identifiers of the corresponding entries in the lexicon and where the information in brackets renders (slot-frame) subcat-instantiations using surface positions).

From this syntactic analysis, the so-called *dependence structure* is constructed, which the system visualizes as presented by (6.dep). Dependence structures abstract away from surface order, auxiliary complexes and the like. (If, in (6.dep), the order corresponds to that of (6.syn), this is because the construction algorithm preserves it accidentially).

For details of the construction, see (Eberle, 2002). The dependence structure of a syntactic analysis encodes the maximally *flat underspecified discourse representation structure* (FUDRS) of the analysis, which, for (6), can be depicted as in (6.fudrs). FUDRSs have been introduced in (Eberle, 1997) mainly to complete Reyle's UDRT-approach (cf. (Reyle, 1993)) by an event semantics component. This means, by an account of the quality and temporal structure of the sentence event(s) with regard to quantification, modality and Aktionsart. *Flat* means, amongst other things, that (ambiguous) lexical items are not analyzed further than into their predicate argument structure at first and that the corresponding representational term is a functional expression where the corresponding function maps contexts which disambiguate the item into the respective more analytic representations. In a way, the function 'flattens' the meaning of the ambiguous term by combining the different readings into one functional relation. Instead of the partial representations that make up UDRSs (which, basically, are classical *discourse representation structures*, DRSs, cf. (Kamp and Reyle, 1993)), FUDRT uses functions from representations into representations and

[1] The roots of the system are implementations of the LMT-project (which encoded syntax based transfer), cf. (McCord, 1989b).

(6.syn)

```
Syntactic analysis no. 1.   Evaluation = 3.3111 ...

------------------------------------------------------------------------
.------- vadv             hier1548203(1,u)          adv(X4,X5)
| `----- sep(com)         ,                         separator
.------- subj(n)          M.1660698(3,4)            noun(cn,[[[nom|sg]],m|X10],nwh)
| `----- nid              Chirac2038972(4)          noun(prop,[[[nom|sg],[dat|sg],[acc|sg]],m|X11],X12)
o------- top              avoir_perf(5,3,6)         verb(fin([[pers3,sg,pres|ind]],X1,ind:dcl:nwh,X2))
`------- auxcomp(pastpart) faire1377809(6,3,7,9,12) verb(i(pastpart([[m|sg]]),X13))
  `----- comp(binf)       passer1426234(7,12,9,u,u) verb(i(inf([X22|X23]),X24))
  | .--- ndet             d(8)                      det(def,[[[nom|pl],[dat|pl],[acc|pl]],m|X21])
  `----- obj(n)           dossier1441144(9)         noun(cn,[[[acc|pl]],m|det],X20)
  `----- iobj(n)         `a(10,12)                  prep([`a|dat],X14,12)
    | .- nadjnum          trois3(11,u)              noun(num,[[[nom|pl],[dat|pl],[acc|pl]],X15|3],X17)
    `--- objprep(dat)     ministre1479209(12)       noun(cn,[[[dat|pl]],X15|aj],X16)
------------------------------------------------------------------------
```

(6.dep)

```
Dependence structure.

------------------------------------------------------------------------
.--- vadv       s(hier,1548203)     adv(p,[]):[[hmu,temploc_b_st_adv,hier]]
.--- subj(n)    s(M.,1660698)       noun(cn,nom,pers3-sg-m,[]):[[title,M.]]
| `- nid        s(Chirac,2038972)   noun(prop,[nom,dat,acc],pers3-sg-m,[]):[[male,human,lastname,Chirac]]
o--- top        s(faire,1377809)    mtv(ind:dcl:nwh,tf(pres,1,0),a):[[so,faire]]
`--- comp(binf) s(passer,1426234)   mtv(dep:inf:nwh,tf(inf,0,X1),a):[[passer]]
| `- obj(n)    empty               coref(9)
| `- iobj(n)     empty               coref(12)
`--- obj(n)     s(dossier,1441144)  noun(cn,acc,pers3-pl-m,[]):[[part0,doc,dossier]]
| `- ndet       s(les,d)            det(acc,pers3-pl-m,[def]):[[les,d]]
`--- iobj(n)    s(ministre,1479209) noun(cn,dat,pers3-pl-X2,[]):[[male,human,prof,ministre]]
  `- ndet       s(trois,3)          noun(num,dat,pers3-pl-X3,[3]):[[trois]]
------------------------------------------------------------------------
```

