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REMARKS ON LEXICAL STRUCTURE AND  
DRS CONSTRUCTION

This paper investigates questions concerning the form and content of a lexicon able to support the systematic semantic representation of texts. We concentrate on questions connected with the transitive and intransitive uses of the German verb *heilen* (to cure/to recover). Our attention will be focussed on the possible argument structures of this verb and on the concept "thematic role". We will use our lexical entries for *heilen* to construct semantic representations of a few sentences within the framework of DRT.

In the second paper of this volume we will study the use of these and similar entries in drawing inferences from semantic representations.

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## 1. Purposes and proceedings<sup>1</sup>

This paper is about the lexicon. It is also, and more importantly, about the construction and use of semantic representations for natural language sentences and texts, and it is in relation to this concern that our proposals about the lexicon should be understood. Adequate semantic representation is impossible without detailed lexical information. The lexicon must have this information, and it must make it available to the algorithms responsible for representation construction and manipulation. In other words, the lexicon must have enough information and it must have it in the right form. It is these two constraints, on lexical content and on lexical form, which have set the framework for the present investigations.

Semantic representations must be *transparent* (in the sense in which the languages of predicate logic provide transparent representations of content; the truth definition for predicate logic fixes the truth conditions of its formulas uniformly and unambiguously); and they must be sufficiently *differentiated* (a formula of propositional logic may, even when it represents the content of a sentence of natural language correctly as far as propositional logic goes, be a representation of little value because it suppresses all quantificational structure).

Whether a semantic representation is differentiated enough shows itself primarily in its ability to support the inferences that can be drawn from the represented text. As we will see, it is in this connection that the role of the lexicon is crucial.

The need to draw inferences from semantic representations arises in two different ways. First, such inferences are needed when we want to make use of semantic representations once they have been constructed – as databases in automated question answering systems, say, or as interfaces in machine translation. All such uses require sophisticated manipulation of the given representations by means of inferential and inference-like processes. Second, inferences are necessary in the course of constructing the semantic representations themselves. For instance, the interpretation (“resolution”) of anaphoric definite descriptions often requires information con-

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cerning such relations as synonymy, hyponymy or antonymy between lexical items. Similarly, the temporal relations between the events described by successive sentences must in many cases be inferred from material present in the partially constructed representation. We will see some examples of such inferences in Kamp & Roßdeutscher (1994), this volume.

Precisely how these demands on semantic representations determine the form of a lexicon that must support their construction depends on the particular theory of semantic representation and representation construction one takes as one's point of departure. The explorations on which we report here are informed by the framework of Discourse Representation Theory. DRT is built on quite specific assumptions both about the form of its semantic representations (its DRSs) and about the algorithms for constructing them. It will be clear from this paper to what extent our ideas about the lexicon have been shaped by those assumptions. This does not mean that what we will have to say would evaporate if the DRT framework were stripped away. But we have made no effort to distinguish between what can stand independently and what is theory-internal.

Our strategy will be to start off by concentrating on quite specific problems and to move gradually and gingerly towards assumptions of a more general nature. We will be looking at a small collection of verbs and derived nouns clustered around the concept of a cure. Our first concern will be with the German verb *heilen*. *Heilen* has a number of different uses, which are distinguished from each other by the sets of complement NPs and/or PPs which accompany them. Although these different uses are semantically as well as syntactically distinct, they all involve the same concept; or, to put it differently, they all make reference to the same type of process, the process of a patient recovering from some disease or other ailment. To make this common denominator of the concepts expressed by the different uses of *heilen* explicit, we will represent the lexical entries corresponding to those uses as conceptual structures each of which contains the common concept – we will refer to it as HEILEN – as a part. To fix the content of this concept, the lexicon must specify the general properties of the processes falling under it – what the various stages of such processes are like; what happens, in the course or as result of the process, to its protagonists; whether the processes are gradual or instantaneous, etc. – as well as make explicit the logical and semantical connections that link the concept with those expressed by other lexical items.

Besides such information about the structure of and relations between concepts, the lexicon also needs to tell us how the lexically expressible

concepts are grammatically realized. We will set our lexicon up in such a way that matters of conceptual structure and matters concerning grammatical realization are clearly separated.

## 2. Thematic roles

It would seem natural to keep information concerning the possible ways in which a concept may be grammatically realized separate from that which regards the logical and semantical properties of the concept itself. Nevertheless, the two kinds of information will have to be closely inter-linked, if only because the lexicon must enable us to correlate the argument phrases that accompany a particular verb occurrence with the right participants in the event, state, or process described by this verb-argument complex. Such correlations are needed, for instance, to determine inferential relations between sentences involving different lexical items, or even different uses of the same lexical item. Consider for example the inference from

- (1) Der Arzt heilte den Patienten mit Tabletten von der Krankheit.  
(The doctor cured the patient of the disease with tablets.)

to

- (2) Die Tabletten heilten die Krankheit.  
(The tablets cured the disease.)

If the verification of this inference is to rely on the different ways in which the occurrences of *heilen* in (1) and (2) are connected to a single concept, then these connections must make explicit that the *von* phrase of sentence (1) plays the same part in the process that is described by (1) as the direct object of sentence (2) plays in the process described by (2).

Correlations of this kind – between the syntactic complements of verbs on the one hand and the protagonists of the events, processes and states of affairs the verb can be used to describe on the other – are crucial to any systematic explanation of lexically based semantic relations between sentences, and in particular of lexically based inference. This has long been recognized and it has given rise to a variety of related notions of “thematic role”. Unfortunately the term ‘thematic role’ has been used in a quite bewildering variety of different ways. It would surely be a worthwhile project to try and disentangle the different strands of syntactic and semantic intuition that have gone into those different uses. But here is not the place to

undertake this and we will limit ourselves to explaining of how we intend to use the term ourselves.

Our position coincides in essence with that of e.g. Dowty (1988): thematic roles are functional relations between events (or processes or states of affairs) of certain types and certain participants of these events processes or states. By way of example, consider verbs of motion. Such verbs are used to describe “motions” – events, in other words, in which some thing moves. This thing – the thing that the given motion is a motion of – we call the motion event’s *theme*. Thus the thematic role “theme” is one which associates, in particular, with each motion event the corresponding entity that the event is a moving of. This is the general view we adopt: Thematic roles are functions from *eventualities* (i.e. events, processes or states) to entities that are implicated (in one way or another) in those eventualities.

The point of thematic roles is that they allow us to capture certain generalizations involving the eventualities for which they are defined and the entities that they assign to them. For instance, we may infer from the fact that  $e$  is a motion and that  $x$  is the theme of  $e$  that  $x$  has changed position between the beginning and the end of  $e$ : there are times  $t_1$  and  $t_2$  such that  $\text{beginning}(e) \leq t_1 < t_2 \leq \text{end}(e)$  and  $\text{pos}(x, t_1) \neq \text{pos}(x, t_2)$ . In the presence of additional information about  $e$ , moreover, we may be able to say more specific things about its theme  $x$ . Thus, if we know that  $e$  was a motion from  $A$  to  $B$ , we can infer that  $x$  was first located at  $A$  and afterwards at  $B$ :  $\text{at}(\text{loc}(x, \text{beginning}(e)), A) \ \& \ \text{at}(\text{loc}(x, \text{end}(e)), B)$ . And so, on.

There are several questions that this conception of thematic roles forces us to ask: (i) What kinds of entities are the arguments of thematic roles? (ii) What sorts of entities are the values of thematic roles? and (iii) Are thematic roles total or partial functions?

(i) Above we described the arguments of thematic role functions as “eventualities”. These we equated with the disjunction of “events”, “processes” and “states”. So, what is an “event”, what is a “process” and what is a “state”? These are important but difficult and much disputed ontological questions, to which one would want satisfactory answers for many reasons other than those that concern us here. However, for present purposes a thorough philosophical analysis of the concepts “event”, “process” and “state” is not that crucial. It suffices to see in what sense events, processes and states function as semantic arguments of the concepts expressed by, in particular, verbs.

Although the view that verbs have referential arguments which have the ontological status of events, states or processes is by now familiar and widely accepted, let us briefly review this issue. Natural languages contain large numbers of expressions, among them verbs, nouns and prepositions, which may be called “attributive terms” inasmuch as it is their function to attribute certain properties to certain entities. Often these properties are simple, in the sense that having them does not involve being related to some other individual. This is the situation most commonly encountered in connection with nouns and adjectives – think of words such as *Frau* (woman), *Delphin* (dolphin), *Tisch* (table), *grün* (green), *feige* (cowardly) – the list is more or less random. However, the property attributed by a noun or adjective may also be relational. We find this for instance with a noun such as *Freund* (friend) or an adjective like *verwandt* (related): to be a friend is always to be somebody’s friend, just as being related means being related to someone or to something. Often, though not always, these relata are made verbally explicit, as in *Freund von Susanne* (friend of Susan’s) or *mit dem afrikanischen Elefanten verwandt* (related to the African elephant).

What appears to be a minority phenomenon in the case of nouns and adjectives is much more common in the case of verbs, and in the case of prepositions it is the law. A preposition, e.g. *in*, can be used to attribute a property to an object, as when we say “*Das Nadelkissen ist in der Schachtel*” (the pincushion is in the box). But as this example illustrates, the property attributed – here to the pincushion – is one that always consists in the object standing in a given relation (denoted by the preposition) to another individual, which is denoted by the NP that is governed by the preposition (here the phrase *die Schachtel* (the box)).

Note that in all cases we have so far considered the attributee, i.e. the entity to which the property is being attributed, is not explicitly mentioned in the phrase in question (the attributee of *Freund von Susanne* (friend of Susan’s) is not the referent of *Susanne* but some individual supplied by some other part of the context in which the phrase appears, etc.). With verbs the matter may seem a little less clear. One view is that verbs, with or without added complement phrases, serve to attribute properties to their subjects. On this view the division between verbs that attribute simple and those that attribute relational properties is by and large that between intransitive and transitive verbs. For instance, in the sentence *Der Kaktus blüht* (the cactus blooms) the intransitive verb *blüht* attributes a simple property of the object denoted by the subject phrase *der Kaktus*. And in *Fritz liebt Susanne* (Fritz loves Susan) the phrase *liebt Susanne* attributes a certain

relational property – that of standing in the loving relation to Susanne – to the individual Fritz. On this view the attributive expression is the verb phrase and the attributee is identified by its “external” argument, the subject NP.

However, there is also another way of viewing the predicational nature of the grammatical clause, one that has at least two quite distinct origins in modern philosophy and linguistics, on the one hand the work of Donald Davidson (1967), who argued that many sentences should be analyzed as descriptions of events, and on the other that of Chomsky (1970) which stresses the similarity between certain clauses, such as, say, *Caesar verwüstete die Stadt* (Caesar destroyed the city) and corresponding nominalizations, in this case *Caesars Verwüstung der Stadt* (the destruction of the city by Caesar). In the light of what we have said above about nouns and noun phrases it seems inescapable to view the nominalization as the attribution of the property of being a destruction of the city by Caesar to some not explicitly given entity, presumably an event. If we want to see the nominalization as a nominalization of the entire clause *Caesar verwüstete die Stadt*, then a similar analysis suggests itself for that clause. So it too must be seen as a complex predicate which attributes some property or other an event that is implicitly understood. If we adopt this latter view, then the predicating part of a simple clause is not just its VP but rather the entire clause. It is this latter view which we adopt here. It has always been the received view within Discourse Representation Theory. (See e.g. Kamp (1981), Kamp & Rohrer (1983), Partee (1984), Eberle (1992)).

An analysis along these lines must acknowledge events – and by the same token also processes and states – as part of its ontology. Precisely what these different sorts of entities are like is, as we said above, an important ontological question, but one that we need not settle for present purposes. The recognition that there are such entities and that it is they that complete clauses should be seen as attributions to, is all we require here.

We have seen that the attributees of nouns can be all manner of things. In particular, when the noun is derived from a verb through nominalization, the attributee can be, as we just saw, an eventuality. With prepositional phrases we find comparable variety: When a prepositional phrase acts as an adjunct to a clause, as in *Er küßte sie bei der Kirche* (he kissed her near the church) the entity to which it presents an attribution is the implicit event which the clause describes. When the phrase attaches to an NP, as in *das Haus bei der Kirche* (the house near the church), the attributee is whatever it must be in view of the governing noun; in the present case

it must be a building, but by changing the noun *Haus* we could force the attributee to be of almost any sort. Therefore, if thematic roles are assigned to the complements of prepositions, then it follows that the domains of such role functions can include besides eventualities also “ordinary” objects (such as houses, persons, etc.). For present purposes, however, this issue may be ignored. For we will concentrate here exclusively on the roles corresponding to the argument phrases for verbs.

(ii) What are the values of thematic roles? In the examples we have so far encountered, the values of roles were persons and other physical things. However, here too there is no absolute limitation on the kinds of things that may turn up as values of role functions; in particular, they may be – besides the things that would qualify as individuals in most ontological schemes – also places, times, states or events. What kind of entity a given role can assign to the referent of a given attribution is usually narrowly limited by the attribution – in this respect role values are subject to the same kinds of constraints as the attributees themselves.<sup>2</sup>

(iii) Are thematic roles total or partial functions? The answer to this question can be brief: Thematic roles are partial. Some verbs (e.g. *fallen* (to fall)) involve themes but no agents, others (e.g. *lächeln* (to smile)) involve agents but no themes, and so on. Indeed, roles are very partial; by and large, the fact that a role is defined for a given attribution is to be seen as positive information associated with the type of attribution in question, not as a default assumption that can be relied on so long as it is not explicitly denied.

The justification for thematic roles, we said, is to be found in the systematicity they enable us to introduce into that part of the lexicon which codifies the logical connections between lexical concepts, and which thereby mediates the inferential relations between sentences in which these concepts are expressed. Is this justification enough? Could we not codify the possible inferences between actual sentences just as effectively by reference to the linguistic arguments of the words which do express the relevant concepts? For instance, could we not, instead of saying that it is the theme which

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<sup>2</sup> An important complication arises in connection with the use of plurals. In a sentence such as *Fritz legte die Bücher auf den Tisch* the theme is not a single physical object (such as a book, say) but the collection of books denoted by the phrase *die Bücher*. In general, the possible types of entities that can act as role values must be extended from atomic to non-atomic entities of the ontological lattice first described by Link (1983).

changes position in an event of motion, adopt the principle that it is the referent of the subject of the motion verb – *fall*, or (intransitive) *move* or *drive* or *fly*, etc. – which undergoes the change of position? Well, we could, but it would seem to lose us a significant generalization. For not all motion verbs are intransitive. For instance, the last three verbs just quoted all have a transitive as well as an intransitive use. And when they are used transitively it is not the subject's but the direct object's referent which changes position as a matter of general necessity.<sup>3</sup> One way to capture the systematic connection between the events described by verbs of motion and the entities that those events are described as motions of is to say that the entity is always the theme of the motion event, and that the theme manifests itself grammatically as the subject of intransitive and as the direct object of transitive motion verbs.

Of course, there may well be other ways in which this connection could be made explicit. So what we just said is no conclusive argument in favour of thematic roles. The basic motive we have, however, for thinking of thematic roles in the way we are proposing does not depend on issues of theoretical economy. It is the intuition that the existence of something that changes position is an intrinsic part of any event that could be called a motion. It is in the very nature of such events that they always have a participant for which this is true, irrespective of precisely how the clause that we use to describe such an event is structured grammatically – i.e. independently of what types of arguments come with the verb (optionally or obligatorily), and how those arguments are realized (that is, with what case or with which preposition).

We have adopted the position that thematic roles are (partial) functions. In this we are in agreement with a great many linguistic theories which use some concept of thematic role. But are they really functions? What grounds do we have for thinking that with each eventuality of a given type there is associated at most one theme, say, or at most one agent? At this point we are in no position to defend this assumption. As the lexical theory we will present in this and subsequent articles unfolds, it will become

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<sup>3</sup> The subject may change position too, as it usually does in the case of *drive* or *fly*. But this is a special property of those particular verbs. With transitive *move* there is in general no implication that the subject changes location. For instance you can, using a pole, move a toy boat from one end of a pool to the other without moving yourself one inch away from your starting position. Likewise, with *fly* the implication of subject motion is not universal, as can be seen in *Fred flew his kite on Primrose Hill*.

clear why and in what sense the assumption is justified. We will see, however, that the assumption must be qualified in certain ways. Two of these we do well to mention at this point.

First, suppose that the NP which occupies a particular argument position of the main verb of some clause may denote a set of individuals (for instance, the NP could be a plural definite description). Then the corresponding thematic role will in the first instance assign the denoted set as value. But often, when the verb has a distributive reading with respect to the given argument position, each of the members of the set will stand in the same role relation to *e* (or stand in that relation to some corresponding part event of *e*). For instance, in the sentence

- (3) Die Firma sandte die Raketen in den Irak.  
(The firm sent rockets to Iraq.)

the NP *die Raketen* identifies the theme of the motion event *e* described by (3) – it is the set of rockets which is moved (to Iraq). The same thing seems to be true of each of the individual rockets in the set – each of them was sent to Iraq. Thus, by parity of reasoning each of the individual rockets would seem to qualify as a theme of *e* in its own right.

We wish to resist this conclusion and insist that only the *set* of rockets is a theme of the event described in (3). From the fact that this set is the theme of *e* it may be inferred to have moved to Iraq. The further conclusion that this is equally true of each individual rocket then follows from this first conclusion by virtue of an additional principle, one that relates to the fact that the verb *senden* (to send) is distributive with respect to its theme argument. (You can't move a set of physical objects without moving each of the objects in it.)

The second qualification is connected with verbs such as *heilen*. When the verb *heilen* is used as in (1)

- (1) Der Arzt heilte den Patienten von seiner Krankheit.  
(The doctor cured the patient of his disease.)

there are two NPs which appear to qualify as themes. For it is true both of the patient and of the disease mentioned in (1) that they undergo changes which are necessary parts of the complex event which (1) describes: The patient changes from sick to healthy, and the disease which afflicted him from existent to non-existent. We will assume therefore that events described by *heilen* involve two distinct theme roles, Theme<sub>1</sub> and Theme<sub>2</sub>. The subscripts “<sub>1</sub>” and “<sub>2</sub>” reflect a general conjecture to the effect that when a



concept allows for more than one theme-like role, these roles are arranged in a certain hierarchy. It is generally the first member of this hierarchy, the Theme<sub>1</sub>, which can be realized as the subject of a verb expressing some concept cognate to the given one. For instance, the Theme<sub>1</sub> of transitive *heilen* can be realized as the subject of the verb *gesundeten*; but there appears to be no verb standing in a similar relation to *heilen* with the Theme<sub>2</sub> as subject (In particular, one can say neither *Die Grippe heilte* nor *Die Grippe gesundete*.)