(6.fudrs)

$$\underline{\text{faire}}_{e_1}\left\{\begin{array}{ll} \text{subj(n):} & \underline{\text{Monsieur}}(\underline{\text{Chirac}})_x, \\ \text{comp(binf):} & \underline{\text{passer}}_{e_2}\left\{\begin{array}{l}\text{obj(n): } \emptyset_\chi, \\ \text{iobj(n): } \emptyset_\psi\end{array}\right\} \& \text{ OC}_1, \\ \text{obj(n):} & \underline{\text{det(def,pl)}}(\underline{\text{dossier}})_{X,\chi} \\ \text{iobj(n):} & \underline{\text{det(quant(3),pl)}}(\underline{\text{ministre}})_{Y,\psi} \\ \text{vadv:} & \underline{\text{hier}} \end{array}\right\} \& \text{ OC}$$

interpretes the order constraints dynamically as stipulations about the order of application.

According to this, (6.fudrs) has to be read as follows: faire, passer, dossier, ... are the *flat* semantic representations of the corresponding words in the sentence (that is: functions decorated by relevant distinguished discourse referents, tense and aspect information, if any, ranging over more specific interpretations of these words, if any). The elements of the sets which are introduced between curly brackets are semantic functors relating to the term which is heading the set, where a specific semantic interpretation (a DRS) can be constructed by applying the functors in accordance with the scope constraints of *OC* where the type of application or composition is identified by the name of the corresponding grammatical function, subj(n), obj(n) etc., via using information from the syntax-semantics interface. (Depending on the meaning(s) of the argument, they may introduce different thematic relations between the distinguished discourse referents of the argument and the functor, i.e., in this sense, they underspecify corresponding thematic roles).

If the set of order constraints *OC* is empty, the order of the applications is not determined further. Initially, when considering the impact of syntax only, this is so, normally, at least for most languages that we deal with in our MT system (for considerations about the influence of surface order on scope, in particular with respect to German, see (Frey, 1993), which our scoping mechanism follows to a large extent). Also, initially, the degree of lexical disambiguation is determined by the impact of syntactic analysis only (which is the filtering caused by the selectional restrictions about complements on the basis of the specific analysis). This is what we mean by *maximally* flat and underspecified. (The depencence-structure-encoding of a FUDRS presents order statements of OCs via additional *scope* literals and disambiguations of lexical predicates via additional predicates about the same DRF or via revision on the semantic typing, which, in the visualization, is rendered by the bracketed list at the end of the description of the lexical items). If there is only one functor to apply to an argument representation, instead of the set notation with curly brackets, the FUDRS may be written using the common functional term notation also. (6.fudrs) makes use of this notational convention with respect to the determiners and the identifier respectively of the subj-, obj- and iobj-complements of *faire*. Note however, that this does not mean that the functor is disambiguated (i.e.: that it is a reading of the corresponding phrase). In particular, (6.fudrs) does not entail whether the plural complements (obj, iobj) must be read distributively or not, which would decide about whether the discourse referents ψ and χ – which are passed to the verb – have to be identified as X and Y respectively (in the collective case) or to some x and some y (in the distributive case). The functors det(def,pl) and det(quant(3),pl) illustrate that dependence structures use interlingual representations for specific closed domains like determination or information about dates. We see that dependence structures interpret the reentrancies of the syntactic analyses in terms of explicit coreference statements. This is done for the purpose of providing more flexibility to the modules operating upon dependence structures, especially to allow for different translations of such items.

Summarizing, in the first place, the impact of constructing the dependence structure is to translate the information of auxiliaries into tense and aspect features and to list the nuclei of the semantic sentence representation together with the constraints about the type and order of possible applications (and composition, to be precise) in a recursive manner.

It is easy to see, how the transfer routine τ must proceed by default: It runs through the dependence structure, guided by the (semantic) ordering constraints of the sentence representation, translating the node structures by the specifications of the bilingual lexicon. This means, when applied to (6.dep), τ should result in the target dependence structure (6.tdep), where τ_n is the transfer relation between nodes, i.e.: the translation of flat word semantics or, loosely speaking, the relation between source and target word, and where τ_s is the transfer relation between application types as designated by the grammatical functions, translating for instance de-complements of nouns, *ncomp(p(de))*, *le mari de la femme*, into noun complements of case genitive, *ngen*, *der Mann der Frau*. The relative scope order, *OC*, should be preserved.

The following default transfer algorithm accords with this specification. It is the backbone of our transfer module.

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

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

(6.tdep)

$$\tau_n(\underline{\text{faire}})_{e_1}\left\{\begin{array}{ll} \tau_s(\text{subj(n)}): & \tau_n(\underline{\text{Monsieur}})(\tau_n(\underline{\text{Chirac}}))_x, \\ \tau_s(\text{comp(binf)}): & \tau_n(\underline{\text{passer}})_{e_2}\left\{\begin{array}{l}\tau_s(\text{obj(n)}):\ \emptyset_\chi,\\ \tau_s(\text{iobj(n)}):\ \emptyset_\psi\end{array}\right\} \&\ \text{OC}_1, \\ \tau_s(\text{obj(n)}): & \underline{\text{det(def,pl)}}(\tau_n(\underline{\text{dossier}}))_{X,\chi} \\ \tau_s(\text{iobj(n)}): & \underline{\text{det(quant(3),pl)}}(\tau_n(\underline{\text{ministre}}))_{Y,\psi} \\ \tau_s(\text{vadv}): & \tau_n(\underline{\text{hier}}) \end{array}\right\} \&\ \text{OC}$$

This allows for translating source sentences into target sentences, which, w.r.t. the level of dependence structure, are isomorphic. In particular, for (6), we could obtain something like (6.T) (which shows the same ambiguities with respect to distributivity and scope as the source sentence).

(6.T)

Gestern ließ Herr Chirac die Akten drei Ministern weitergeben.
Yesterday, Mr. Chirac made pass the files to three ministers.

Of course, it might be that the final result of the MT system is not at all isomorphic to the source description, also with respect to the cases as have been considered so far. But then, this is due to the target generation grammar's trying to render some pragmatic markedness of the source in the target on the basis of investigations of the source descriptions (marked orderings for example etc.) or simply for stylistic reasons. A possible variation of (6.T) in this respect could be: *Gestern veranlasste Herr Chirac, dass die Akten an drei Minister weitergegeben wurden.*

In contrast, there are cases of structural divergence which must be treated in transfer, provided the result of transfer be a correct (flat) semantic description of a correct target sentence (such that this description could be constructed from this target sentence by the target analysis components). An example is *incorporation*, as is needed to correctly deal with (the expanded forms of) (4). Such cases of restructuring are described and triggered by so-called τ-instructions which accompany the entries in the lexicon. (For an overview of the available formal means, see (Eberle, 2001)). In order to describe the transfer relation of the following simpler version of (4), (7), appropriately, the entry of *süchtig* must stipulate something like (7.lex).

(7) *Irene ist süchtig nach Heroin.*
Irene s'adonne à l'héroïne.
Irene is addicted to heroin.