### 3. Semantic and syntactic components of lexical entries

As we have characterized thematic roles, their significance is logical and semantic. In accordance with this intuition we will write information concerning the roles connected with a lexical item into the semantic component of its lexical entry. At the center of this component is what we will call a *concept*. Formally, a concept acts as a predicate with one or more arguments. One argument, the so-called *referential* argument, has a special status. It is the entity that qualifies as the referential argument of a concept that can be said to *instantiate* or *realize* it. We saw in the last section that for concepts expressed by nouns or adjectives the referential argument is an entity that belongs to what is traditionally called the *extension* of the adjective or noun; when the concept is expressed by a verb, the argument is, we have argued, an eventuality.<sup>4</sup>

Besides a referential argument many concepts have certain additional arguments. We assume that each non-referential argument  $a_i$  of a given concept  $C$  is related to its referential argument via a fixed thematic role  $r_i$ . Whenever  $C$  is instantiated, i.e. when the concept's referential argument is instantiated by an entity  $a$ ,  $C$ 's non-referential arguments are instantiated as well, in such a way that each non-referential argument  $a_i$  is instantiated by the value which the role  $r_i$  assigns to  $a$ .

The semantic components of the entries for some verbs and adjectives which we will present in this article will contain not only specifications of the relevant concept  $C$  and the thematic roles of its arguments, but some

<sup>4</sup> With prepositions, we argued, the argument is sometimes an eventuality, viz. when the preposition is governed by a verb, while in other cases, when the preposition is governed by an adjective or noun, its referential argument is an entity from the extension of that noun or adjective. In this paper we will restrict attention to concepts expressed by words belonging to these four categories.

other information as well (pertaining e.g. to sortal restrictions on the arguments of C). As a matter of fact, we have made no serious attempt to make the semantic components of these entries complete. For instance, they ought to contain, besides what we have written into them here, also information concerning aspect, indexicality, distributivity, etc.<sup>5</sup>

A lexical item not only has a semantic content. It also has its phonological and orthographical shape. Moreover, its non-referential arguments are realized in morphologically specific ways – for instance, they appear with a certain case marking or are governed by a particular preposition. This information will make up the *syntactic* component of the lexical entry. It is crucial that the syntactic and the semantic component of a lexical entry be properly correlated. For otherwise the DRS construction algorithm, to which only syntactic information is directly accessible, will not be able to introduce the contents of the semantic component correctly into the DRS. (This will become clearer in Appendix 1.)

Correlation of the syntactic and the semantic component is complicated by the circumstance that their argument sets often do not match. Consider again the German verb *heilen*. We will denote the central concept of the semantic component for *heilen* as “HEILEN”. The instantiations of this concept are processes of recovery – processes which consist in some organism (or alternatively some organism’s part) recovering from some ailment. Careful reflection on the nature of such processes shows that it is reasonable to assume (in line with what we suggested earlier) that the concept HEILEN has besides its referential argument two others, each of which stands to the referential argument in a theme-like role relation. (As said, we refer to these roles as Theme<sub>1</sub> and Theme<sub>2</sub>). Intransitive uses of *heilen* do not syntactically realize the Theme<sub>2</sub> argument. It is not just that they do not have to; they aren’t able to. For while (4.i), without explicit realization of this argument, is fine, (4.ii), which attempts to realize it, is out.

- (4) (i) Der Fuß heilte.  
(The foot healed.)
- (4) (ii) Der Fuß heilte vom Knochenkrebs.  
(The foot healed of the bone cancer.)

<sup>5</sup> It is often not easy to decide what information should be included. Often the decision will depend on the particular purpose or purposes which the given lexicon is to serve. In large part the difficulties one encounters in making such decisions relate to a well-known and irksome problem: Where is the line between linguistic and extra-linguistic knowledge?

As this example shows, a lexical entry for the *heilen* of (4.i) must (i) make explicit that instantiations of the corresponding concept HEILEN always involve two participants, the participant that gets better and the ailment that he gets rid of, and (ii) make explicit that the second participant may not be realized syntactically. This lexical entry will thus consist of a semantic component which specifies two arguments (for the concept HEILEN) and a syntactic component licencing only one argument phrase for the verb *heilen*. Moreover, the syntactic component will have to specify how the licenced argument is syntactically realized, viz as subject phrase, with nominative case. Finally, the two components must be correlated in such a way as to make clear that the one syntactic argument corresponds to the first participant (the one that recovers) and not to the second.

We have found it convenient to present the syntactic argument structure of a given verb and the correspondence between this structure and the semantic arguments mentioned in the semantic part of the entry in the following form: The syntactic arguments are listed in their natural, unmarked order (that is, in the left-to-right order in which they appear in an unmarked clause.<sup>6</sup> Each item in this list consists of: (i) the generalized case information concerning the (syntactic) argument phrase; and (ii) the thematic role of the concept argument realized by that phrase. There are various ways in which what we have referred to as “generalized case information” could be represented. The representation for which we have opted is due to Haider (1993). The principles underlying this representation are the following:

- (1) With each verb is associated a given set of so-called *theta roles*  $\theta$ . These theta roles are arranged in a fixed hierarchy, the *theta-hierarchy*. When the verb is used as head of a clause, all or some of its theta roles are assigned to the argument phrases accompanying it; in those cases where not all roles are assigned, the set of those that are assigned must form an initial segment of the theta hierarchy.

<sup>6</sup> In certain languages, such as in particular German, the syntactic components of verb entries must also specify the natural order (“Grundstellung”) in which the arguments appear in the clause. Frey (1993) supplies substantial evidence that among the possible orders in which the arguments of a given verb may be arranged there always is one “unmarked” order. When the arguments appear in this order, their scope relations are fully determined by their actual positions; marked argument orders always imply scope ambiguities.

- (2) Those argument phrases which get assigned a theta role also get assigned a particular *case* (Nom, Acc, etc.). The mechanism of case assignment is assumed to directly involve so-called “case-indices”, usually denoted as  $f_1, f_2, f_3, \dots$ . We will make the simplifying assumption that these case indices are fully identifiable in terms of the cases they assign, so that we may refer to them with the names of those cases, i.e. as “Nom”, “Acc”, “Dat”, or, where the argument phrase is a prepositional phrase, by the combination of preposition and the case of the NP it governs. Case assignment is partially determined by the theta hierarchy in that the argument phrase which bears the highest theta role (in the sense of this hierarchy) always gets nominative case.

The notation we adopt exploits these principles as follows. The syntactic component of a verb entry specifies the set of theta roles associated with the given use of the actual verb. Moreover, it associates with each theta role (a) a corresponding case assigner and (b) a thematic role; this role is one of the thematic roles of the concept which the verb expresses. The association of theta role and thematic role is the interface between the arguments of the concept expressed by the verb and the phrases denoting them in the sentence. Thus the entry for *heilen* instantiated in (4.i) will have the following form (5):

- (5) *heilen*  $\{\langle \theta_1, f_1 \rangle\}$   
 e: HEILEN( $y_{th1}, z_{th2}$ ) Theme<sub>1</sub> Theme<sub>2</sub>

In this as in all following entries the upper part constitutes the syntactic and the lower part the semantic component. The syntactic component is to be read in the following way. The verb in question, *heilen*, occurs on the left. It is followed by the different argument phrases which are syntactically realized by the verb and which correspond to arguments of the corresponding concept. In the present instance there is just one such argument. Syntactically it is realized with nominative case, here indicated by the case index  $f_1$ . The denotatum of this phrase plays the thematic role of Theme<sub>1</sub>; this role is mentioned directly underneath, in the tier reserved for the semantic component.

For the time being we identify the case indices  $f_i$  with particular morphological case markers, such as Nom(inative), Acc(usative), Dat(ive), *von* + Dat(ive), etc. Upon this identification (5) comes to look like (6):

- (6) *heilen*  $\{\langle \theta_1, \text{Nom} \rangle\}$   
 e: HEILEN( $y_{th1}, z_{th2}$ ) Theme<sub>1</sub> Theme<sub>2</sub>

Let us consider one more entry, this one for the transitive verb *essen*, as it appears in

- (7) Fritz aß einen Kuchen.  
(Fritz ate a cake.)

In (7) we find two non-referential arguments, one having the role of Agent and the other that of Theme. Accordingly the lexical entry for this use of *essen* looks like (8):

- (8) *essen*                                    {d< $\theta_1$ , Nom>, (< $\theta_2$ , Acc>)}<sup>7</sup>  
e: ESSEN( $x_{ag}$ ,  $y_{th}$ )                    Agent            Theme

There is one aspect of this entry that needs explaining. The second argument, marked as < $\theta_2$ ,  $f_2$ >, is placed within parentheses. This is to indicate that the argument is syntactically optional, i.e. that there is besides the use of *essen* exemplified in (7) also one in which this argument is absent. (9) is an instance of this intransitive use of the verb.

- (9) Fritz aß trotzdem.  
(Fritz ate nevertheless.)

Since the agent role is always realized,<sup>8</sup> the corresponding argument phrase in (8) is without parentheses.

#### 4. Selectional restrictions

We saw in the last section that the intransitive use of *heißt* is restricted insofar as it does not allow explicit syntactic realization of the semantic role we labelled Theme<sub>2</sub>. This is not the only restriction that such uses are subject to. There are also limits on what sorts of things can play the role of Theme<sub>1</sub>. Consider for instance the contrast between the acceptable (10.i) and (10.iv) and the unacceptable (10.ii) and (10.iii):

<sup>7</sup> The “d” in front of “< $\theta_1$ , Nom>” indicates that the argument represented as < $\theta_1$ , Nom> is the *designated argument* of the given clause. The distinction between designated and non-designated arguments is important in connection with certain lexico-syntactic rules such as the one which forms passive verb forms out of active ones. (See Haider (1993), Frey (1993)). Since such rules are not discussed in this report, the reader may ignore the d.

<sup>8</sup> Except in constructions such as agentless passives and middles; but that is a different story.

- (10) (i) Der Fuß heilte. (= (4.i))  
 (ii) Der Kleiderschrank heilte. (The wardrobe healed.)  
 (iii) Der Patient heilte. (The patient got better.)  
 (iv) Die Wunde heilte. (The wound healed.)

In fact, the descriptively correct generalization appears to be that the subject of intransitive *heilen* must denote either (a) a bodily part (as in (10.i)) or else (b) a lesion (as in (10.iv)). We will ignore the (b) case for now (we will return to it in section 9) and concentrate on the differences between (10.i), (10.ii) and (10.iii).

As we see it, the infelicity of (10.ii) derives from the nature of the concept HEILEN: The processes instantiated by this concept are processes of regeneration that are specific to (living) organisms – only an organism is the sort of thing that can undergo such a process. A wardrobe is not. It is an artefact. Artefacts share with organisms the possibility of being in bad as well as in good shape. But the processes by which they can change from bad shape to good are not of the same kind as those which turn unhealthy organisms into healthy ones. Artefacts can't heal, they can only be *fixed*. Thus the selectional restriction on *heilen* which excludes entities other than organisms or their parts as denotata of the verb's subject is one which follows from the fact that intransitive *heilen* expresses the concept HEILEN. In a fully developed concept lexicon, which makes all semantic and logical connections between HEILEN and other concepts (among them in particular the concepts ORGANISM and ARTEFACT) explicit, this restriction should be either available as an axiom or else derivable as a theorem. In the minute lexicon fragment which we develop in this paper we will be content to encode such restrictions directly into the lexical entry for *heilen*. Since the restriction to organisms and their parts relates to the concept HEILEN, we will enter it into the entry's semantic component.

The restriction illustrated by (10.iii) is one of a quite different sort. This is not a restriction connected with the concept expressed, but one related, in a way that we have not yet been able to see as anything but idiosyncratic, to its particular lexical realization by the German verb *heilen*. An indication of the idiosyncratic nature of this restriction is that the counterparts of *heilen* in certain other languages are not subject to it. For instance, neither French *guérir* nor Dutch *genezen* are subject to it. Such interlingual comparisons also point up the difference between the present restriction and the one discussed in the preceding paragraph: The restriction manifest in (10.ii) appears to hold across the board – it applies to *guérir*

and *genesen* no less than to *heilen*. This is indeed what we would expect if each of these verbs expressed the concept HEILEN, and if it were the concept to which the restriction in the first instance applies. By the same token the fact that the cited German, French and Dutch verbs do not behave in the same way with respect to the restriction shown by (10.iii) is an indication that this restriction is not a restriction on the designated concept.

Since this last restriction on *heilen* is independent of the concept expressed, it will be entered into the syntactic component of *heilen*'s lexical entry.

(11)	<i>heilen</i>	{<θ <sub>1</sub> , Nom>}	
		*organism(i) <sup>9</sup>	
	e: HEILEN(y <sub>th1</sub> , z <sub>th2</sub> )	Theme <sub>1</sub>	Theme <sub>2</sub>
		SEL RESTR	SEL RESTR
		organism	ailment
		or <b>body part</b>	or disease

Compare (11) with (11.i), the entry for German *gesund*, as it occurs in (11.ii):

(11.i)	<i>gesund</i>	{<θ <sub>1</sub> , Nom>, <θ <sub>2</sub> , von + Dat>}	
		*body part(i)	
	e: HEILEN(y <sub>th1</sub> , z <sub>th2</sub> )	Theme <sub>1</sub>	Theme <sub>2</sub>
		SEL RESTR	SEL RESTR
		<b>organism</b>	<b>ailment</b>
		or body part	or <b>disease</b>

(11.ii) Der Patient gesundete von der Grippe.

## 5. Causativization

We have seen that *heilen* has transitive as well as intransitive uses. A typical example of the former is found in the following sentence.

- (12) (i) Der Arzt heilte den Patienten von der Krankheit.  
(The doctor cured the patient of the disease.)

<sup>9</sup> Such idiosyncratic restrictions are stated as exclusion conditions. They will always be marked with a \*. The i in parentheses is meant to point at the idiosyncratic nature of the restriction.

In Section 3 we argued that the direct object of (1) represents the Theme<sub>1</sub> and the *von* phrase the Theme<sub>2</sub>. But what about the subject? Intuitively the subject of (12.i) denotes the individual who *brought about* the cure – the individual whose action caused a process of the kind described by intransitive *heilen* and by *gesund*, in other words, a process of type HEILEN.

This is how we will analyze transitive uses of *heilen*: They denote complexes consisting of a certain action performed by the subject, which causes a process of type HEILEN the participants of which are identified by the other argument phrases. (In the case of (12.i) these are the direct object and the *von* phrase.) Thus (12.i) denotes a complex event consisting of an action by one person (the doctor) bringing about another event, the recovery of some other individual (the patient). The role played by the denotation of the grammatical subject of (12.i) is traditionally referred to as *Agent*. We adopt this term. However, in cases like the present one, where the sentence describes a complex consisting of an action which causes a process, the Agent role will be directly defined on the causing action, and only derivatively on the entire complex.

We represent the conceptual part of the lexical entries for transitive *heilen* just as we have informally described it: It is to be a *causal complex* *ec* consisting of an event *e'* bringing about a process *e* of the kind denoted by the underlying intransitive verb. As a first approximation the representation is of the form (13).

(13)	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px 10px;"><i>e'</i></td> <td style="padding: 2px 10px;"><i>e</i></td> </tr> <tr> <td colspan="2" style="border-top: 1px solid black; padding: 2px 10px;"><i>e'</i> CAUSE <i>e</i></td> </tr> <tr> <td colspan="2" style="padding: 2px 10px;">Agent(<i>e'</i>) = <i>x</i></td> </tr> <tr> <td colspan="2" style="padding: 2px 10px;"><i>e</i>: HEILEN(<i>y</i><sub>th1</sub>, <i>z</i><sub>th2</sub>)</td> </tr> </table>	<i>e'</i>	<i>e</i>	<i>e'</i> CAUSE <i>e</i>		Agent( <i>e'</i> ) = <i>x</i>		<i>e</i> : HEILEN( <i>y</i> <sub>th1</sub> , <i>z</i> <sub>th2</sub> )	
<i>e'</i>	<i>e</i>								
<i>e'</i> CAUSE <i>e</i>									
Agent( <i>e'</i> ) = <i>x</i>									
<i>e</i> : HEILEN( <i>y</i> <sub>th1</sub> , <i>z</i> <sub>th2</sub> )									
ec:									

(13) is to be read as saying that *ec* is an event which consists in some event *e'* causing some process *e*, where moreover *e* is a process that instantiates the concept HEILEN. *ec* has three obligatory participants, the Agent of the causing event *e'*, and the two arguments, Theme<sub>1</sub> and Theme<sub>2</sub> of the caused process *e*. As we said in the last paragraph, the role of Agent which is defined directly on the causing event *e'* will be regarded as defined derivatively for the entire complex *ec*. We will adopt this same convention also in relation to the two other roles represented in (13), Theme<sub>1</sub> and Theme<sub>2</sub>. They are directly defined only on *e*, but indirectly also on *ec*.

(13) is only a first approximation to the conceptual entry for transitive *heilen* because of the following notorious problem. (This problem has frus-



trated attempts to account for the meaning of lexicalized causatives in terms of their intransitive counterparts since the early seventies; at the time it constituted one of the major stumbling blocks to generative semantics.) The meaning of transitive *heilen*, like that of its English counterpart *cure*, is not just that someone causes someone to get better. Suppose for instance that some irresponsible doctor has given one of his patients up for dead and that his ostentatious neglect produces in her a fury, and with it a will to live, which turn her around, so that eventually she recovers.

In this case it would be correct to say that the doctor's behaviour caused the patient to get better. But it would be stretching matters to say that he had cured her.

This is a quite general problem arising with *lexicalized causatives*. By a *lexicalized causative* we will understand any lexical verb which describes event complexes of the kind represented in (13), consisting of an action or event causing a process of some given type. As a rule the causal relation between action  $e'$  and process  $e$  which such lexical causatives describe is not just any causal relation; the verb requires that this relation be of a special "direct" and/or "intended" kind. It has proved extremely difficult to articulate what distinguishes the causal relations which are implied by lexicalized causatives from causal relations in general and we have nothing to offer on this point. We will simply assume that each causative verb  $V$  involves some relation  $R$  between  $e'$  and  $e$  which entails that  $e'$  caused  $e$  and that this relation is uniquely determined by  $V$ . We denote this relation as  $\text{CAUSE}_V$ .<sup>10</sup>

In the light of this observation it is necessary to replace schema (13) by something like (13')<sup>11</sup>:

<sup>10</sup> For many process verbs  $V$  there are corresponding lexical causatives  $V'$ , in the sense that the first verb describes processes of some type  $C$  and the second verb describes complexes to the effect that some action causes a process of type  $C$ . The notation  $\text{CAUSE}_V$  implies that there never exist, for any given process verb  $V$ , two corresponding causatives  $V'$  and  $V''$ , which both express that the agent caused the process instantiating  $C$ , but where the causal relations are distinct. We are not absolutely certain that this situation does not arise, but so far we are not aware of any examples of this sort.

<sup>11</sup> That (13') is to replace (13) as core of the conceptual component of the entry for transitive *heilen* does not mean, however, that (13) is to be regarded as superfluous. (13) will still serve to characterize the meaning of non-lexicalized causatives, i.e. of compounds such as German *machen, daß y von x gesundet* or alternatively *y's Gesundheit von x verursachen* (= "cause the cure of  $y$  from  $z$ ").

(13')

ec:	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; padding: 2px 5px;"><math>e'</math></td> <td style="border: 1px solid black; padding: 2px 5px;"><math>e</math></td> </tr> <tr> <td colspan="2" style="border: 1px solid black; padding: 2px 5px;"> <math>e'</math> CAUSE<sub><i>heilen</i></sub> <math>e</math>  Agent(<math>e'</math>) = <math>x</math>  <math>e</math>: HEILEN(<math>y_{th1}, z_{th2}</math>) </td> </tr> </table>	$e'$	$e$	$e'$ CAUSE <sub><i>heilen</i></sub> $e$ Agent( $e'$ ) = $x$ $e$ : HEILEN( $y_{th1}, z_{th2}$ )	
$e'$	$e$				
$e'$ CAUSE <sub><i>heilen</i></sub> $e$ Agent( $e'$ ) = $x$ $e$ : HEILEN( $y_{th1}, z_{th2}$ )					

Concepts which we represent as “CAUSE<sub>V</sub>”, where V is some verb are all causal relations and thus entail the general relation of causation CAUSE. So we have axiom scheme (14).

(14)

<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; padding: 2px 5px;"><math>e_1</math></td> <td style="border: 1px solid black; padding: 2px 5px;"><math>e_2</math></td> </tr> <tr> <td colspan="2" style="border: 1px solid black; padding: 2px 5px;"><math>e_1</math> CAUSE<sub>V</sub> <math>e_2</math></td> </tr> </table>	$e_1$	$e_2$	$e_1$ CAUSE <sub>V</sub> $e_2$		⇒	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; padding: 2px 5px;"><math>e_1</math> CAUSE <math>e_2</math></td> </tr> </table>	$e_1$ CAUSE $e_2$
$e_1$	$e_2$						
$e_1$ CAUSE <sub>V</sub> $e_2$							
$e_1$ CAUSE $e_2$							

(14) is one of many general principles which support the conceptual framework underlying our lexicon. We assume that this framework, or at any rate a large part of it, is given in the form of an axiomatic theory, to which we refer as LT (for “lexical theory”) (14) should be seen as one of the axioms of the lexical theory LT. In the course of this and the following sections we will encounter several others.

Natural languages have various devices for expressing causative concepts. Sometimes, as in the case of *heilen*, the very same verb is used to describe processes of a certain type (the intransitive use) and causal complexes involving caused processes of this type (the transitive use). Sometimes causative verb and process verb stand in some close phonological relationship, as do *sitzen* and *setzen* (to sit and to put) or *liegen* and *legen* (to lie and to lay). In addition, many languages contain regular constructions which transform intransitive process verbs into transitive verbs or verb complexes. Thus German uses the verb *lassen*, as in *fliegen lassen* (to fly); English has the verbs *let* and *make* for this purpose. Such causative constructions seem to be associated with uniform causal relations.

Transitive *heilen* can occur with various combinations of argument phrases. Besides (12.i) we find for instance

- (12) (ii) Der Arzt heilte den Patienten.  
(The doctor cured the patient.)
- (iii) Der Arzt heilte die Grippe.  
(The doctor cured the flue.)

Since the lexical entry of a verb must specify which roles are realized and how (i.e. with which case marking and/or preposition), we cannot make

do with a single entry for the three uses of *heilen* that are found in (12.i) and (12.ii, iii). Our notation for optional arguments (see (11.i)) enables us to account for the uses in (12.i) and (12.ii) in a single entry. But (12.iii) requires an entry of its own, which must make explicit that Theme<sub>2</sub> is realized as direct object and that Theme<sub>1</sub> cannot be realized at all. To conclude this section we present these two entries for transitive *heilen*.<sup>12</sup>

(15)	(i)	<i>heilen</i>	{d<θ <sub>1</sub> , Nom>, <θ <sub>2</sub> , Acc>, (<θ <sub>3</sub> , von +; Dat>)}																							
		<table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <td>e'</td> <td>e</td> </tr> <tr> <td colspan="2">ec: e' CAUSE e</td> </tr> <tr> <td colspan="2">Agent(e') = x</td> </tr> <tr> <td colspan="2">e: HEILEN(y<sub>th1</sub>, z<sub>th2</sub>)</td> </tr> </table>	e'	e	ec: e' CAUSE e		Agent(e') = x		e: HEILEN(y <sub>th1</sub> , z <sub>th2</sub> )		<table border="0" style="display: inline-table; vertical-align: middle;"> <tr> <td>Agent</td> <td>Theme<sub>1</sub></td> <td>Theme<sub>2</sub></td> </tr> <tr> <td>SEL RESTR</td> <td>SEL RESTR</td> <td>SEL RESTR</td> </tr> <tr> <td>capable of</td> <td><b>organism</b></td> <td><b>ailment</b></td> </tr> <tr> <td>an intention</td> <td>or <b>body part</b></td> <td>or <b>disease</b></td> </tr> <tr> <td>to cure</td> <td></td> <td></td> </tr> </table>	Agent	Theme <sub>1</sub>	Theme <sub>2</sub>	SEL RESTR	SEL RESTR	SEL RESTR	capable of	<b>organism</b>	<b>ailment</b>	an intention	or <b>body part</b>	or <b>disease</b>	to cure		
e'	e																									
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to cure																										
(15)	(ii)	<i>heilen</i>	{d<θ <sub>1</sub> , Nom>, <θ <sub>2</sub> , Acc>}																							
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e'	e																									
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Agent	Theme <sub>1</sub>	Theme <sub>2</sub>																								
SEL RESTR	SEL RESTR	SEL RESTR																								
capable of	organism	<b>ailment</b>																								
an intention	or body part	or <b>disease</b>																								
to cure																										

## 6. Some meaning postulates relating to the concept HEILEN

In the last section we encountered in (14) a first specimen of the many different postulates which make up the lexical theory LT. Many of these postulates have a form reminiscent of the *meaning postulates* discussed in the philosophical literature on lexical meaning; this is the term by means of which we will often refer to such postulates too. In this section we look at a couple of such meaning postulates which directly concern the concept HEILEN. The first pair captures the intuition that the processes denoted by HEILEN are intrinsically changes in one of their principal participants (to which we will refer in this paragraph as “the theme” of the process) changes which lead from the condition of suffering from some ailment to the condition of not suffering from it. More generally, for a substantial class of process concepts C there are corresponding state concepts P such that the processes instantiating C can be described as processes of the theme “becoming P”. (We make no attempt here to characterize this class in in-

<sup>12</sup> For a complete list of the lexical entries we propose in this, see Appendix 2.

dependent terms).<sup>13</sup> For each process concept *C* in this class we denote the associated property *P* as *RES(C)*. *RES(C)* is such that any process instantiating *C* yields a result state which consists in the process's theme instantiating *RES(C)*. Formally *RES(C)* is a concept with a referential argument, which is always a state of affairs, and one non-referential argument, which, in the cases of instantiation that matter here, is always the theme of a process instantiating *C*.

To speak blandly of “the theme” won't quite do. For sometimes, as we have seen in the case of *HEILEN*, a concept has more than one argument playing a theme role. Where this is so, the result state may involve more than one of these roles. In the case of *HEILEN*, for instance, the result state consists in the *Theme<sub>1</sub>* no longer having the *Theme<sub>2</sub>*; or, as we will put it, the *Theme<sub>2</sub>* is “separated” (in a sense appropriate to the concept *HEILEN*) from the *Theme<sub>1</sub>*.<sup>14</sup> Thus for *HEILEN* and a number of similar process concepts the result state consists in the two themes standing to each other in a certain relation. We represent this as (16):

(16) *s*: (*RES(HEILEN)*)(*Theme<sub>1</sub>*(*e*), *Theme<sub>2</sub>*(*e*))

<sup>13</sup> In the case of the concept *HEILEN* the property *P* is denoted by the adjective *gesund* (or by the now obsolete adjective *heil*). There are many process verbs for which the corresponding result state type is denoted by an adjective that stands in a very simple morphological relation to the verb, e.g. *grün* – *ergrünen*, *trocken* – *trocknen*, *bleich* – *erbleichen*. We note that the past participle of the process verb, *geheilt*, does not describe *RES(HEILEN)* quite as we intend it. See fn. 16.

<sup>14</sup> This would seem to be the point to mention a question which we have dodged so far: What is a “disease”? Are diseases “types”, such as typhoid, measles, pneumonia, etc., so that your pneumonia, say, and mine are instances of one and the same entity? Or are they “tokens”, so that your pneumonia and my pneumonia are two distinct items both falling under the concept *pneumonia*? We do not think that the ways in which the world *heilen* is used give any clear indication one way or the other. But of course, for the theory it will make some difference how the concept of a disease is construed. For instance, on the assumption that your disease is never the same as mine, getting better means that the *Theme<sub>2</sub>* is not only removed from the patient, but that it is actually destroyed. On the other conception, the disease merely withdraws from the patient in question, but survives in other, less fortunate individuals. The question appears to be somewhat different in connection with ailments that are not diseases – ailments such as cuts, bruises, burns, sores, etc. Here the identity conditions seem to be more clearly defined; and they seem to be of the token rather than the type variety: Surely your bruise is not the same as mine, not even if they are in the same place, feel much the same, etc. So, for the sake of uniformity we might go for the token account also in the case of diseases.

In general the state resulting from a process of a given type  $C$  will involve a relation between some selection  $u_1, \dots, u_n$  from the arguments of  $C$ :

$$(17) \quad s: (\text{RES}(C))(u_1, \dots, u_n)$$

We assume that each of the arguments of  $\text{RES}(C)$  plays a theme role in relation to  $C$ .

The principle that every process of type  $C$  results in a state of the corresponding result type is expressed in (18). (“ $\Rightarrow$ ”) denotes the relation of temporal abutment):

$$(18) \quad \begin{array}{|c|} \hline e \quad u_1 \dots u_n \\ \hline C(e) \\ u_1 = \text{Theme}_1(e) \\ \cdot \\ u_n = \text{Theme}_n(e) \\ \hline \end{array} \Rightarrow \begin{array}{|c|} \hline s_2 \\ \hline s_2: \text{RES}(C)(u_1, \dots, u_n) \\ \cdot \\ e)(s_2 \\ \hline \end{array}$$

Just as processes of the type HEILEN lead to certain result states, they presuppose certain types of states as preconditions. For instance, one cannot be cured of an ailment without having that ailment at the time when the process starts. We refer to the state type that is a precondition for the occurrence of a process of type  $C$  as  $\text{PRE}(C)$ . In general, this type is just the contrary of the result state type.

$$(19) \quad s: \text{PRE}(C)(u, v) \Leftrightarrow s: \neg \exists \text{RES}(C)(u, v)$$

The principle that each process of type  $C$  presupposes that a state of type  $\text{PRE}(C)$  obtains when the process starts can be stated in the same way as the relation between  $C$  and  $\text{RES}(C)$ , see (20):

$$(20) \quad \begin{array}{|c|} \hline e \quad u_1 \dots u_n \\ \hline C(e) \\ u_1 = \text{Theme}_1(e) \\ \cdot \\ u_n = \text{Theme}_n(e) \\ \hline \end{array} \Rightarrow \begin{array}{|c|} \hline s_1 \\ \hline s_1: \text{PRE}(C)(u_1, \dots, u_n) \\ \cdot \\ s_1)(e \\ \hline \end{array}$$

We described the result states produced by processes instantiating HEILEN informally as the patient (or  $\text{Theme}_1$ ) having become separated from the ailment (or  $\text{Theme}_2$ ). This is a feature that HEILEN shares with a number of other concepts, among them the processes involved in the event complexes denoted by such causative verbs as *befreien*, (to free) *trennen* (to se-

parate), *entbinden* (to release, to deliver) and *säubern* (to clean). Indicative of this aspect of the result states of such processes is that when both of the arguments of the result state concept are syntactically realized as arguments of the process verb (or of the corresponding causative verb) then one of them – the Theme<sub>2</sub> – is realized as a prepositional phrase with *von* (Compare (12. i)).<sup>15</sup>

The concept RES(C) should not be misconstrued as implying that its instantiations are always the result of a process of type C. This is not what we intend. For instance, to be in a state characterizable as RES(HEILEN)(y, z) (where z is some disease, say typhoid) simply means that one does not have z. This is evidently a state that a person can be in without having reached it through being cured of z – he might never have had the disease in the first place. Similarly one can be in a state of the type PRE(C) without this leading to a process of type C. Thus someone can be in the precondition state for being cured of diabetes without such a process subsequently occurring: Having diabetes is (alas) anything but a guarantee that recovering from diabetes will follow.<sup>16</sup>

## 7. Using lexical entries in DRS-construction

As we said at the outset, lexical entries are needed among other things in the construction of Discourse Representation Structures, and it is this need that has been our guideline in the exploration of lexical structure. It may have become evident by now that we think of the lexicon's contributions to DRS construction as transitions from the kind of DRS conditions that were treated as irreducible in extant versions of DRT (such as e.g. in Kamp & Reyle (1993)) – conditions such as “e: x *heilen*”, where *heilen* is the German verb and e and x are discourse referents – to conditions that make reference to the corresponding concepts or conceptual structures.

<sup>15</sup> In the case of HEILEN the “separation” often comes about through the actual *disappearance* of the first entity – i.e. when the disease or infection from which the patient had been suffering ceases to be – but even with HEILEN this isn't always so; and the separations effected by processes described by other verbs – e.g. *befreien* or *trennen* – typically do not bring about the destruction of the *von*-object.

<sup>16</sup> It is for this reason that RES(HEILEN) is not correctly described by the participle *geheilt* (see fn. 13). *geheilt* implies not only that its subject is in the state in question, but also that this state was reached through a process of the type HEILEN. Thus it says too much to qualify as designator of the concept RES(HEILEN).

We will treat these transitions as insertions into the DRS  $K$  of appropriate “instantiations” of certain *schematic DRSs*; these schematic DRSs are supplied by the relevant lexical entries. The “instantiation” of a schematic DRS is effected by replacing some of the (*schematic*) discourse referents it contains by discourse referents belonging to  $K$ . Lexical entries such as those in (15) must deliver these schematic DRSs.

Let us see how this works for the comparatively simple entries for intransitive *heilen*. In the next section we will then tackle the more challenging problem of constructing DRSs for sentences that involve transitive uses of this verb. We begin by considering what is about the simplest possible problem of its kind, the construction of a DRS for the sentence (4. i).

(4) (i) Der Fuß heilte.

To obtain the DRS we want to construct we follow initially the DRS construction algorithm described in Kamp & Reyle (1993), chapter 5. This procedure has the virtue of introducing into the DRS (in order to account for the semantics of tense and aspect) the discourse referents for events and states which are also needed in the transition from DRS conditions containing lexical items to those containing conceptual structures. For (4. i) the procedure of Kamp & Reyle (1993) yields the DRS (21).

(21)

n e x
e < n der Fuß(x) e: x heilen

According to that procedure, however, (21) cannot be reduced any further. In order to obtain the representation we want, the condition “e: x *heilen*” must be processed further, so that the German predicate *heilen* is replaced by the appropriate conceptual structure. To this end we need a lexical entry for *heilen*. But which? For we have stated three entries for *heilen*, viz (11), (15. i) and (15. ii). Intuitively it is clear that it is (11) that we want, for the *heilen* in (4. i) is intransitive. But how is this fact really recognized? This is a problem we want to set aside for now. (It will be taken up in Appendix 1.) So let us assume, then, that it is the entry (11) that is to be used in the construction step which will modify the condition “e: x *heilen*”. We will describe this further construction step as involving a schematic DRS that is obtained from the lexical entry for *heilen*. The condition “e: x *heilen*” that is to be replaced in (21) is obtained from this schematic DRS by identifying

some of its (“schematic”) discourse referents with the discourse referents occurring in the condition, that is, with  $e$  and  $y$ . The condition set of the schematic DRS is obtained from the entry (11) by taking the conceptual part “ $e$ : HEILEN( $y_{th1}, z_{th2}$ )” from (11) and adding equational conditions “ $y = \text{Theme}_1(e)$ ” and “ $z = \text{Theme}_2(e)$ ” that express the thematic relations between the arguments of the conceptual part, as indicated in (11) by the subscripts on the variables. The universe of the structure is to consist of the discourse referents occurring in the conceptual part; we give them in bold face to indicate that they have the status of schematic discourse referents – what this means will be explained presently. In this way we obtain the structure (22).

(22)

<b>e</b>	<b>y</b>	<b>z</b>
<b>e</b> : HEILEN( <b>y</b> , <b>z</b> ) <b>y</b> = Theme <sub>1</sub> ( <b>e</b> ) <b>z</b> = Theme <sub>2</sub> ( <b>e</b> )		

To obtain the new conditions for (21) the discourse referents of (22) which correspond to discourse referents in the old condition “ $e$ :  $x$  *heilen*” must be identified with these. In the present case  $e$  corresponds with  $e$  and  $y$  with  $x$ . It should be intuitively clear that the “interface” components – i.e. the upper parts – of our verb entries play a crucial part in this determination. How, will be explained in Appendix 1.

Using these identifications the schematic DRS is now inserted in stead of the old condition, yielding DRS (23).<sup>17</sup>

(23)

<b>n</b>	<b>e</b>	<b>y</b>	<b>z</b>
<b>e</b> < <b>n</b> der Fuß( <b>y</b> ) <b>e</b> : HEILEN( <b>y</b> , <b>z</b> ) <b>y</b> = Theme <sub>1</sub> ( <b>e</b> ) <b>z</b> = Theme <sub>2</sub> ( <b>e</b> )			

<sup>17</sup> A construction algorithm that was fully worked out would replace the condition “der Fuß( $x$ )”, where *der Fuß* is still a predicate of German, by a condition involving a concept accessed by *Fuß*. Since we have not said anything about lexical entries for nouns, such as *Fuß*, we have no way of defining such conditions, and so we will have to make do with “conditions” like “der Fuß( $x$ )” or “Fuß( $x$ )”. All DRSs which we will construct in this paper will be provisional in this way.



The boldface **z** in (23) is an example of an *implicit discourse referent*. Implicit discourse referents act as *implicit arguments*. They are discourse referents which represent those arguments of the inserted conceptual structure that are not realized by noun phrases in the processed text. Implicit arguments are not available as antecedents for pronominal anaphora, as is shown for instance by the following example:

- (24) Der Fuß heilte schließlich. Es hatte den Patienten aber Monate lang geplagt.  
(Finally the foot healed. It had troubled the patient for months.)

Here *es* cannot be understood as referring to the ailment (*das Leiden*) which had been affecting the foot. (Compare this with the unproblematic

- (25) Der Fuß heilte schließlich. Er hatte aber Monate lang große Schmerzen bereitet.  
(Finally the foot healed. It had caused the patient much pain for months.)

where the pronominal reference to *der Fuß* is entirely unproblematic.)

The sketch we have given of how (21) is to be transformed into (23) begs a number of questions. First, we have said nothing about the problem of selecting the relevant lexical entry. Since the same word (in this case *heilen*) may have a number of distinct entries corresponding to different uses, this problem is non-trivial. Directly related to this problem is that of determining which discourse referents in the DRS that is to be transformed correspond to which schematic discourse referents in the schematic DRS that is supplied by the selected lexical entry. Both problems will be discussed in Appendix 1.