(7.lex)

- $\underline{\text{süchtig}}$ [acomp(p(nach)]

C: $\underline{\text{u(pred)}}$-(sein & w(V)) & d(acomp)-w(N)

τ: $\emptyset$ &

$$\text{V: adonner}\left[\begin{array}{l}\text{item(rflx)},\\ \text{item(comp(p(à)),}\tau\text{(N))},\\ \text{e}\\ \text{tp(d([acomp,adjt]),d(adjt))}\end{array}\right]$$

(7.lex) treats the case of *süchtig* being used predicatively in a construction which is headed by *sein* and where the acomp-slot of the adjective is filled. All other cases (which would be described using corresponding C:-statements –C: for *condition*) are omitted (i.e. attributive use or predicative use without prepositional complement or headed be *machen/make* etc.). In this case, the variables V and N can be instantiated and they designate the predicative structure as a whole and the prepositional complement of the adjective. Now, going on the assumption that this specific C is satisfied, τ defines the transfer equivalent of *süchtig* to be the 'empty structure'. Simultaneously, V obtains the translation *adonner*. This means, the default *être* (which is provided by the entry of *sein*) is overridden. Also, the default τ-assumptions about the slots of the verb are overridden (partially): The predicative complement is stripped off ('e'). Instead, it is introduced a new complement which effectuates reflexive use of the verb in the target sentence and a new prepositional complement (to the preposition *à*), whose value is the translation of the prepositional complement of *süchtig*, designated by N. As said, lexical lookup co-describes such specific τ-statements to the corresponding partial representations, such that, when the transfer routine runs through the source structure and reaches the top node of V, instead of translating according to the default, it follows the described specific instructions about the translation of the word and its slots (the representation of the word and its functors), such that we obtain the french translation as shown in (7).

3 The problem revisited

The system as is described so far represents (4.b), that we repeat here as (8), by a dependence structure which corresponds to the FUDRS (8.fudrs) below.

(8) *Irene ist verzweifelt und süchtig nach Heroin.*

What does (8.fudrs) stands for? For simplicity, assume that the lexical material does not carry any sophisticated ambiguity or meaning other than what relates to the subject we are concerned with here. This means, Irene is a name and behaves like a name, except for its presuppositional impact. This means, it introduces a one-place predicate into the representation only and nothing else. verzweifelt has just an intersective predicative meaning 'verzweifelt' (and doesn't treat the different nuances of the word) and so on. With regard to coordination, we only consider the use that we need here. This means und combines adjectives and verbs only. Thus, we interprete the functional lexical terms as stipulated by the lexical data base (LDB) below. LDB should be sufficient for constructing (8.fudrs) from a suited slot grammar analysis of (8) on the basis of the (FU)DRS construction algorithm.

The use of lambda abstraction in the LDB-entries follows common conventions of DRT and lambda calculus. Note that *süchtig* obtains two interpretations. The first one reflects the use without, the second with prepositional complement (as in (8)). In the latter case, we assume that the predicate relates to an additional property, not to an additional object (to *heroin* as such, not to a specific instance of this, with respect to our example). Heroin obtains two interpretations also, the first one reflects the use as common noun and the second the use as determined phrase (DP), as in (8). The considered use of *sein* introduces a state *s* which asserts the property of the predicative argument to hold for the discourse referent from the subject. As said, the representation of *und* can deal with coordinations of modifiers (adjectives) and VPs. (The construction algorithm allowing composition, it can use this representation also for adverbials). Since there are no (relevant) scope ambiguities in (8.fudrs), this FUDRS corresponds to the DRS (8.drs), provided the lexical definitions of LDB. (Here and till the end of the paper, we continue omitting temporal information):

(8.drs)

u s
irene(u)
s: [verzweifelt(u) ; süchtig(u,λ x. heroin(x))]

Note that, semantically, there is no relevant difference between this representation and the following representation (8.drs2), which distributes the description of *s* into two different states, provided MP holds, which is a common meaning postulate about the co-occurrence of complex states.