## 8. DRS construction for transitive *heilen*

We now come to the transitive uses of *heilen*. DRS construction for sentences containing such transitive uses represents a more interesting challenge than the construction considered in Section 7. First, there are, as we have seen, several lexical entries for transitive *heilen*, which differ from each other with regard to the question which conceptual arguments are syntactically realized. Also, the conceptual parts of these entries are, we saw (cf. (15.i)), more complex than the conceptual part of (11), which was used in the DRS construction of Section 7. For ease of reference we repeat the entry for the use of *heilen* exemplified in (12.i)

- (12) (i) Der Arzt heilte den Patienten von der Krankheit.  
(The doctor cured the patient of the disease.)
- (15) (i) *heilen*      {d< $\theta_1$ , Nom>, < $\theta_2$ , Acc>, (< $\theta_3$ , von + Dat>)}  

$e'$	$e$	Agent	Theme <sub>1</sub>	Theme <sub>2</sub>
ec:	$e'$ CAUSE <sub>heilen</sub> $e$	SEL RESTR	SEL RESTR	SEL RESTR
	$x = \text{Agent}(e')$	capable of	<b>organism</b>	<b>ailment</b>
	$e: \text{HEILEN}(y_{th1}, z_{th2})$	an intention	or <b>body part</b>	or <b>disease</b>
		to cure		

The use of (15. i) in DRS construction (such as, in particular, the construction of the DRS for (12. i)) involves a slight complication that we did not encounter when dealing with intransitive *heilen* in the last section. As in (22) we want to add equations which capture thematic relations that hold between the arguments of the conceptual part. One of these is the agent selection. As we noted when describing the entries for transitive *heilen* in section 5, we take this relation to connect the agent not just with one, but with two events, the complex event *ec* described by the transitive verb and its component event *e'*. It is in virtue of this correlation that we are able to pass from the condition “Agent(*e'*) = *x*” contained in the conceptual part of (15. i) to the condition “Agent(*ec*) = *x*”, which is to be indicated in the schematic DRS that is to be extracted from the entry and which will be needed to establish the correspondence between its schematic discourse referent *x* and the right discourse referent of a DRS into which the schematic DRS is to be incorporated. (Once again we refer to Appendix 1 for details.) Since the correlation between “*x* = Agent(*ec*)” and “*x* = Agent(*e'*)”, and similarly between “*y* = Theme<sub>1</sub>(*ec*)” and “*y* = Theme<sub>1</sub>(*e*)” and between “*z* = Theme<sub>2</sub>(*ec*)” and “*z* = Theme<sub>2</sub>(*e*)” – is assumed to be systematic, we can state this as part of our lexical theory LT. The relevant axioms are given as (26) and (27).

- (26) 

ec	$e'$	$e$
ec: $e'$ CAUSE <sub>heilen</sub> $e$		

 $\Rightarrow$ 

Agent( <i>ec</i> ) = Agent( <i>e'</i> )
---
- (27) 

ec	$e'$	$e$
ec: $e'$ CAUSE <sub>heilen</sub> $e$		

 $\Rightarrow$ 

Theme <sub>1</sub> ( <i>ec</i> ) = Theme <sub>1</sub> ( <i>e</i> )
--

To construct the DRS for (12. i) we proceed, as in the DRS construction for (4. i) above, by first applying the construction algorithm of Kamp & Reyle (1993). This yields the DRS (28).

(28)

n	ec	x	y	z
ec < n				
der Arzt(x) der Patient(y) die Krankheit(z)				
ec: x <i>heilen</i> y von z				

Again we set aside the question how the right lexical entry (i.e. (15.i)) is chosen and how the discourse referents *ec*, *x*, *y*, *z* are recognized as corresponding to the schematic discourse referents **ec**, **x**, **y**, **z**. (Cf. Appendix 1). Given these correspondences, we already know how to insert the schematic DRS determined by the conceptual part of (15.i) into (28). The result is (29).

(29)

n	ec	x	y	z												
ec < n																
der Arzt(x) der Patient(y) die Krankheit(z)																
<table border="1"> <tr> <td>e'</td> <td>e</td> </tr> <tr> <td colspan="2">e' CAUSE<sub>heilen</sub> e</td> </tr> <tr> <td colspan="2">x = Agent(e')</td> </tr> <tr> <td>ec:</td> <td>e: HEILEN(y, z)</td> </tr> <tr> <td></td> <td>y = Theme<sub>1</sub>(e)</td> </tr> <tr> <td></td> <td>z = Theme<sub>2</sub>(e)</td> </tr> </table>					e'	e	e' CAUSE <sub>heilen</sub> e		x = Agent(e')		ec:	e: HEILEN(y, z)		y = Theme <sub>1</sub> (e)		z = Theme <sub>2</sub> (e)
e'	e															
e' CAUSE <sub>heilen</sub> e																
x = Agent(e')																
ec:	e: HEILEN(y, z)															
	y = Theme <sub>1</sub> (e)															
	z = Theme <sub>2</sub> (e)															
x = Agent(ec)																
y = Theme <sub>1</sub> (ec)																
z = Theme <sub>2</sub> (ec)																

In (29) all discourse referents from the universe of the schematic DRS that gets inserted have been replaced by (non-schematic) discourse referents. Compare this case with the DRS corresponding to

(12) (iii) Der Arzt heilte die Grippe.

The use of *heilen* in this sentence corresponds to the lexical entry

(15) (ii) *heilen*

ec:	e'	e	{d < θ <sub>1</sub> , Nom >,	< θ <sub>2</sub> , Acc >}
	e' CAUSE <sub>heilen</sub> e		Agent	Theme <sub>1</sub>
	x = Agent(e')		SEL RESTR	SEL RESTR
	e: HEILEN(y <sub>th1</sub> , z <sub>th2</sub> )		capable of	organism
			an intention	or body part or <b>disease</b>

to cure

In (12.iii) the role of Theme<sub>1</sub> is not syntactically realized, so the corresponding schematic referent is not replaced. We obtain (30).

(30)

n	ec	x	y	z												
ec < n																
der Arzt(x) die Grippe(z)																
<table border="1" style="margin: 5px auto; border-collapse: collapse;"> <tr> <td style="padding: 2px;">e'</td> <td style="padding: 2px;">e</td> </tr> <tr> <td colspan="2" style="padding: 2px;">e' CAUSE<sub>heilen</sub> e</td> </tr> <tr> <td colspan="2" style="padding: 2px;">x = Agent(e')</td> </tr> <tr> <td style="padding: 2px;">ec:</td> <td style="padding: 2px;">e: HEILEN(y, z)</td> </tr> <tr> <td colspan="2" style="padding: 2px;">y = Theme<sub>1</sub>(e)</td> </tr> <tr> <td colspan="2" style="padding: 2px;">z = Theme<sub>2</sub>(e)</td> </tr> </table>					e'	e	e' CAUSE <sub>heilen</sub> e		x = Agent(e')		ec:	e: HEILEN(y, z)	y = Theme <sub>1</sub> (e)		z = Theme <sub>2</sub> (e)	
e'	e															
e' CAUSE <sub>heilen</sub> e																
x = Agent(e')																
ec:	e: HEILEN(y, z)															
y = Theme <sub>1</sub> (e)																
z = Theme <sub>2</sub> (e)																
x = Agent(ec)																
y = Theme <sub>1</sub> (ec)																
z = Theme <sub>2</sub> (ec)																

### 9. One phrase, two roles – *Die Wunde heilt*

In Section 4 we observed that the phrases which may fill the argument slots of particular verbs are often subject to selectional restrictions and that these restrictions are of two distinct kinds. On the one hand the concept which the verb expresses typically imposes constraints on the kinds of individuals that can play certain roles in the events, states or processes instantiating the concept. For instance, we noted that a wardrobe cannot be the Theme<sub>1</sub> of a healing process simply because it is not the kind of thing that can heal. Even less can it be the Theme<sub>2</sub> of such a process, for a wardrobe is not something that an organism can suffer from in the way one can suffer from an ailment or disease. On the other hand particular verbs are subject to restrictions which cannot be explained on the basis of the concepts they express – often this is shown by the fact that the restriction does not apply to another word (from the same or some other language) which is used to describe the same states, processes or events. Let us briefly review the restrictions of this second, word-specific kind which attach to intransitive *heilen*.

(i) The subject of *heilen* cannot denote a complete organism, though it may denote part of an organism. Thus (31.i) is bad, while (31.ii) is good

(31) (i) \*Der Patient heilte.

(31) (ii) Der Fuß heilte.

This is different in for instance French or Dutch, where all of the following are felicitous

- (32) (i) Le patient guérit. (The patient got better.)  
 (32) (ii) Le pied guérit. (The foot healed.)  
 (32) (iii) De patient genas. (The patient got better.)  
 (32.) (iv) De voet genas. (The foot healed.)

(In German, as we saw, a patient's getting better is expressed with the help of a lexical item distinct from *heilen*, viz. the verb *gesund*en.)

(ii) A curious restriction (but one which for all we know at this point holds across languages and so may have a conceptual foundation after all) is that while both Theme<sub>1</sub> and Theme<sub>2</sub> can be realized as direct objects of transitive *heilen*, only Theme<sub>1</sub> can occur as subject of intransitive *heilen*. Thus (33.i, ii, iii) are grammatical, while (33.iv) is not

- (33) (i) Der Arzt heilte den Fuß.  
 (33) (ii) Der Arzt heilte die Grippe. (= (12.ii))  
 (33) (iii) Der Fuß heilte. (= (4.i))  
 (33) (iv) \*Die Grippe heilte.

(iii) Another restriction of a somewhat similar nature is that intransitive *heilen* does not permit realization of Theme<sub>2</sub> as *von*-phrase. So while we have the transitive use represented by (34.i)),

(34) (i) Der Arzt heilte den Fuß vom Knochenkrebs.

the corresponding intransitive use

(34) (ii) Der Fuß heilte vom Knochenkrebs.

is not possible.

Two of these facts were already mentioned in Section 4, and all of them are formally accounted for by the lexical entries for *heilen* we gave in subsequent sections. We have repeated them here so as to provide the proper background for the data which will be the focus of this section, all of which concern the possibilities and impossibilities of combining the verb *heilen* with a complement phrase of the form *die Wunde*.

These are the empirical facts we will consider. First, note that one can say

- (35) (i) Die Wunde heilte.  
(The wound healed.)

In this respect *die Wunde* seems to behave like *der Fuß* (cf. (31. ii)). Another way in which *die Wunde* and *der Fuß* show parallel behaviour is that we can say neither (36. i) nor (36. ii)

- (36) (i) Der Arzt heilte den Patienten von seiner Wunde.  
(36) (ii) Der Arzt heilte den Patienten von seinem Fuß.

There are also distributional data, however, which point towards a similarity between *die Wunde* and phrases that denote diseases or other ailments. Thus (37. i–iii) are all deviant:

- (37) (i) Der Arzt heilte die Wunde von der Infektion.  
(The doctor cured the wound of the infection.)  
(37) (ii) Der Arzt heilte die Wunde von der Verletzung.  
(The doctor cured the wound of the injury.)  
(37) (iii) Der Arzt heilte die Wunde von der Verwundung.

The deviance of these sentences seems to parallel the impossibility of (38. i) and (38. ii)

- (38) (i) Der Arzt heilte die Krankheit vom Fieber.  
(The doctor cured the disease of the fever.)  
(38) (ii) Der Arzt heilte die Krankheit von der Infektion.  
(The doctor healed the disease of the infection.)

In contrast, (39. i, ii) seem to be good, certainly much better than (37) and (38)

- (39) (i) Der Arzt heilte den Fuß von der Infektion.  
(39) (ii) Der Arzt heilte den Fuß vom Fieber.  
(39) (iii) Der Arzt heilte den Fuß von der Verletzung.

As they stand, these facts seem to present a serious problem for our analysis of HEILEN as a concept involving the two distinct thematic roles Theme<sub>1</sub> and Theme<sub>2</sub>. For what *is* the role which *die Wunde* represents in each of the sentences in (35)–(39) that are good? On the one hand the parallel between (35) and (4. i) and that between (36. i) and (36. ii) suggest that the referent of *die Wunde* plays the role of Theme<sub>1</sub> in these sentences. On the other hand, that the sentences in (37) and (38) are bad whereas those in

(39) are fine suggests that wounds can play in relation to HEILEN only the role of Theme<sub>2</sub>.

The answer we propose to this dilemma is that NPs such as *die Wunde* – there are a few more nouns that give rise to NPs of this type, e.g. *Bruch, Schnitt, Geschwür* – do double duty; in the contexts we have considered they act simultaneously as representatives both of Theme<sub>1</sub> and of Theme<sub>2</sub>. Compare

(35) Die Wunde heilte.

with

(40) (i) Der verwundete Fuß heilte. (The wounded foot healed.)

(40) (ii) Der gesunde Fuß heilte. (The healthy foot healed.)

Of the last two sentences (40. i) is as good as (35. i), while (40. ii) is decidedly strange. The reason for the difference in acceptability between (40. i) and (40. ii) is this. The NP which describes the theme of a process of type C may describe this theme as being in a state in which it is when the process starts, but not as being in the state it is in when the process has been completed; in other words, it may describe the theme as being in a state of type PRE(C) but not as being in a state of type RES(C). Thus in the present case, where the concept is HEILEN, the NP may describe its referent as failing to be in the state of being healthy, but not as being in that state.

If all the subject NP of (40. i) did was to ascribe to the mentioned foot the property of not being healthy at the time when the healing process started, this part of it would be simply redundant. But of course the NP does more than that. For it says of the foot that it was wounded, and that is one of many ways in which a foot can fail to be healthy. Much the same may be said, we think, about the phrase *die Wunde*. It describes, like the NP *der verwundete Fuß*, some part or region of an organism (although one cannot infer from the phrase *die Wunde* on its own which part) and says of this part that it fails to be in the state of health in the specific way of being wounded. Glossed in this way the phrase refers to an entity that plays the role of Theme<sub>1</sub>. At the same time, however, – this is the difference between *die Wunde* and *der verwundete Fuß* – *die Wunde* also denotes that which negatively affects the denoted body part at the outset of the process which the verb describes, and which must disappear in the course of that process (the process of this part getting healed) and in this capacity it represents the role of Theme<sub>2</sub>. Since *die Wunde* fills both these roles, sentences like (37. i–iii)

cannot be good: The role of Theme<sub>2</sub> is already represented in these sentences by the direct object phrase. So there is no room for a *von*-phrase which attempts to represent this role as well. Alternatively the point might be put like this: The result of any process falling under HEILEN is, we said, the “separation” of its Theme<sub>1</sub> from its Theme<sub>2</sub>. In the case of (37) this would mean that the referent of the *von*-phrase gets separated from that of the phrase *die Wunde* – that the former disappears while the latter remains. The trouble with this is that the getting better of a wound is precisely that it – qua wound – *does* disappear. So either we see the denotation of the phrase as going the same way as whatever it is that the wounded region is said to suffer from (i.e. the referent of the *von*-phrase) – in which case there is no case of separation – or we see it as remaining, as still being there after the process is completed – but then the wound will still be there at the end of the healing process. In fact, this last possibility appears to be a real (if perhaps no more than a marginal) one. Sentence (37.i), for instance, would seem to constitute an acceptable utterance if it were said of a self-professed saint, who misses no opportunity to display his stigmata (which, as a matter of fact, constitute his principal professional asset). For him the “natural” state would be one in which he has his stigmata all right but in which they are not infected. If one of his stigmata does get infected, then “curing the stigma” can be interpreted as curing the stigma just of its infection while yet keeping it intact as a stigma – curing the wound altogether would, in this case, bring about a state of professional infirmity as well as, less relevantly, an improvement in physical health.

While it is its playing the Theme<sub>2</sub> role of HEILEN which explains why the phrase *die Wunde* cannot felicitously occur in the sentences under (37), it is its representing the Theme<sub>1</sub> role which explains why it cannot figure in the sentences listed under (36): One cannot cure somebody (or some part or organ of that somebody) of his wound, because the phrase functions in part to denote the wounded region, and that region does not disappear in the healing process and so does not get separated from the entity denoted by the direct object.

The phenomenon of multiple role representation is not unique to the relation in which NPs involving the nouns *Wunde*, *Bruch*, etc. stand to the concept HEILEN. The same kind of double duty we find with *jeden Fleck* in a sentence such as the advertising slogan

- (41) Wir reinigen Ihnen jeden Fleck.  
(We clean (for you) every spot.)



The function of *jeden Fleck* in (41) parallels that of *die Wunde* in the examples we have looked at. The phrase refers on the one hand to regions of the garments or materials which will, if the advertiser's promises are to be trusted, become clean if those garments or materials are left to his ministrations, while on the other hand it also refers to that *from* which the garment has to be separated in order for it to become clean. That NPs with *Fleck* as head noun have this second function is shown by discourses like

- (42) Ich brachte das Kleid mit dem Fleck<sub>i</sub> in die Reinigung. Gott sei dank wurde er<sub>i</sub> entfernt.  
(I brought the dress with the spot to the cleaners. Thank goodness it was removed.)

The meaning of the second sentence of (42) is that whatever constitutes the dirt part of what is denoted by *der Fleck* was separated from that which this dirt dirties (and which preferably should be left intact by the cleaning process): (41) does not mean that when the cleaners have done what they promised, the object of their labours will have a hole in every place where previously there was a spot.

The case where the subject of *heilen* does double duty requires a separate lexical entry, in which the double role of the single syntactic argument is made explicit by a form of "coindexation". In the entry (11.iii) this coindexation is realized by the reference "D(eterminer) P(hrase): Nom" under "Theme<sub>2</sub>" to the case assigner.

- (11) (iii) *heilen*  $\{ \langle \theta_1, \text{Nom} \rangle \}$   
term, denoting  
body part *and*  
ailment
- |  |                     |                    |
|--|---------------------|--------------------|
| e: HEILEN( <sub>y<sub>th1</sub></sub> , <sub>z<sub>th2</sub></sub> ) | Theme <sub>1</sub>  | Theme <sub>2</sub> |
|  | SEL RESTR           | SEL RESTR          |
|  | organism            | ailment            |
|  | or <b>body part</b> | or disease         |
|  |                     | <b>ailment,</b>    |
|  |                     | denoted by         |
|  |                     | DP: Nom            |

What should be the semantic representation of sentences in which this entry of *heilen* is used? The main question we must address is whether the subject of such a sentence, such as for instance the phrase *die Wunde* in (35), con-

tributes the same denotatum to the two argument positions of the concept for which it is responsible, or whether these contributions involve distinct entities. Put in this way the question has a clear and simple answer: There must be two denotata. For how could a thing be separated from itself? But this leads to the second question: How are the two denotata connected? We can only give a brief answer to this question, which raises a number of further ontological issues that we will leave for what they are. Consider the concept of a hole. Holes are *relational* in a sense in which material objects such as houses or walls or trousers are not. One way to see this has to do with how one can get rid of a hole. If you have a hole in your trousers, you can get rid of it by getting the hole (meticulously) fixed, but you can also put an end to its existence by burning the trousers. For entities such as trousers or walls there is no clear analogue to this second way of abrogating the life of a hole: To terminate a pair of trousers you have to destroy *them*; you can't do it by destroying their immediate surroundings. This difference is symptomatic of the fact that a hole is by definition always a hole *in* something else.