(8.drs2)

u s1 s2
irene(u)
s1: [verzweifelt(u)]
s2: [süchtig(u,λ x. heroin(x))]

MP

s t x
t ⊆ s
s: [P(x) ; Q(x)]

$\Longrightarrow$

s1 s2
s1: [P(x)]
s2: [Q(x)]
t ⊆ s1
t ⊆ s2

s1 s2 t x
s1: [P(x)]
s2: [Q(x)]
t ⊆ s1
t ⊆ s2

$\Longrightarrow$

s
t ⊆ s
s: [P(x) ; Q(x)]

From this second representation, we easily obtain the french representation with the second state condition (s2: $\boxed{\text{süchtig(u,}\lambda\text{ x. heroin(x))}}$) replaced by a condition about an event of *adonner* (e: $\boxed{\text{adonner(u,u,}\lambda\text{ x. heroin(x)}}$), according to the τ-stipulations of the lexical entry of *süchtig*, provided appropriate encoding of DRS and lexical τ-stipulations which allows to identify the condition *u(pred)-sein* with the s: $\boxed{\text{Q(x)}}$ schema of the DRS and to replace the different conditions accordingly.

However, in order to apply MP and to obtain this, we were forced to analyse the input into a DRS proper, this means, to disambiguate the input thus far that the representation corresponds to a reading. Since, normally, there is a whole bunch of readings, the strategy must be to avoid this as long as possible. Also, when generating the target string from a

(8.fudrs)

$$\underline{\text{sein}}_s \left\{ \begin{array}{ll} \text{subj(n):} & \underline{\text{Irene}}_x, \\ \text{pred(a):} & \underline{\text{und}}(\underline{\text{verzweifelt}}_x, \underline{\text{süchtig}}_x \left\{ \text{acomp(p(nach)):}\underline{\text{heroin}} \right\} \& \text{ OC}_1) \end{array} \right\} \& \text{ OC}$$

LDB

- $\underline{\text{irene}}_x \quad \in \quad \text{DP}$

  $$= \begin{array}{|l|} \hline \text{x} \\ \text{irene(x)} \\ \hline \end{array}$$

- $\underline{\text{verzweifelt}} \quad \in \quad \text{(t/e)/(t/e) (=ADJ)}$

  with:

  $$\underline{\text{verzweifelt}}(\lambda \text{ x.P(x)}) = \lambda\text{x.} \begin{array}{|l|} \hline \text{P(x)} \\ \text{verzweifelt(x)} \\ \hline \end{array}$$

- $\underline{\text{süchtig}} \quad \in \quad \text{(t/e)/(t/e) or (t/e)/(t/e)/DP}$

  with:

  $$\underline{\text{süchtig}}(\lambda \text{ x.P(x)},\text{K}_y) = \lambda\text{x.} \begin{array}{|l|} \hline \text{P(x)} \\ \text{süchtig(x,}\lambda \text{ y.K}_y) \\ \hline \end{array}$$

  (where K is the representation of the prepositional complement, K optional)

- $\underline{\text{heroin}} \quad \in \quad \text{(t/e) or DP}$

  with:

  $$\underline{\text{heroin}}_y^{|(t/e)} = \text{heroin(y)}$$

  $$\underline{\text{heroin}}_y^{|DP} = \begin{array}{|l|} \hline \text{y} \\ \text{heroin(y)} \\ \hline \end{array}$$

- $\underline{\text{sein}} \quad \in \quad \text{(t/(e,ADJ))}$

  with:

  $\underline{\text{sein}}_s(\chi,\lambda\ (\lambda \text{ x.P(x)}).\ \lambda\text{x.Q(x)})$

  $$= \begin{array}{|ll|} \hline \text{s} & \\ \text{s:} & \begin{array}{|l|} \hline \\ \text{Q}(\chi) \\ \hline \end{array} \\ & \\ \hline \end{array}$$

  (with P instantiated by TRUE, i.e. stripped off)

- $\underline{\text{und}} \quad \in \quad \text{(XP/(XP,XP))}$

  (provided the arguments are of type XP)

  with:

  $\underline{\text{und}}(\lambda\ (\lambda \text{ x.P(x)}).\ \lambda\text{x.Q(x)},\lambda\ (\lambda \text{ x.P(x)}).\ \lambda\text{x.R(x)})\ )$

  $$= \lambda \text{ x.P(x).} \begin{array}{|l|} \hline \text{Q(x)} \\ \text{R(x)} \\ \hline \end{array}$$

  $$\underline{\text{und}}(\lambda \text{ x.VP1},\lambda \text{ x.VP2}) = \lambda \text{ x.VP1 } \cup \text{ VP2}$$

DRS, we are faced with all problems of text planning as are known from the task of generating text from knowledge representations. For example, how do we decide about which event or state is described by the matrix clause and which other not or whether two events or states should be described via a coordination and whether this coordination should be factorized or not. (In short, this is the factorizing problem the other way round and a large number of other presentation problems in addition). Therefore, a good solution of the problem must minimize disambiguation and must provide a maximum of structural information, what means, in this context: a minimal amount of lambda conversions applied, to the effect of the entire representation consisting of a maximal amount of partial representations. It also must make MP available for these representations.

4 Solution

Disambiguating evaluation of FUDRSs is performed along different lines. Besides evaluation of lexical terms according to functional definitions as mentioned above and some other types of disambiguation, there is so-called *linearization* of a FUDRS, which means that the ordering constraints are completed such that all scope ambiguities disappear, in the sense that there is just one DRS which can be constructed from the FUDRS by applying the partial representations to each other according to these ordering constraints. We obtain maximal substructural transparency as claimed in the last section if we suppress application, even if there is no choice left, i.e. if the FUDRS is linear with respect to the considered argument and functor(s). This maximal transparency is provided by the dependence-structure-encoding of FUDRSs (where the determination of relative scope and other types of disambiguation introduce new literals, but do not change the dependency relations by amalgamating nodes and their representations.

Since, in our system, transfer is defined for the level of dependence structure already, it remains to formulate a rewriting rule for dependence structures which conforms to MP and which allows to switch from dependence structures with complex pred-coordinations to dependence structures where the coordination is raised to VP and vice versa. Below, we present the corresponding FUDRT-equivalent, called distributive law (DL). (Assuming simultaneous substitution of predicate/function variables), it can be shown that DL and MP are equivalent with respect to (F)UDRT model-theory (also, if completed by suitable situational parameters). DL should be self-explanatory, except, possibly, for the ordering statements: OC can contain conditions only which rule the internal structure of $\underline{\mathrm{Q}}$, $\underline{\mathrm{R}}$ and the relation between subj and pred, $\overline{\mathrm{OC1}}$ can relate to subj and pred of $\underline{\mathrm{sein}}_{s1}$ and the internal structure of $\underline{\mathrm{Q}}$ only and correspondingly for OC2. Then, the statements guarantee that scope relations are distributed correctly.

Now, if we assume in accordance with the lexicon formalism described in (Eberle, 2001) that there are conditions of τ-instructions which (can) trigger specific semantic evaluation and if we additionally assume that *u(pred)-V* is such a statement (provided the corresponding instruction requires some specific translation of V) and if we assume that this statement triggers application of the rewriting rule of DL whenever the source structure shows u(conj)-u(pred)-V instead of u(pred)-V, we obtain what we want: When evaluating the conditions of the τ-instructions, the source structure is rewritten in this case such that the τ-instruction proper easily can be co-described to the corresponding (new) verb representations. The transition from (8.dep) to (8.dep2) that we render below, illustrate the effect of DL with respect to the dependence-structure of (8). In contrast to (8.dep), (8.dep2) indeed conforms to the constraints of the transfer description of the lexical entry of *süchtig*: It holds *u(pred)-sein*. In short, interpreting such constraints dynamically in the sense that it is tried to infer them from structures via applying DL when they cannot be matched directly means that they trigger restructuring of the semantic representation during transfer such that factorized coordinations 'pop up' automatically and lexically driven, whenever needed. Note that the restructuring is minimal with respect to the translation problem and maximally preserves information for the following generation of the target string.