Much the same is true of the concept of a wound. A wound is a wound insofar as it is the wound of some organism or body part. But there is nevertheless a subtle difference between the words *hole* and *wound*. The location of a hole is in general quite clearly defined and it is to be found there where the matter constituting the object in which it is a hole is not. With wounds the matter is not so neat. A wound is in general not just absence of tissue, but rather tissue torn or damaged in some other way: a wound has a material substratum which a hole does not; making the wound disappear is to restore that substratum to its original "unwounded" condition. It is this circumstance that enables the phrase *die Wunde* to do double duty in (35): The phrase can be understood on the one hand as focussing on the tissue or body part that is wounded and on the other on the wound that this tissue or body part has – as something more abstract, which will have disappeared completely when the wounded tissue is healed.

To represent (35) in the spirit of this discussion we must distinguish these two different entities to which the phrase *die Wunde* can be taken to point.<sup>18</sup> Here we will be very brief indeed. We assume that organisms can

<sup>18</sup> Does *die Wunde* in (35) have one referent or two? We have tried to leave this matter undecided by using such non-technical terms as "indicate" and "focus on". It seems to us that the double duty analysis which we propose in this section raises a non-trivial problem for the traditional conceptions of reference. We have no solution to offer.

sustain wounds in the same sense in which material objects can have holes, and that these wounds can be made to disappear by restoring the organism. Furthermore, we assume that noun phrases such as *die Wunde* can be used to “indicate” both entities of this type and also the corresponding (wounded) parts of the organisms that have them. Evidently entities of the first kind and entities of the second kind always come in pairs. These pairs are related by a metaphysical relation, which we call WOUNDOF – WOUNDOF( $z, y$ ) means that  $z$  is a wound (in the “hole” sense of the word) and that  $y$  is the organism or body part of which  $z$  is a wound. With this stipulation the DRS for (35) takes on the following form (35’):

(35’)

e	y	z
e < n		
body part(y)		WOUNDOF( $z, y$ )
e: HEILEN( $y, z$ )		
y = Theme <sub>1</sub> (e)		
z = Theme <sub>2</sub> (e)		

The moral of this section has been two-fold. First, we wanted to give a flavour of the intricacies of argument and role management that govern some of the superficially idiosyncratic restrictions on verb-argument combinations that can be found in natural language. Secondly, and more specifically, our aim has been to demonstrate that the relationship between syntactically realized argument phrases and thematic roles (“thematic roles” in the semantic sense in which we use the term) fails to be straightforwardly one-to-one. Earlier we saw that not every thematic role is always syntactically realized. In the present section we have seen that it may also happen that one and the same argument phrase expresses several thematic roles at once.

## 10. Optional roles

Besides

(43) Der Arzt heilte den Patienten.

we also find sentences such as

(43) (i) Der Arzt heilte den Patienten mit seinem Skalpell.  
(The doctor cured the patient with his scalpel.)

- (43) (ii) Der Arzt heilte den Patienten mit Kamille.  
(The doctor cured the patient with camomile.)
- (43) (iii) Der Arzt ging mit seiner Assistentin ins Krankenhaus.  
(The doctor went to the hospital with his assistant.)
- (43) (iv) Der Arzt heilte den Patienten in seiner Privatabteilung.  
(The doctor cured the patient in his private ward.)
- (43) (v) Der Arzt heilte den Patienten innerhalb von drei Wochen.  
(The doctor cured the patient within three weeks.)

in each of which there is, besides the argument phrases we already encountered in earlier examples, an additional one, referring to manner, space or time of the described event. Each of these phrases is *optional* in the sense that if we leave it out, the result is again a well-formed sentence (viz. the sentence (43)). In this regard they are like the phrase *von der Grippe* in the sentence

- (12) (i) Der Arzt heilte den Patienten von der Grippe.  
(The doctor cured the patient of the flu.)

But, according to the treatment we have given, there is also a difference: In (43.i)–(43.v) it is not only the prepositional phrase but also the *semantic role it realizes* that is optional.

What justifies this distinction, between on the one hand roles that are syntactically optional but semantically obligatory and on the other roles that are semantically as well as syntactically optional?

As we see it, there are two different types of role optionality – more precisely, if all those roles that are commonly treated as optional in the literature qualify as optional, then they do so in virtue of satisfying one of two quite different criteria. The first criterion is this: Suppose that the phrase *a* is an optional constituent of the clause *b* – so that we obtain a well-formed clause *b'* when we drop *a* from *b*. Then the thematic role expressed by *a* is *semantically optional* if the event type described by *b'* can be instantiated by events which have no participants playing the role which *a* expresses.

An example of semantic optionality in this sense is the role expressed by *mit seiner Assistentin* in

- (43) (iii) Der Arzt ging mit seiner Assistentin ins Krankenhaus.  
(The doctor went to the hospital with his assistant.)

– a role sometimes referred to as that of *concomitant* (this at any rate is the term we will use for it). There are events of the type that is described by the clause we get by eliminating *mit seiner Assistentin* from (43. iii):

- (44) Der Arzt ging ins Krankenhaus.  
(The doctor went into the hospital.)

and where a doctor goes to the hospital all by himself.

Another role that is optional in this same sense is the one expressed by *mit dem Skalpell* in

- (43) (i) Der Arzt heilte den Patienten mit dem Skalpell.  
(The doctor cured the patient with his scalpel.)

This role is usually referred to as *instrument*. It is optional insofar as there are cases of a doctor curing a patient without using any instrument at all, cases in which he cures the patient, say, through a mere act of will. Here the case is not so clear-cut, however. For even in those cases where the doctor seems to have used no external means to bring about the cure – where there has been, as we just put it, nothing besides his will or intention to cure the patient – does not his will or intention qualify in some sense as the “instrument” he used? After all, it seems just possible to describe the case with the sentence:

- (46) Der Arzt heilte den Patienten mit seiner Willenskraft.  
(The doctor cured the patient with his will power.)

Intuitively, the issue whether the instrument role is to be considered obligatory correlates with the question whether or not we are always, when a cure is mentioned but no instrument, justified in asking “Cured him – but with what?”. If this reaction is always legitimate, the role should be considered obligatory; otherwise it should count as optional. We are uncertain whether the question is always legitimate. Possibly this is a matter that can only be settled by arbitration, and if that is so, then there is an inherent indeterminacy in our criterion for optionality.

There is another aspect to this problem that deserves our attention. As a rule a doctor who cures his patient with the help of his scalpel will also have the will to cure the patient. So, if it is his will that qualifies as a kind of “instrument” in case no ordinary instrument has been used, isn’t it also an instrument in those cases where it was present *and* an ordinary instrument was involved as well? For another example that presents this same problem, consider

- (47) Der Wärter suchte den Raum mit einer Taschenlampe ab.  
(The guard searched the room with a torch light.)

You can search a room with or without a special light source. But even when you do not need one (for instance because the search occurs in broad daylight) there is still something that you can be said to use: you could still be said to “search with your eyes”. Again, this can be said just as well in a situation where you search the space with a torch. So, in this case both the torch and your eyes seem to qualify as instruments. This is a quite general aspect of the notion of an instrument: Many actions involve the employment or deployment of several “instruments”, not just one.

Nevertheless it seems that language does not reflect this. In each natural sentence there is room for only one instrument phrase. This is a special case of an apparently general linguistic principle, according to which no thematic role type can be realized by more than one argument phrase in a single clause. When we describe an event involving what appear to be several instances of the same role, we therefore have to make a choice which one we want to include as “the instrument” in our sentence. In syntax this principle is known as the *theta criterion*.

The complexities of the distinction between optional and obligatory roles we have noted find striking illustrations in the domain of German dative phrases. The intricate semantic and pragmatic properties of German datives constitute a topic in its own right, which deserves a separate essay. Here we will only mention a few of the many different purposes to which the dative in German can be put. One, but only one, of the ways in which datives can be used is to express what is often called the role of *beneficiary*. Typical examples are the *dir* of

- (48) Ich habe dir ein Buch gekauft.  
(I have bought you a book.)

and *seiner Gastgeberin* in

- (49) Fritz hat seiner Gastgeberin das Geschirr gewaschen.  
(Fritz did the dishes for his hostess.)

Both datives refer to individuals for whose benefit the described action was undertaken.<sup>19</sup> Both represent roles that are clearly optional by our criterion. For it is perfectly possible to buy a book or do the dishes without

<sup>19</sup> In German grammars, this use is sometimes referred to as “*dativus commodi*”.

doing it for anyone. In this respect the datives of (48) and (49) differ from that of

- (50) Ich habe ihr ein Buch geschenkt.  
(I gave you a book.)

which is not only semantically but also syntactically obligatory, and that of

- (51) Sie hat ihm eine Geschichte vorgelesen.  
(She read him a story.)

which is semantically obligatory although syntactically optional. (51) is semantically obligatory insofar as one cannot engage in what is described by the German verb *vorlesen* without there being someone to whom one does it.

How closely the distinction may depend on the particular lexical items involved is illustrated by the next three sentences, all with the verb *schreiben*.

- (52) (i) Er hat ihr ein Gedicht geschrieben.  
(He has written her a poem.)  
(52) (ii) Er hat ihr einen Brief geschrieben.  
(He has written her a letter.)  
(52) (iii) Er hat ihr ein paar Zeilen geschrieben.  
(He has written her a few lines.)

The *ihr* of (52.i) seems parallel to that of (48): Just as one can buy a book without doing it for anyone, so one can write a poem without writing it for somebody. With the dative of (52.ii) the matter is less clear. Here, it rather looks as if the role expressed by the dative phrase is obligatory. For how can one write a letter without writing it to some person? True, the judgement may be open to debate. For isn't it possible to write open letters, which aren't addressed to anyone in particular? Even there, it might be argued, there must be some make-believe sense in which the "letter" has an addressee, for if it didn't, it could not really qualify as a letter even in a derivative sense. But there is a further consideration. Even one who grants that the sentence

- (53) Er hat einen Brief geschrieben.  
(He has written a letter.)

has an interpretation which does not entail that there was someone to whom the letter was written might still maintain that the role expressed by the

dative of (52. ii) is obligatory. For he might argue that the particular meaning of the verb *schreiben* as it occurs in (52. ii) is different from that which it has in the context of (53), and that it is only when *schreiben* is used with this latter meaning that it does not imply an addressee.

This possibility is especially important in connection with (52. iii). Surely the sentence

- (54) Er hat ein paar Zeilen geschrieben.  
(He has written a few lines.)

does not carry the implication that there was someone to or for whom the lines were written. But that does not seem good enough to conclude that the dative of (52. iii) expresses an optional role. For again, the phrase *ih<sub>r</sub> ein paar Zeilen schreiben* appears to have a special sense, in which *ein paar Zeilen* takes on a meaning close to “letter” or “note”. Where the verb phrase carries that meaning, the role expressed by the dative is arguably obligatory.<sup>20</sup>

As these examples show, it will not be easy to draw a sharp dividing line between the semantically optional and the semantically obligatory roles. Perhaps this isn't even possible at all. Fortunately, this does not seriously affect the lexical enterprise to which the present paper is devoted. We need *some* division between semantically obligatory and semantically optional roles, so that we can confine the argument specifications of our lexical entries to those roles that are obligatory in the sense of this division. For if we do not impose such a limit, we will have to specify a different lexical entry for every possible combination of verb, noun phrases and prepositional phrases and thus we will multiply lexical entries beyond all reason. *Precisely* where we draw the line between obligatory and optional roles is not crucial, so long as the roles which qualify as optional on any reasonable application of the criterion end up on the optional side. The resulting lexicon

<sup>20</sup> A further consequence of this analysis is that the dative of (52. iii) is not only semantically obligatory in the sense under discussion, but that it is also obligatory in another sense. The dative of (52. iii) is not obligatory in the strict syntactic sense of the word, since we still have a grammatical sentence when the dative is eliminated from it. But in a way the dative *cannot* be eliminated from (53. iii); for the result is a sentence whose main verb no longer has the same meaning. This type of obligatoriness is akin to syntactic obligatoriness, insofar as one might argue that elimination of the dative from (52. iii) is not really possible after all. What one gets when the dative is taken out is an ill-formed sentence, which happens to look identical with another, well-formed sentence, in which the main verb is a different one.



might be somewhat less compact or elegant than it could have been on a narrower conception of obligatory role. But it would still be a workable one. Keeping out the roles which are optional on any reasonable interpretation of the criterion will serve our purpose well enough.

The central problem which the distinction between optional and obligatory roles poses for the lexicon is not that of discovering the unique, “right” definition of the distinction between optional and obligatory roles. There are many definitions that will do. Rather, the problem is to articulate, once a reasonable definition has been chosen, what contributions optional roles make to the meanings of sentences in which they are syntactically realized. Since optional roles are not explicitly represented in the entries of the verbs for which they are optional, these contributions cannot be read off the entries as they stand, and we need principles to determine how they semantically affect the conceptual structures which the entries make available directly. To appreciate this problem, let us have another look at our earlier example (49):

- (49) Fritz hat seiner Gastgeberin das Geschirr gewaschen.  
(Fritz did the dishes for his hostess.)

We argued that the role expressed by the “*dativus commodi*” *seiner Gastgeberin* in (49) is optional. Accordingly, the lexical entry for *waschen* will not have a slot for the thematic role of beneficiary which this dative expresses. But then, some other component of our over-all theory will have to tell us what semantic contribution the dative phrase makes to the meaning of (49). In fact – this is the very idea behind the notion of a semantically optional role! – this component should have the form of a general principle, which specifies how the role affects the conceptual entry of each member of the open class of verbs which allow for a *dativus commodi* – a principle which, in combination with the entry of any such verb *V*, enables us to construct the correct DRSs for sentences in which *V* is accompanied by such a dative. Presumably such principles would figure among the axioms of the lexical theory LT. But what exactly should be their form, or what information they should contain – these are questions to which we do not have any answers at the present time.

The second notion of optionality that is implicit in the way in which the term “optional” has been used is exemplified by the prepositional phrases of (43.iv, v), which we repeat here:

- (43) (iv) Der Arzt heilte den Patienten in seiner Privatabteilung.  
(The doctor cured the patient in his private ward.)

- (43) (v) Der Arzt heilte den Patienten innerhalb von drei Wochen.  
(The doctor cured the patient within three weeks.)

or by those of the intransitive, but in other respects similar sentences

- (55) (i) Der Patient gesundete im Landeskrankenhaus.  
(The patient recovered in the county hospital.)
- (55) (ii) Der Patient gesundete in der letzten Märzwoche.  
(The patient recovered in the last week of March.)

Such phrases, which denote the spatial or temporal location of the described events, processes or states – are as a rule syntactically optional.<sup>21</sup> Moreover, if the explicitly listed verb argument combinations are to specify only the obligatory roles, the roles represented by these phrases ought to qualify as optional as well. For surely one would not want to specify spatial or temporal locating phrases explicitly as part of the argument structure of each and every verb – doing so would lead to pointless redundancies.

It is clear, however, that the “roles” identified by temporal and spatial locating phrases are not optional by the criterion we have been discussing up to now. For it is true of all types of events and of all or most types of states that they are located in time, and it is true of many types of events that they are situated somewhere in space. (It makes no sense to suppose, say, of any event type that there might be an event instantiating it which would not be located in time.) So, if temporal locating phrases are to count as optional, they should do so by a criterion different from the one we have been using so far.

A distinction that seems to point in the right direction, but of which we aren't quite sure whether it quite does the job it is supposed to do, is the following: The location of an event or state does not affect its identity in the way in which the identity of any of its obligatory participants affects it. Thus it seems generally possible to reflect on the causal effects that a given event – a given cure, say – would have had, had it happened at some other time than the one at which it actually did occur. We conceive of such counterfactual situations as involving the very same particular event

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<sup>21</sup> There are a few verbs which take such phrases as genuine complements, for instance *take place*, *occur* and *obtain*. These verbs differ from those that are discussed in this essay in that they take subject phrases denoting events or states, rather than subject phrases which identify one of the thematic roles associated with the kind of state or event that the verb describes. Such verbs require a separate treatment.

that really did happen, and express ourselves accordingly. Thus one could ask in relation to a given cure: “Could this particular cure of A’s have occurred in March?”, or speculate: “Had this cure only occurred a few weeks earlier, A would not have lost his job.”. In contrast, it seems quite odd to contemplate of a cure – in which, say, person A makes a recovery from pneumonia – what *its* effects would have been had its Theme<sub>1</sub> not been A but some other person B. Of course, we can contemplate what the world would have been like, had there been a cure of B instead of a cure of A. But the question “Could this particular cure of A’s have been B’s cure instead?” hardly seems coherent. Generalizing from this example we suggest that the roles of temporal and spatial location are semantically “optional” in relation to the concept HEILEN insofar as the values which these roles take for particular events that instantiate this concept are not constitutive of the identity of those events. Generalizing further, we suggest that location is not essential to event identity not only for the concept HEILEN, but for virtually all concepts that are expressed by verbs. An obvious exception are location verbs such as *live* and *stay*.

It is fairly clear – or so, at least, it seems to us – that the present criterion classifies the thematic roles of temporal and spatial location as semantically optional (with respect to all or almost all verbs) and that it places the Theme<sub>1</sub> role of HEILEN squarely on the side of the semantically obligatory. But in many other cases it is not so clear what verdict the criterion delivers. Consider for instance the Theme<sub>2</sub> role in relation to HEILEN. Suppose again that A recovered from pneumonia. Is it clear that this particular event – this particular instance of the concept HEILEN, could not have been the same event, had it been, say, bronchitis, that A had recovered from? In other words, could *this* event have been a recovery from bronchitis? We are inclined to think that it could not, but we are not quite sure. Indeed, it is often difficult to be sure about such questions. For they concern the identity of events, and the identity of events is a matter about which it is notoriously difficult to have reliable intuitions. In fact, intuitions about event identity seem to be so uncertain and so often at variance with each other that we doubt whether there is a single notion of event on which our intuitions are targeted. If there isn’t – if our pretheoretical conception of events leaves a certain irreducible amount of play within which any precise event concept would have to be fixed by stipulation – then there will be of necessity a corresponding indeterminacy in our second criterion for optionality of thematic role, which could only be removed by a similarly stipulative definition.

So it looks as if our second criterion for semantic optionality is no better off than the first: Neither the first nor the second criterion can be relied on to give unequivocal guidance in general. The same is true of their disjunction – according to which a role *r* qualifies as optional relative to the verbal concept *C* if it so qualifies either on the first or on the second criterion. This may seem unsatisfactory, but – and here we repeat what was said in conclusion to our discussion of the first criterion – it isn't quite as bad as it looks. So long as we can find some reasonable division between optional and obligatory roles which keeps the number of distinct lexical entries for each individual verb within sensible bounds, our lexical needs will have been served well enough. That the division will be to some extent arbitrary is something we may have to learn to live with. But there is no reason why we should find that very hard.

More important than the exact place in which we draw the line between obligatory and optional roles is (to repeat what we said in connection with the first criterion) the articulation of general principles which will enable us to construct DRSs for sentences in which verbs are accompanied by noun phrases or prepositional phrases expressing optional roles. For the two types of phrases which have served as the starting point for our discussion of the last three pages – i.e. the locating phrases of (55. i, ii) – this problem is much simpler than it is for the cases considered earlier (those represented by examples (44)–(54)). In fact, the existing work within DRT concerning the interpretation of tenses and temporal adverbs could be said to address (and go a good way towards solving) this problem for the case of temporal locating phrases.<sup>22</sup> A parallel treatment has been explored for spatial locating phrases.<sup>23</sup>

Where it is possible to distinguish between the obligatory and the optional, there is typically room for a three-fold and not just a two-fold distinction: the obligatory, the optional and the prohibited. So it is also in the case at hand: not only can argument phrases be divided into those that are optional and those that are obligatory; it is equally possible to distinguish between phrases that are optional – and which are, by the same token, optionally absent when they are absent – and phrases which cannot accompany the given verb at all, phrases whose *absence* is *obligatory*. To our knowledge this third category – of phrases which are prohibited from clauses with a given main verb – has not received much explicit attention.

<sup>22</sup> See in particular Bras (1990), Kamp & Reyle (1993) or Kamp & Rohrer (1985).

<sup>23</sup> Mayer (1988)

Perhaps this should not be surprising. For if all you are interested in is to correctly interpret grammatically correct sentences, then this third category may be ignored, since it is never going to be instantiated in any of the sentences or texts with which you will deal.

The situation is different, however, when the lexicon is to support not only the interpretation of natural language, but also natural language generation (i.e. generation of natural language sentences from semantic representations such as DRSs). An algorithm for natural language generation must be able to avoid ungrammatical outputs. So it must know which verb-argument phrase combinations are prohibited. So the lexical theory on which the generation algorithm is based must contain explicit information about such prohibitions.

Let us give just one simple example of the kind of prohibition we have in mind. Note that one cannot say

- (59) Die Wunde heilte mit Penizillin.  
(The wound healed with penicillin.)

The generation algorithm must know that the instrument of a cure cannot be construed as instrument of the process of getting better. For such processes (and presumably for many other process types as well) the instrument role is not defined. Consequently an instrumental phrase cannot go with a verb which describes events of such a type.

The general principle underlying this prohibition is that instruments presuppose an agent: In order that Instr(e) be defined it is necessary that Agent(e) be defined as well. This principle entails among other things that processes of type HEILEN cannot have Instruments. For, according to our analysis at least, such processes have themes but no agents.

## 11. Instruments and causers

In this section we will argue that the notion of an instrument needs to be refined if we are to explain some of the distributional facts connected with the verb *heilen*. The need for such a refinement arises in connection with the following contrast. Besides

- (43) (i) Der Arzt heilte den Patienten mit dem Skalpell.  
(The doctor cured the patient with his scalpel.)

we also find sentences such as

- (43) (ii) Der Arzt heilte den Patienten mit Kamille.  
(The doctor cured the patient with camomile.)

Superficially it may seem that the roles which the *mit*-phrases play in these two sentences are quite similar and that the phrase *mit Kamille* qualifies as instrument phrase in (43.ii) no less than *mit dem Skalpell* does in (43.i). Nevertheless there is an important difference between them, which shows up in the contrast between the unproblematic

- (60) (i) Die Kamille heilte den Patienten.  
(The camomile cured the patient.)

and the marginal

- (60) (ii) Das Skalpell heilte den Patienten.  
(The scalpel cured the patient.)

Informally the difference between (60.i) and (60.ii) might be described by saying that a drug such as camomile can be considered the causer of the cure, but that tools like scalpels cannot.

The explanation we venture for this contrast runs as follows. Once a “drug” (i.e. a substance which may produce a cure through chemical action) has been introduced into the body, it is then, as it were, left to do its work without further intervention. What happens afterwards can be conceived as a separate causal process in which the person who administered the drug or ordered it to be taken no longer plays any part. It is natural to consider the drug the causal agent of this process, and it is this conception that justifies a sentence like (60.i). With a tool such as a scalpel the situation is different. In the normal course of events it can do its work only when and so long as it is being manipulated by the person who handles it. Here it makes little sense to conceive of the cure in such a way that it includes, besides the process of recovery, a further event that has the scalpel as a participant but not the person who used it: there is no causal complex relative to which the scalpel qualifies as the principal or salient cause; any such complex will also include the one who used the scalpel. Intuitively it is that individual who, as the agent of the action that produced the cure, has a unique, or at least highly preferential claim to being the causal agent.

These considerations lead us to a distinction between two types of Instrument:

- (i) Instruments which can be conceived as acting on their own, once the agent has applied or introduced them; and

- (ii) instruments whose action is conceived as strictly auxiliary to that of the agent by whom they are being employed.

We call the former *Instrument Causers*, while retaining for the latter the simple denotation *Instrument*.<sup>24</sup>

A second implication of our explanation is that the event structure described in a sentence such as (43.ii) must allow for a more complex articulation than the one we have proposed for the lexical entry of transitive *heilen*. The articulation of the event structure described by (43.ii), which highlights the special status of the camomile and thereby accounts for the grammaticality of (60.i), is given in the DRS (61).

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<sup>24</sup> Are the role of instrument and that of instrument-causer really distinct roles, or should they be seen as subvarieties of a single thematic role? It is not easy to see how to decide this. But the following consideration would seem relevant: Suppose that it is true of all members of a given class that they performed a certain action with a certain kind of thing, but that in some cases this thing functioned as an instrument-causer while in others it was used in such a way that it could not be seen as a cause in its own right. If we could describe this situation by means of a single quantificational sentence this might be taken as evidence that the instrument-causer and the non-causer variety of instrument can be conceived as subspecies of a single thematic role; if such a unified description of the situation is not acceptable, that might indicate that the two roles are thought of as genuinely distinct. The following example may help to explain what we have in mind. Consider the sentence

(1) Jeder Mediziner hat seinen Patienten mit dem Rhinoceroshorn geheilt.

(All doctors revitalized their patients with rhinoceros horns.)

Could this sentence be asserted in a situation in which some of the doctors had used their rhino horn as an instrument-causer and the others had used it as an instrument in the non-causer sense of "instrument"? Suppose for instance that half of the doctors achieved their result by having their patients swallow portions of ground rhino horn, whereas the other half were equally successful by suitably prodding their patients with (un-ground) rhino horns? Could (1) be used to describe this situation? Unfortunately the evidence does not seem very clear. We think the sentence might be used in this context. But it sounds a bit like a joke in this case, and so it is hard to extract a clear moral from this example. (We owe the point to Mats Rooth).

(61)

	n	ec	x	w	y	z																																																																																																		
	ec < n																																																																																																							
	der Arzt(x)		Kamille(w)		der Patient(y)																																																																																																			
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Here the discourse referent *ec'* represents the sub-complex of which the camomile is the causal agent, while *ec* represents the total complex. The event complex represented by *ec'* is that described by the sentence (60.i), instantiating the lexical entry (15.iii).

(15) (iii) *heilen*      {d< $\theta_1$ , Nom>, < $\theta_2$ , Acc>, << $\theta_3$ , von + Dat>>}}

	e'		e			
ec:	e' CAUSE <sub>heilen</sub> e					
	x = Causer(e')					
	e: HEILEN(y <sub>th1</sub> , z <sub>th2</sub> )					

	Causer	Theme <sub>1</sub>	Theme <sub>2</sub>
	SEL RESTR	SEL RESTR	SEL RESTR
	natural force	<b>organism</b>	or <b>ailment</b>
	medicine	<b>body part</b>	or <b>disease</b>
	or remedy		

In contrast to (61) the representation of the event complex described by (43.i) involves only the three event discourse referents that are by now familiar from our causative analysis of transitive *heilen*:



(62)

n	ec	x	v	y	z																
ec < n																					
der Arzt(x)		das Skalpell(v)		der Patient(y)																	
<table border="1"> <tr> <td>e'</td> <td>e</td> </tr> <tr> <td colspan="2">ec:</td> </tr> <tr> <td colspan="2">e' CAUSE<sub>heilen</sub> e</td> </tr> <tr> <td colspan="2">x = Agent(e')</td> </tr> <tr> <td colspan="2">v = Instrument(e')</td> </tr> <tr> <td colspan="2">e: HEILEN(y, z)</td> </tr> <tr> <td colspan="2">y = Theme<sub>1</sub>(e)</td> </tr> <tr> <td colspan="2">z = Theme<sub>2</sub>(e)</td> </tr> </table>						e'	e	ec:		e' CAUSE <sub>heilen</sub> e		x = Agent(e')		v = Instrument(e')		e: HEILEN(y, z)		y = Theme <sub>1</sub> (e)		z = Theme <sub>2</sub> (e)	
e'	e																				
ec:																					
e' CAUSE <sub>heilen</sub> e																					
x = Agent(e')																					
v = Instrument(e')																					
e: HEILEN(y, z)																					
y = Theme <sub>1</sub> (e)																					
z = Theme <sub>2</sub> (e)																					
x = Agent(ec)																					
v = Instrument(ec)																					
y = Theme <sub>1</sub> (ec)																					
z = Theme <sub>2</sub> (ec)																					

Here the “promotion” of instrumental phrase to subject is not possible, as there is no sub-complex in which the (discourse referent representing the) scalpel has the status of causal agent.

An as yet only implicit premise of this explanation is that the subjects of “causative” verbs such as transitive *heilen* (i.e. verbs which describe a process in which a certain result state of one participant (the Theme<sub>1</sub>) comes about through the causal agency of another) must always represent the role of causal agent, but that the interpretation of such verbs involves a hidden ambiguity in that the event complex they describe may vary. Which event complex is intended will usually be clear from the choice of subject phrase: When the phrase can be transformed into an instrumental phrase in a redescription of the event, it is the subcomplex that the clause must be understood to describe; when this is not possible, what is described is the full complex. For instance, we saw that (60.i) can be interpreted by the inner causal structure (represented by the discourse referent *ec'*) of the event complex described by (43.ii). The event complex determined by (43.i) does not have such an embedded causal complex. By the same token (60.ii) can only be interpreted as describing the outer causal complex, which is tantamount to attributing to the scalpel an agentive role, which we normally reserve for human agents.

Putting things this way leads to a further question: what is the general principle concerning subject phrases which accounts for the fact that with “causative” verbs the subject phrase can only represent roles of causal

agency, whereas, as is now generally accepted, the subjects of other verbs, such as for instance intransitive motion verbs (e.g. *gehen* (to walk)) or certain psychological verbs (e.g. *erfreuen* (to please)), can represent other roles, like (as with the verbs just cited) that of Theme? A second and related question is how precisely the class of “causative” verbs should be defined. Evidently the explanation we have proposed in this section presupposes that this class transcends the idiosyncratically delimited group of those verbs that are causativizations of “underlying” intransitive process verbs (in the manner in which, according to the present paper, transitive *heilen* is the causativization of intransitive *heilen*.) But these too are questions we can only raise.

The questions we have tried to address in this paper all arise out of an attempt to come to grips with the lexical properties of the verb *heilen*. To repeat, our interest in these questions and in lexical questions generally, stems from the persuasion that lexical information is crucial both in the construction of semantic representations and for the drawing of inferences from these. (As we have argued in many places, inference is crucial to text interpretation, so that the two – representation construction and inference – are intimately interwoven.) The inferential role of the lexicon will be investigated in the second paper in this volume.

Our reflexions on the structure of lexical entries and the lexical properties of *heilen* end – for the time being – here. Of the road towards the sort of lexicon we see as necessary, we have covered in this paper only the tiniest bit. We are painfully aware of this. As a matter of fact we have gone somewhat further along this road than this paper shows. Some indication of this can be found in the third paper in this volume.

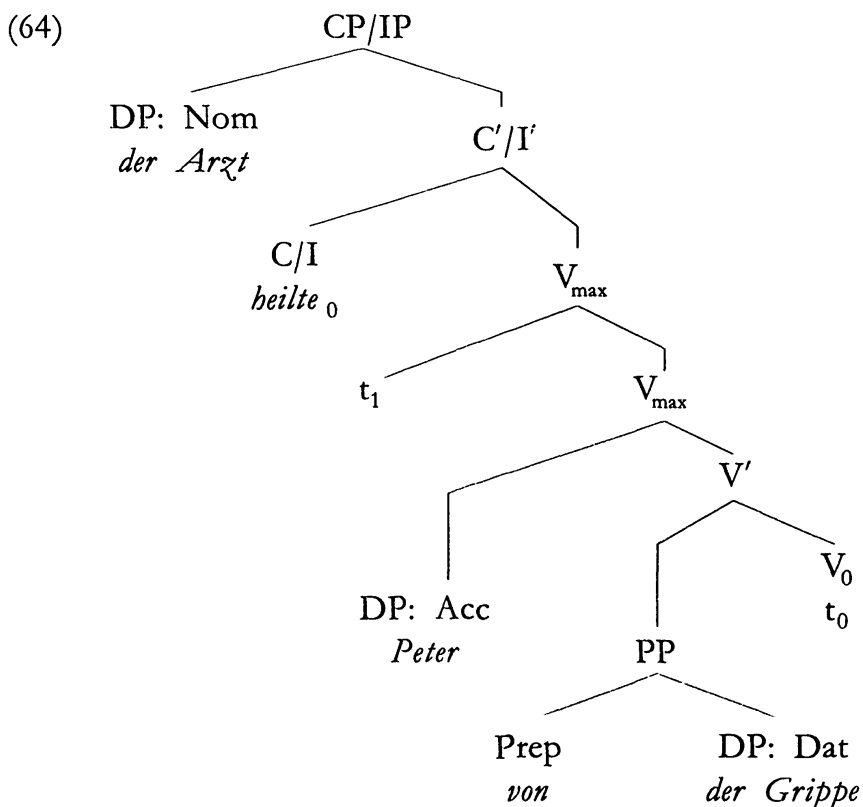
## Appendix 1. DRS construction in greater detail

In the few sample DRS constructions which we have presented in this paper we have skipped a number of details. In this appendix we will have a closer look at some of these.

In order to do this we must be more precise about the syntactic input to the DRS construction algorithm than we have been up to now. Precisely how the syntactic inputs are defined does not matter all that much – DRS construction tends to be adaptable to a fairly wide band of assumptions about the underlying syntactic structures which serve as its inputs – but it should be settled one way or the other. We have opted here for a German grammar developed in Frey & Tappe (ms) within the framework

of the theory of Government and Binding.<sup>25</sup> This grammar assumes that all argument phrases (the subject phrase included) are dominated by the verb's maximal projection,  $V_{\max}$ . The positions which these argument phrases occupy within  $V_{\max}$  are hierarchically arranged in a right branching structure, as in the following tree (64) for the sentence (63).

- (63) Der Arzt heilte Peter von der Grippe.  
(The doctor cured Peter of the flu.)



(64) is typical of German clauses in that some of its argument phrases – *Peter, von der Grippe* – occur in their base positions, while others have moved. In (64) only the subject *der Arzt* has moved from its base position indicated by the trace  $t_1$  to its actual position in the “Vorfeld”. The hierarchical relations between the actual positions occupied by the argument phrases and the positions of their traces are instrumental in determining the possible

<sup>25</sup> This Grammar is based substantially on work of Haider (1993) and earlier work of Frey, published in Frey (1993).

scope relations between the arguments.<sup>26</sup> For a sentence like (63) this is admittedly of no direct importance since its argument phrases are all “referential”. Their discourse referents have to be anchored or accommodated in the context. Thus all the argument phrases have maximal “scope” irrespective of their hierarchical position in the syntactic tree. The only thing that matters for sentences like (63) is therefore what the *set* of their argument phrases looks like, its so-called “ArgSet”. We assume that the parser produces this set as one component of its output, in the form of a set of pairs, each consisting of (i) the NP or PP in question, and (ii) its *generalized case information* (for an NP this is its case, for a PP it is its preposition + the case of the NP governed by it). Thus the Argset of (64) will be the three element list

(65) {⟨der Arzt, Nom⟩, ⟨Peter, Acc⟩, ⟨von der Grippe, von + Dat⟩}.<sup>27</sup>

So the parser will assign to (63) not just the tree (64), but a pair consisting of (i) this tree and (ii) the corresponding ArgSet (65). To verify that its output is grammatical the parser must then check whether the ArgSet it has computed corresponds to one of the entries of the verb. Let us consider briefly what, given the assumptions we have so far made about the lexicon, such a check involves. The verb entries we have proposed in this paper associate with each verb a set of semantically obligatory arguments. These are then distinguished into three categories, the syntactically obligatory, the syntactically optional and the syntactically prohibited arguments. This threefold distinction has been made explicit in that the syntactically obligatory arguments appear in the specification of the verb’s argument struc-

<sup>26</sup> Frey has noted that the positions of quantificational argument phrases fully determine their scope so long as they occur in their base positions, but that scope ambiguities arise when one or more quantificational NPs have been moved. For instance, the sentence

(1) Der Arzt hat fast jeden seiner Patienten von mindestens einer Krankheit geheilt.  
(The doctor almost every patient of his of at least one disease cured.)

has only a reading in which *fast jeden seiner Patienten* has scope over *mindestens einer Krankheit*. In contrast,

(2) Von mindestens einer Krankheit hat dieser Arzt fast jeden seiner Patienten geheilt.  
is ambiguous between a reading in which *von mindestens einer Krankheit* has scope over *fast jeden seiner Patienten* and one in which *fast jeden seiner Patienten* has scope over *von mindestens einer Krankheit*.

<sup>27</sup> In most cases the case feature can be unambiguously read off from the argument phrase. But sometimes this is not so, cf the sentence *Eine Frau heilte eine Frau vom Lungenkrebs*.



The matching problem is slightly more complicated when the sentence's ArgSet contains semantically optional as well as semantically obligatory arguments. Consider for instance

- (43) (i) Der Arzt heilte den Patienten mit dem Skalpell.  
(The doctor cured the patient with his scalpel.)

The parser will assign this sentence the ArgSet

$\{\langle \textit{der Arzt}, \text{Nom} \rangle, \langle \textit{der Patient}, \text{Acc} \rangle, \langle \textit{das Skalpell}, \textit{mit} + \text{Dat} \rangle\}$ .

Intuitively the lexical entry which is realized by this ArgSet is the entry represented by (15.i.2), whose GrArg is

$\{\langle \text{Agent}, \text{Nom} \rangle, \langle \text{Theme}_1, \text{Acc} \rangle\}$ .

But in this case there is no straightforward 1-1 correspondence between the two sets. To see that the sets match nonetheless in the relevant sense, the parser must recognize the third member of the given ArgSet as representing an optional argument of the concept HEILEN. So long as we can take for granted that the input string is a grammatical sentence, this is unproblematic. The ArgSet member is semantically optional provided its generalized case information matches the generalized case information of none of the members of the entry's GrArg. So all that is needed in this case is that the GrArg of the given entry can be embedded within the ArgSet.

For cases like (43.i) our original matching requirement is thus too strict. Matching does not require a 1-1 correspondence between ArgSet and GrArg but an embedding of the latter into the former. But in general to require embedding and nothing else would not be quite good enough. For consider again our first example in this section:

- (63) Der Arzt heilte Peter von der Grippe.  
(The doctor cured Peter of the flu.)