5 Summary

We have tried to motivate a method of restructuring the semantic representation which serves as input to the transfer component whenever this component, directed by the specifications of the bilingual lexicon, needs a distributive representation of a factorized coordination. We think that for a number of reasons 'unfolding' the coordinations on the fly takes it over to the alternative of doing it always (and) during semantic construction, which means: preceding transfer. The method applies to the dependence-structure-encoding of FUDRSs, which allows for variable depth of analysis and dynamic evaluation according to suggestions like (Kay et al., 1994). We spelled out the method with respect to (two-place) coordinations of adjectives in predicative construc-

DL

$$\underline{\text{sein}}_s \left\{ \begin{array}{ll} \text{subj(n):} & \text{K}_x, \\ \text{pred(a):} & \underline{\text{und}}(\, \underline{\text{Q}}_x,\, \underline{\text{R}}_x) \end{array} \right\} \& \text{ OC} \quad \Leftrightarrow \quad \underline{\text{und}}(\underline{\text{sein}}_{s1} \left\{ \begin{array}{ll} \text{subj(n):} & \text{K}_x, \\ \text{pred(a):} & \underline{\text{Q}}_x \end{array} \right\} \&\text{OC1}, \underline{\text{sein}}_{s2} \left\{ \begin{array}{ll} \text{subj(n):} & \text{x}, \\ \text{pred(a):} & \underline{\text{R}}_x \end{array} \right\} \&\text{OC2})$$

where ex. OC1', OC2': OC=OC1' $\cup$ OC2' and OC1 $\cong$ OC1', OC2 $\cong$ OC2'

(8.dep)

```
Dependence tree.

----------------------------------------------------------------------
o----- top                   s(sei,2)             mtv(ind:dcl:nwh,tf(pres,0,X1),a):[[se,v_adj,sei]]
| .--- subj(n)               s(Irene,457755)      noun(prop,nom,pers3-sg-f,[]):[[human,fem,vname,Maria]]
|    . --- lconj                 s(verzweifelt,759336) adj(p,X3,X4,[]):[[verzweifelt]]
  '+--- pred(a)               s(und,coord)     adj(p,X6,X7,[]):[]
     '--- rconj                 s(s"uchtig,856507)     adj(p,X6,X7,[]):[[noadv,s"uchtig]]
       '- acomp(p([nach|dat])) s(heroin,332228)      noun(cn,dat,pers3-sg-nt,[]):[[mass,droge0,heroin]]
----------------------------------------------------------------------
```

(8.dep2)

```
Dependence tree.

----------------------------------------------------------------------
o----- top                   s(sei,2)             mtv(ind:dcl:nwh,tf(pres,0,X1),a):[[se,v_adj,sei]]
|  .--- subj(n)               s(Irene,457755)      noun(prop,nom,pers3-sg-f,[]):[[human,fem,vname,Maria]]
'-+--- lconj                 s(sei,2)             mtv(ind:dcl:nwh,tf(pres,0,X2),a):[[se,v_adj,sei]]
| '--- pred(a)               s(verzweifelt,759336) adj(p,X3,X4,[]):[[verzweifelt]]
'----- rconj                 s(sei,2)             mtv(ind:dcl:nwh,tf(pres,0,X5),a):[[se,v_adj,sei]]
  '--- pred(a)               s(s"uchtig,856507)    adj(p,X6,X7,[]):[[noadv,s"uchtig]]
  | '- acomp(p([nach|dat])) s(heroin,332228)      noun(cn,dat,pers3-sg-nt,[]):[[mass,droge0,heroin]]
  '--- subj(n)               empty                coref(1)
----------------------------------------------------------------------
```

tions. Generalizing the distributive law DL, which is at the basis of the method, is rather straightforward however, such that the procedure can be made available for other types of coordinative structures easily. A prototype version of the method has been implemented on the basis of the *Personal Translator* technology.

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