If embedding were all we require, then the ArgSet of this sentence would match the entry (15.i.2) just as well as (15.i.1) and the parser would not know which of these two entries to choose. Intuitively this is wrong. The entry realized in (63) is (15.i.1), not (15.i.2). Choosing (15.i.2) would mean that the parser did not identify the phrase *von der Grippe* as expressing the Theme<sub>2</sub> of HEILEN. (Later in this section, when we describe how the chosen entry is used in constructing the DRS, it will become clear that choosing the second entry would not produce a DRS with the well-defined truth conditions). To prevent the parser from making the wrong choice

in this case, we must supplement the embedding requirement with a proviso to the effect that the part of ArgSet which is covered by the chosen embedding be *maximal*: The verb should not have another entry which permits a matching that covers a proper superset of the part covered by the selected entry.

It is not clear, however, how this proviso should be stated in general. Consider for instance the verb *beladen*, as it occurs in the sentences

- (67) (i) Er belud den Wagen mit Heu.  
(He loaded the cart with hay.)  
(ii) Er belud den Wagen mit der Heugabel.  
(He loaded the cart with a pitchfork.)

By the principles we have been applying to the analysis of *heilen* and other verbs, *beladen* has three semantically obligatory roles, Agent, Theme<sub>1</sub> (the thing that gets filled) and Theme<sub>2</sub> (that with which the Theme<sub>1</sub> is filled). For the entry of *beladen* instantiated in (67.i) the Theme<sub>2</sub> is syntactically optional, while the Agent and the Theme<sub>1</sub> are syntactically obligatory. In addition *beladen* allows Instrument as a semantically optional role, as shown in (67.ii). The problematic case for our proviso is (67.ii). If the parser opts for the maximal embedding, the *mit*-phrase will be identified as representing that which is loaded onto the cart. Admittedly this is a possible interpretation for (67.ii). But it is not the one that first comes to mind. To get the plausible reading, according to which the pitchfork is used to put something else onto the cart, the proviso would have to be suspended. At present we do not properly understand the principles that determine when the proviso should be operative and when not.

But let us return to the DRS construction of (63). The parser, we said, having arrived at a parse of the input sentence, and therewith of an identification of the sentence's ArgSet, must find an entry whose GrArg matches the ArgSet, in the sense of there being an embedding  $h$  from the former set into the latter which preserves the generalized case specifications. To insert the conceptual structure of the chosen entry into the DRS, the parser substitutes in the schematic DRS extracted from the entry in the manner described in section 7 for each schematic discourse referent corresponding to a member  $\langle r, g \rangle$  of GrArg the discourse referent introduced by the argument phrase  $h(\langle r, g \rangle)$ . The result of these substitutions is then attached to the  $V_0$  node of the parse tree, while the remaining schematic discourse referents are added to the local DRS universe.

Let us see how this procedure can be implemented in detail. We proceed in a manner consistent with the kind of construction procedure described by Kamp & Reyle (1993).

Once the parser has chosen a suitable entry for the verb and proved its suitability by embedding the entry's GrArg into the ArgSet of the parsed string, it has established four data structures:

- (i) the syntactic parse tree
- (ii) the ArgSet
- (iii) (a pointer towards) the chosen entry
- (iv) an embedding  $h$  from the GrArg of that entry into the ArgSet mentioned in (ii) which preserves general case specifications. In the case of (63) the result is as in (68).

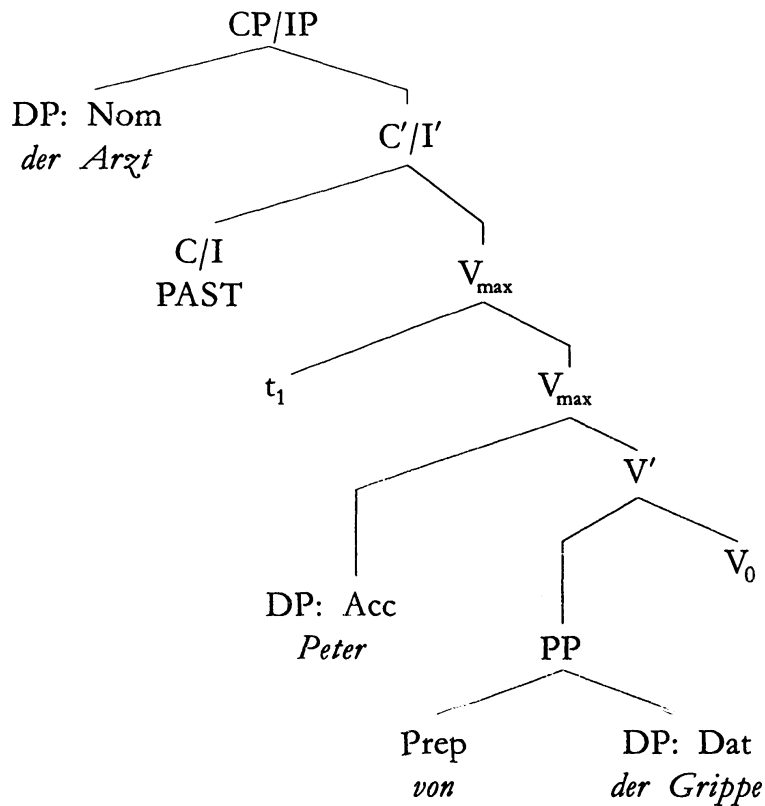
- (68) (i)
- 
- ```

graph TD
    CP_IP[CP/IP] --- DP_Nom["DP: Nom  
der Arzt"]
    CP_IP --- C_I_prime[C'/I']
    C_I_prime --- C_I["C/I  
heilte_0"]
    C_I_prime --- V_max_1[V_max]
    V_max_1 --- t1[t_1]
    V_max_1 --- V_max_2[V_max]
    V_max_2 --- DP_Acc["DP: Acc  
Peter"]
    V_max_2 --- V_prime[V']
    V_prime --- PP[PP]
    V_prime --- V_0["V_0  
t_0"]
    PP --- Prep["Prep  
von"]
    PP --- DP_Dat["DP: Dat  
der Grippe"]
  
```
- (ii)  $\{\langle \text{der Arzt, Nom} \rangle, \langle \text{Peter, Acc} \rangle, \langle \text{von der Grippe, von + Dat} \rangle\}$
- (iii) (15.i.1)
- (iv)  $\{h(\langle \text{Agent, Nom} \rangle) = \langle \text{der Arzt, Nom} \rangle,$   
 $h(\langle \text{Theme}_1, \text{Acc} \rangle) = \langle \text{Peter, Acc} \rangle,$   
 $h(\langle \text{Theme}_2, \text{von + Dat} \rangle) = \langle \text{von der Grippe, von + Dat} \rangle\}$



Proceeding along the lines of Kamp & Reyle (1993) we insert, as a first step in the DRS construction of the parsed sentence, the entire information package consisting of (i)–(iv) into the position occupied by the clause in the text DRS under construction. In the present case, where we assume that the context DRS into which (63) must be incorporated is empty, this step amounts to taking the information package as the single item inhabiting the DRS constructed so far and as occupying the top level of this DRS.

(69)

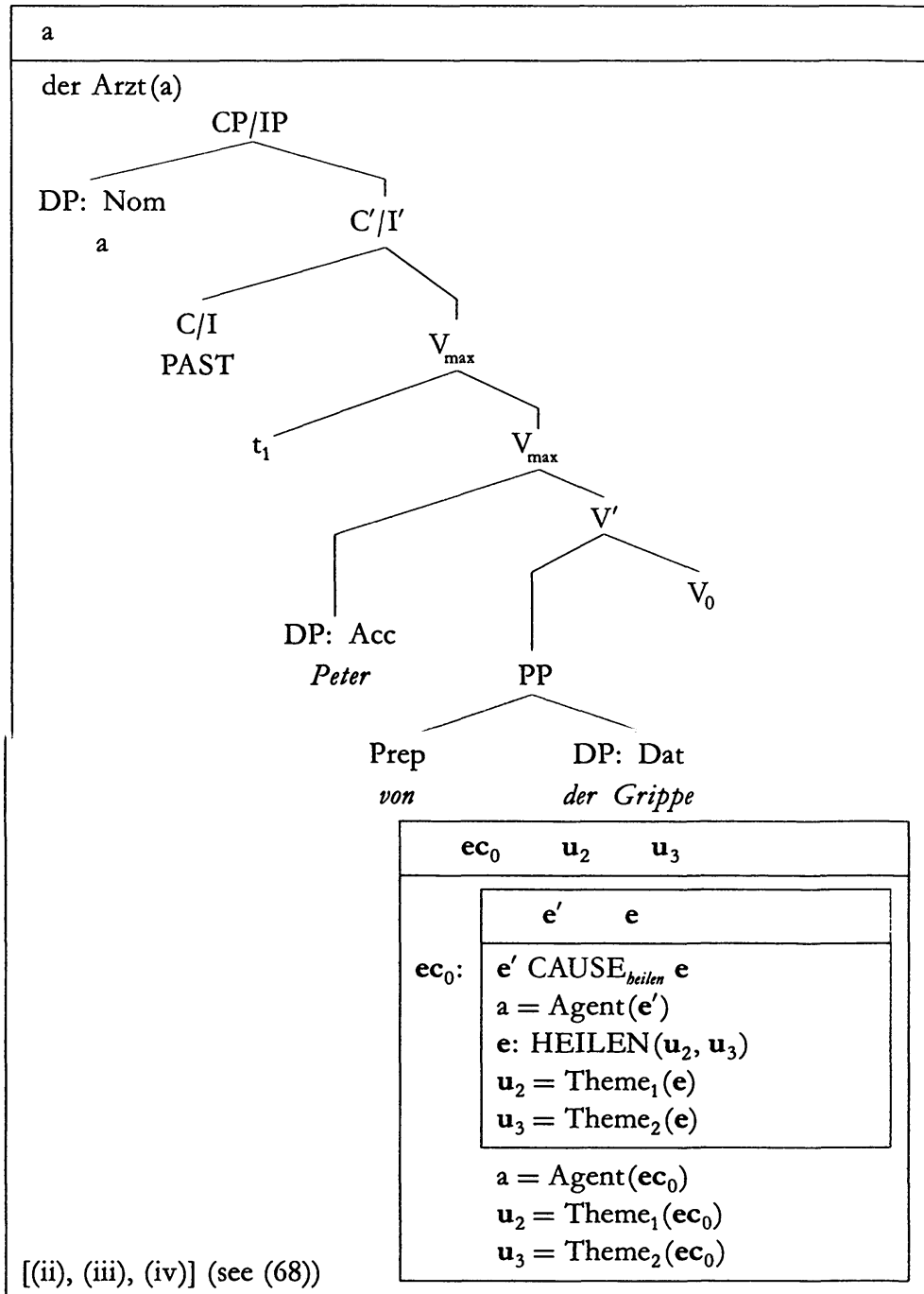


|          | $ec_0$                                                                                                                                               | $u_1$ | $u_2$ | $u_3$ |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|
|          |                                                                                                                                                      | $e'$  | $e$   |       |
| $ec_0$ : | $e'$ CAUSE <sub>heilen</sub> $e$<br>$u_1 = \text{Agent}(e')$<br>$e$ : HEILEN( $u_2, u_3$ )<br>$u_2 = \text{Theme}_1(e)$<br>$u_3 = \text{Theme}_2(e)$ |       |       |       |
|          | $u_1 = \text{Agent}(ec_0)$                                                                                                                           |       |       |       |
|          | $u_2 = \text{Theme}_1(ec_0)$                                                                                                                         |       |       |       |
|          | $u_3 = \text{Theme}_2(ec_0)$                                                                                                                         |       |       |       |

[(ii), (iii), (iv)] (see (68))

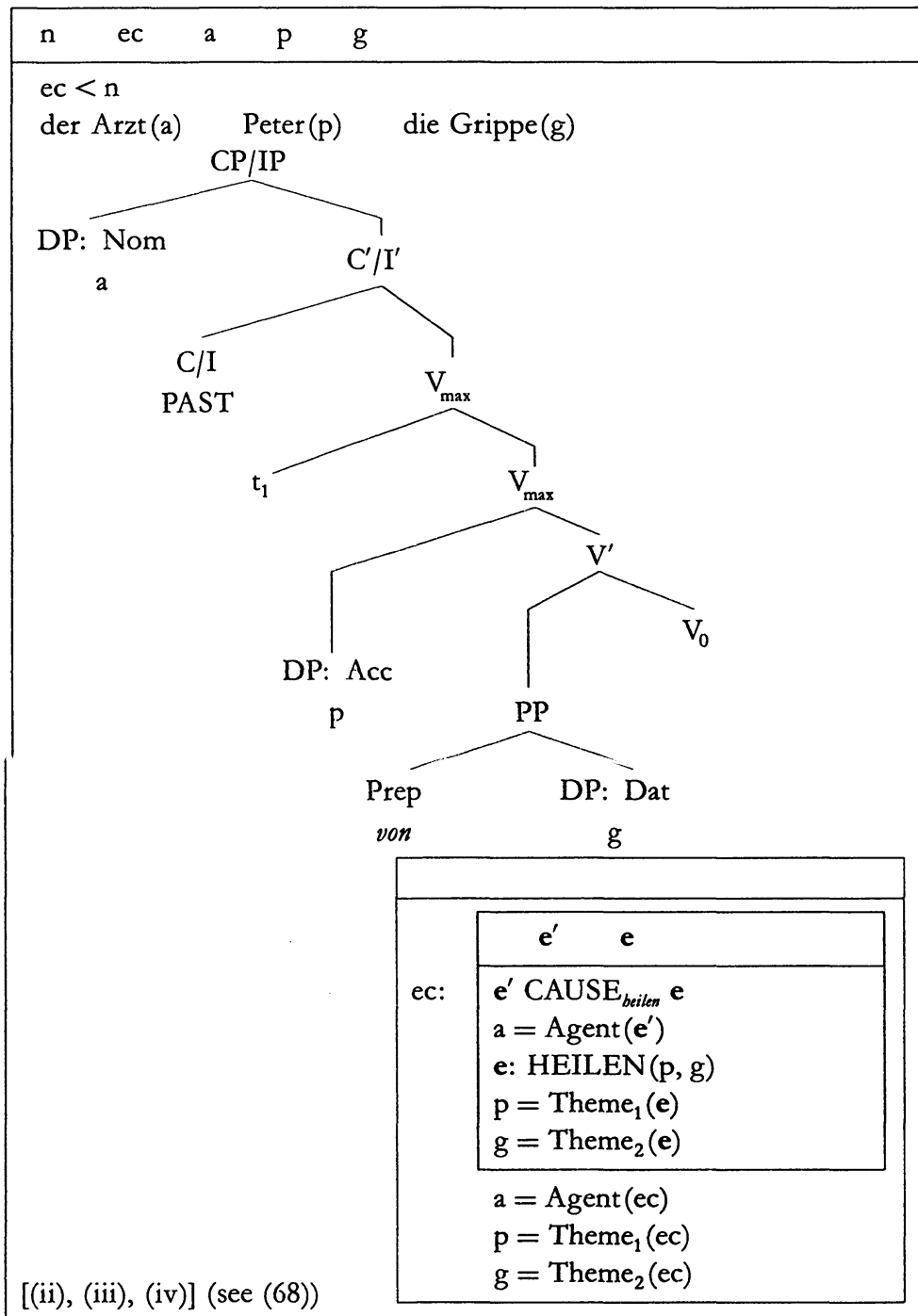
Next, we remove the actual occurrence of the verb from the tree and insert at the  $V_0$  node the schematic DRS obtained in the manner described in section 7, keeping (68. ii, iii, iv) in an auxiliary file. This yields the structure (69) (see page 155).

(70)



We now process the tree in the familiar way, starting with the NP *der Arzt*. As usual, a discourse referent, a, say, is introduced for this NP. Since by assumption we are interpreting (63) with respect to an empty context DRS, this discourse referent cannot be anchored, but must be added to the context “afresh” together with its determining condition, which for simplicity we

(71)



represent as “der Arzt(a)”. This much is familiar from existing construction algorithms and of no direct importance here. What is important is that within the schematic DRS which has been attached to the  $V_0$  node a gets identified with the schematic discourse referent corresponding to the member  $\langle r, g \rangle$  of GrArg such that  $\langle \text{der Arzt}, \text{Nom} \rangle = h(\langle r, g \rangle)$ . As ((69.iv) shows, the relevant member of GrArg is  $\langle \text{Agent}, \text{Nom} \rangle$ . The schematic discourse referent corresponding to this pair is  $u_1$ , something that follows directly from (i) the condition “Agent( $e'$ ) = x” in (15.i.1), (ii) the general principle that for causative verbs Agent( $e'$ ) = Agent(ec), and (iii) the fact that  $u_1$  is the schematic discourse referent replacing x in the transition from the conceptual structure of (15.i.1) to the schematic DRS. The identification of  $u_1$  with a has the effect of removing  $u_1$  from the universe of the schematic DRS and substituting a for it in all conditions of that DRS. In this way we obtain (70) (see page 156).

The other two argument phrases are processed analogously. The final step concerns the “binding” of the referential argument of the verb. We are assuming that this discourse referent is bound by the finite tense element associated with the C/I node. The binding takes the form of replacing the schematic discourse referent for the event (here:  $ec_0$ ) by a discourse referent which is placed in the relevant DRS universe and temporally related to the appropriate reference time (here: n).

The result of these operations is the structure (71) (see page 157).

Simplifying this in the usual way and throwing away the auxiliary file which has now done its duty we obtain the more familiar structure (72).

(72)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----------|---------------|---|------|---|--------------------------------|--|-------------------|--|-----------------|--|----------------------------|--|----------------------------|--|
| n                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | ec | a        | p             | g |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| $ec < n$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| der Arzt(a)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |    | Peter(p) | die Grippe(g) |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| ec:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| <table border="1" style="margin-left: 20px; border-collapse: collapse;"> <tr> <td style="text-align: center; padding: 2px;"><math>e'</math></td> <td style="text-align: center; padding: 2px;">e</td> </tr> <tr> <td colspan="2" style="padding: 2px;"><math>e'</math> CAUSE<sub>heilen</sub> e</td> </tr> <tr> <td colspan="2" style="padding: 2px;">a = Agent(<math>e'</math>)</td> </tr> <tr> <td colspan="2" style="padding: 2px;">e: HEILEN(p, g)</td> </tr> <tr> <td colspan="2" style="padding: 2px;">p = Theme<sub>1</sub>(e)</td> </tr> <tr> <td colspan="2" style="padding: 2px;">g = Theme<sub>2</sub>(e)</td> </tr> </table> |    |          |               |   | $e'$ | e | $e'$ CAUSE <sub>heilen</sub> e |  | a = Agent( $e'$ ) |  | e: HEILEN(p, g) |  | p = Theme <sub>1</sub> (e) |  | g = Theme <sub>2</sub> (e) |  |
| $e'$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | e  |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| $e'$ CAUSE <sub>heilen</sub> e                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| a = Agent( $e'$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| e: HEILEN(p, g)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| p = Theme <sub>1</sub> (e)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| g = Theme <sub>2</sub> (e)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| a = Agent(ec)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| p = Theme <sub>1</sub> (ec)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |
| g = Theme <sub>2</sub> (ec)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |    |          |               |   |      |   |                                |  |                   |  |                 |  |                            |  |                            |  |

We have gone through this rather tedious exercise in order to demonstrate explicitly how the syntax-semantics interface of our lexical entries comes into play when, in the construction of an actual DRS, the arguments of the entry's conceptual structure must be identified with the discourse referents introduced by the argument phrases which accompany the verb in its clause. Of course, there are various other ways of setting up the construction algorithm besides the one we have sketched. But in essence, the mechanism which establishes the right correlations between schematic discourse referents and real discourse referents will always be the same and will make use of the same interface information that our lexical entries encode.

Appendix 2. A list of lexical entries of verbs around *heilen*

|                                               |                                          |                    |
|-----------------------------------------------|------------------------------------------|--------------------|
| (E1) (i) (= 11)                               |                                          |                    |
| <i>heilen</i>                                 | $\{\langle\theta_1, \text{Nom}\rangle\}$ |                    |
|                                               | *organism(i)                             |                    |
| e: HEILEN( $y_{\text{th1}}, z_{\text{th2}}$ ) | Theme <sub>1</sub>                       | Theme <sub>2</sub> |
|                                               | SEL RESTR                                | SEL RESTR          |
|                                               | organism                                 | ailment            |
|                                               | or <b>body part</b>                      | or disease         |

Instance: (1) Der Fuß heilte

|                                               |                                                                                           |                    |
|-----------------------------------------------|-------------------------------------------------------------------------------------------|--------------------|
| (E1) (ii) (= 11.i)                            |                                                                                           |                    |
| <i>gesunden</i>                               | $\{\langle\theta_1, \text{Nom}\rangle, \langle\theta_2, \text{von} + \text{Dat}\rangle\}$ |                    |
|                                               | *body part(i)                                                                             |                    |
| e: HEILEN( $y_{\text{th1}}, z_{\text{th2}}$ ) | Theme <sub>1</sub>                                                                        | Theme <sub>2</sub> |
|                                               | SEL RESTR                                                                                 | SEL RESTR          |
|                                               | <b>organism</b>                                                                           | <b>ailment</b>     |
|                                               | or body part                                                                              | or <b>disease</b>  |

Instance: (2) Der Patient gesundete (von der Grippe)

|               |                                          |
|---------------|------------------------------------------|
| (E1) (iii)    |                                          |
| <i>heilen</i> | $\{\langle\theta_1, \text{Nom}\rangle\}$ |
|               | term, denoting                           |
|               | body part <i>and</i>                     |
|               | ailment                                  |

|                                 |                     |                    |
|---------------------------------|---------------------|--------------------|
| e: HEILEN( $y_{th1}, z_{th2}$ ) | Theme <sub>1</sub>  | Theme <sub>2</sub> |
|                                 | SEL RESTR           | SEL RESTR          |
|                                 | organism            | ailment            |
|                                 | or <b>body part</b> | or disease         |
|                                 |                     | <b>ailment,</b>    |
|                                 |                     | denoted by         |
|                                 |                     | DP: Nom            |

Instance: (3) Die Wunde heilte

(E1) (iv) (= 15.i)

|                                 |                                                                                                                                                                                                                                                                                                                                                                                 |                                                                           |   |                                             |               |            |                                   |                                 |              |                                    |  |         |  |  |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|---|---------------------------------------------|---------------|------------|-----------------------------------|---------------------------------|--------------|------------------------------------|--|---------|--|--|
|                                 | <i>heilen</i>                                                                                                                                                                                                                                                                                                                                                                   | {d< $\theta_1$ , Nom>, < $\theta_2$ , Acc>, << $\theta_3$ , von + Dat>>}} |   |                                             |               |            |                                   |                                 |              |                                    |  |         |  |  |
|                                 | <table border="1"> <tr> <td>e'</td> <td>e</td> </tr> </table>                                                                                                                                                                                                                                                                                                                   | e'                                                                        | e | Agent Theme <sub>1</sub> Theme <sub>2</sub> |               |            |                                   |                                 |              |                                    |  |         |  |  |
| e'                              | e                                                                                                                                                                                                                                                                                                                                                                               |                                                                           |   |                                             |               |            |                                   |                                 |              |                                    |  |         |  |  |
| ec:                             | <table border="1"> <tr> <td>e' CAUSE<sub>heilen</sub> e</td> <td></td> <td></td> </tr> <tr> <td>x = Agent(e')</td> <td>capable of</td> <td><b>organism</b> or <b>ailment</b></td> </tr> <tr> <td>e: HEILEN(<math>y_{th1}, z_{th2}</math>)</td> <td>an intention</td> <td><b>body part</b> or <b>disease</b></td> </tr> <tr> <td></td> <td>to cure</td> <td></td> </tr> </table> | e' CAUSE <sub>heilen</sub> e                                              |   |                                             | x = Agent(e') | capable of | <b>organism</b> or <b>ailment</b> | e: HEILEN( $y_{th1}, z_{th2}$ ) | an intention | <b>body part</b> or <b>disease</b> |  | to cure |  |  |
| e' CAUSE <sub>heilen</sub> e    |                                                                                                                                                                                                                                                                                                                                                                                 |                                                                           |   |                                             |               |            |                                   |                                 |              |                                    |  |         |  |  |
| x = Agent(e')                   | capable of                                                                                                                                                                                                                                                                                                                                                                      | <b>organism</b> or <b>ailment</b>                                         |   |                                             |               |            |                                   |                                 |              |                                    |  |         |  |  |
| e: HEILEN( $y_{th1}, z_{th2}$ ) | an intention                                                                                                                                                                                                                                                                                                                                                                    | <b>body part</b> or <b>disease</b>                                        |   |                                             |               |            |                                   |                                 |              |                                    |  |         |  |  |
|                                 | to cure                                                                                                                                                                                                                                                                                                                                                                         |                                                                           |   |                                             |               |            |                                   |                                 |              |                                    |  |         |  |  |

Instance: (4) Der Arzt heilte den Patienten (von der Krankheit)

(E1) (v) (= 15.ii)

|                                 |                                                                                                                                                                                                                                                                                                                                                                   |                                             |   |                                             |               |            |                         |                                 |              |                                |  |         |  |  |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|---|---------------------------------------------|---------------|------------|-------------------------|---------------------------------|--------------|--------------------------------|--|---------|--|--|
|                                 | <i>heilen</i>                                                                                                                                                                                                                                                                                                                                                     | {d< $\theta_1$ , Nom>, < $\theta_2$ , Acc>} |   |                                             |               |            |                         |                                 |              |                                |  |         |  |  |
|                                 | <table border="1"> <tr> <td>e'</td> <td>e</td> </tr> </table>                                                                                                                                                                                                                                                                                                     | e'                                          | e | Agent Theme <sub>1</sub> Theme <sub>2</sub> |               |            |                         |                                 |              |                                |  |         |  |  |
| e'                              | e                                                                                                                                                                                                                                                                                                                                                                 |                                             |   |                                             |               |            |                         |                                 |              |                                |  |         |  |  |
| ec:                             | <table border="1"> <tr> <td>e' CAUSE<sub>heilen</sub> e</td> <td></td> <td></td> </tr> <tr> <td>x = Agent(e')</td> <td>capable of</td> <td>organism <b>ailment</b></td> </tr> <tr> <td>e: HEILEN(<math>y_{th1}, z_{th2}</math>)</td> <td>an intention</td> <td>or body part or <b>disease</b></td> </tr> <tr> <td></td> <td>to cure</td> <td></td> </tr> </table> | e' CAUSE <sub>heilen</sub> e                |   |                                             | x = Agent(e') | capable of | organism <b>ailment</b> | e: HEILEN( $y_{th1}, z_{th2}$ ) | an intention | or body part or <b>disease</b> |  | to cure |  |  |
| e' CAUSE <sub>heilen</sub> e    |                                                                                                                                                                                                                                                                                                                                                                   |                                             |   |                                             |               |            |                         |                                 |              |                                |  |         |  |  |
| x = Agent(e')                   | capable of                                                                                                                                                                                                                                                                                                                                                        | organism <b>ailment</b>                     |   |                                             |               |            |                         |                                 |              |                                |  |         |  |  |
| e: HEILEN( $y_{th1}, z_{th2}$ ) | an intention                                                                                                                                                                                                                                                                                                                                                      | or body part or <b>disease</b>              |   |                                             |               |            |                         |                                 |              |                                |  |         |  |  |
|                                 | to cure                                                                                                                                                                                                                                                                                                                                                           |                                             |   |                                             |               |            |                         |                                 |              |                                |  |         |  |  |

Instance: (5) Der Arzt heilte die Krankheit

(E1) (vi)

|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                   |   |                                             |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|---|---------------------------------------------|---------------|------------|------------------|---------------------------------|--------------|--------------------------------|--|---------|-----------------|--|--|---------|--|--|------------|--|
|                                 | <i>heilen</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                | {d< $\theta_1$ , Nom>, < $\theta_2$ , Acc>}       |   |                                             |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |
|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | term, denoting<br>body part <i>and</i><br>ailment |   |                                             |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |
|                                 | <table border="1"> <tr> <td>e'</td> <td>e</td> </tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                | e'                                                | e | Agent Theme <sub>1</sub> Theme <sub>2</sub> |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |
| e'                              | e                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                   |   |                                             |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |
| ec:                             | <table border="1"> <tr> <td>e' CAUSE<sub>heilen</sub> e</td> <td></td> <td></td> </tr> <tr> <td>Agent(e') = x</td> <td>capable of</td> <td>organism ailment</td> </tr> <tr> <td>e: HEILEN(<math>y_{th1}, z_{th2}</math>)</td> <td>an intention</td> <td>or <b>body part</b> or disease</td> </tr> <tr> <td></td> <td>to cure</td> <td><b>ailment,</b></td> </tr> <tr> <td></td> <td></td> <td>denoted</td> </tr> <tr> <td></td> <td></td> <td>by DP: Acc</td> </tr> </table> | e' CAUSE <sub>heilen</sub> e                      |   |                                             | Agent(e') = x | capable of | organism ailment | e: HEILEN( $y_{th1}, z_{th2}$ ) | an intention | or <b>body part</b> or disease |  | to cure | <b>ailment,</b> |  |  | denoted |  |  | by DP: Acc |  |
| e' CAUSE <sub>heilen</sub> e    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                   |   |                                             |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |
| Agent(e') = x                   | capable of                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | organism ailment                                  |   |                                             |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |
| e: HEILEN( $y_{th1}, z_{th2}$ ) | an intention                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | or <b>body part</b> or disease                    |   |                                             |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |
|                                 | to cure                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>ailment,</b>                                   |   |                                             |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |
|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | denoted                                           |   |                                             |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |
|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | by DP: Acc                                        |   |                                             |               |            |                  |                                 |              |                                |  |         |                 |  |  |         |  |  |            |  |

Instance: (6) Der Arzt heilte die Wunde

(E1) (iv')

|     |                                                 |                                                                           |
|-----|-------------------------------------------------|---------------------------------------------------------------------------|
|     | <i>heilen</i>                                   | {d< $\theta_1$ , Nom>, < $\theta_2$ , Acc>, << $\theta_3$ , von + Dat>>}} |
|     |                                                 | Causer            Theme <sub>1</sub> Theme <sub>2</sub>                   |
|     |                                                 | SEL RESTR      SEL RESTR      SEL RESTR                                   |
| ec: | $e'$ CAUSE <sub>heilen</sub> e                  | natural force, <b>organism</b> or <b>ailment</b>                          |
|     | x = Agent(e')                                   | medicine <b>body part</b> or <b>disease</b>                               |
|     | e: HEILEN(y <sub>th1</sub> , z <sub>th2</sub> ) | or drug                                                                   |

Instance: (4') Die Kamille heilte den Patienten (von der Grippe)

Axioms for classes of concepts

|                                                                |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                   |
|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------|-----------------------------------------|---|-----------------------------------------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------------------------------------------------|-------------------|
| (18)                                                           | <table border="1"> <tr><td>e    u<sub>1</sub> ... u<sub>n</sub></td></tr> <tr><td>C(e)</td></tr> <tr><td>u<sub>1</sub> = Theme<sub>1</sub>(e)</td></tr> <tr><td>.</td></tr> <tr><td>u<sub>n</sub> = Theme<sub>n</sub>(e)</td></tr> </table> | e    u <sub>1</sub> ... u <sub>n</sub> | C(e) | u <sub>1</sub> = Theme <sub>1</sub> (e) | . | u <sub>n</sub> = Theme <sub>n</sub> (e) | ⇒ | <table border="1"> <tr><td>s<sub>2</sub></td></tr> <tr><td>s<sub>2</sub>: RES(C)(u<sub>1</sub>, ..., u<sub>n</sub>)</td></tr> <tr><td>e)(s<sub>2</sub></td></tr> </table> | s <sub>2</sub> | s <sub>2</sub> : RES(C)(u <sub>1</sub> , ..., u <sub>n</sub> ) | e)(s <sub>2</sub> |
| e    u <sub>1</sub> ... u <sub>n</sub>                         |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                   |
| C(e)                                                           |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                   |
| u <sub>1</sub> = Theme <sub>1</sub> (e)                        |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                   |
| .                                                              |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                   |
| u <sub>n</sub> = Theme <sub>n</sub> (e)                        |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                   |
| s <sub>2</sub>                                                 |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                   |
| s <sub>2</sub> : RES(C)(u <sub>1</sub> , ..., u <sub>n</sub> ) |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                   |
| e)(s <sub>2</sub>                                              |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                   |

(19) s: PRE(C)(u, v) ⇔ s: ¬∩ RES(C)(u, v)

|                                                                |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                    |
|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------|-----------------------------------------|---|-----------------------------------------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------------------------------------------------|--------------------|
| (20)                                                           | <table border="1"> <tr><td>e    u<sub>1</sub> ... u<sub>n</sub></td></tr> <tr><td>C(e)</td></tr> <tr><td>u<sub>1</sub> = Theme<sub>1</sub>(e)</td></tr> <tr><td>.</td></tr> <tr><td>u<sub>n</sub> = Theme<sub>n</sub>(e)</td></tr> </table> | e    u <sub>1</sub> ... u <sub>n</sub> | C(e) | u <sub>1</sub> = Theme <sub>1</sub> (e) | . | u <sub>n</sub> = Theme <sub>n</sub> (e) | ⇒ | <table border="1"> <tr><td>s<sub>1</sub></td></tr> <tr><td>s<sub>1</sub>: PRE(C)(u<sub>1</sub>, ..., u<sub>n</sub>)</td></tr> <tr><td>s<sub>1</sub>)(e</td></tr> </table> | s <sub>1</sub> | s <sub>1</sub> : PRE(C)(u <sub>1</sub> , ..., u <sub>n</sub> ) | s <sub>1</sub> )(e |
| e    u <sub>1</sub> ... u <sub>n</sub>                         |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                    |
| C(e)                                                           |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                    |
| u <sub>1</sub> = Theme <sub>1</sub> (e)                        |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                    |
| .                                                              |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                    |
| u <sub>n</sub> = Theme <sub>n</sub> (e)                        |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                    |
| s <sub>1</sub>                                                 |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                    |
| s <sub>1</sub> : PRE(C)(u <sub>1</sub> , ..., u <sub>n</sub> ) |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                    |
| s <sub>1</sub> )(e                                             |                                                                                                                                                                                                                                             |                                        |      |                                         |   |                                         |   |                                                                                                                                                                           |                |                                                                |                    |

|                                                  |                                                                                                                                              |                               |                                                  |   |                                                                                 |                                     |
|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|--------------------------------------------------|---|---------------------------------------------------------------------------------|-------------------------------------|
| (14)                                             | <table border="1"> <tr><td>e<sub>1</sub>    e<sub>2</sub></td></tr> <tr><td>e<sub>1</sub> CAUSE<sub>v</sub> e<sub>2</sub></td></tr> </table> | e <sub>1</sub> e <sub>2</sub> | e <sub>1</sub> CAUSE <sub>v</sub> e <sub>2</sub> | ⇒ | <table border="1"> <tr><td>e<sub>1</sub> CAUSE e<sub>2</sub></td></tr> </table> | e <sub>1</sub> CAUSE e <sub>2</sub> |
| e <sub>1</sub> e <sub>2</sub>                    |                                                                                                                                              |                               |                                                  |   |                                                                                 |                                     |
| e <sub>1</sub> CAUSE <sub>v</sub> e <sub>2</sub> |                                                                                                                                              |                               |                                                  |   |                                                                                 |                                     |
| e <sub>1</sub> CAUSE e <sub>2</sub>              |                                                                                                                                              |                               |                                                  |   |                                                                                 |                                     |

|                                  |                                                                                                               |               |                                  |   |                                                                     |                       |
|----------------------------------|---------------------------------------------------------------------------------------------------------------|---------------|----------------------------------|---|---------------------------------------------------------------------|-----------------------|
| (26)                             | <table border="1"> <tr><td>ec    e'    e</td></tr> <tr><td>ec: e' CAUSE<sub>heilen</sub> e</td></tr> </table> | ec    e'    e | ec: e' CAUSE <sub>heilen</sub> e | ⇒ | <table border="1"> <tr><td>Agent(ec) = Agent(e')</td></tr> </table> | Agent(ec) = Agent(e') |
| ec    e'    e                    |                                                                                                               |               |                                  |   |                                                                     |                       |
| ec: e' CAUSE <sub>heilen</sub> e |                                                                                                               |               |                                  |   |                                                                     |                       |
| Agent(ec) = Agent(e')            |                                                                                                               |               |                                  |   |                                                                     |                       |

|                                                  |                                                                                                               |               |                                  |   |                                                                                            |                                                  |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------|----------------------------------|---|--------------------------------------------------------------------------------------------|--------------------------------------------------|
| (27)                                             | <table border="1"> <tr><td>ec    e'    e</td></tr> <tr><td>ec: e' CAUSE<sub>heilen</sub> e</td></tr> </table> | ec    e'    e | ec: e' CAUSE <sub>heilen</sub> e | ⇒ | <table border="1"> <tr><td>Theme<sub>i</sub>(ec) = Theme<sub>i</sub>(e)</td></tr> </table> | Theme <sub>i</sub> (ec) = Theme <sub>i</sub> (e) |
| ec    e'    e                                    |                                                                                                               |               |                                  |   |                                                                                            |                                                  |
| ec: e' CAUSE <sub>heilen</sub> e                 |                                                                                                               |               |                                  |   |                                                                                            |                                                  |
| Theme <sub>i</sub> (ec) = Theme <sub>i</sub> (e) |                                                                                                               |               |                                  |   |                                                                                            |                                                  |

|                                  |                                                                                                               |               |                                  |   |                                                                               |                                 |
|----------------------------------|---------------------------------------------------------------------------------------------------------------|---------------|----------------------------------|---|-------------------------------------------------------------------------------|---------------------------------|
| (27')                            | <table border="1"> <tr><td>ec    e'    e</td></tr> <tr><td>ec: e' CAUSE<sub>heilen</sub> e</td></tr> </table> | ec    e'    e | ec: e' CAUSE <sub>heilen</sub> e | ⇒ | <table border="1"> <tr><td>Instrument(ec) = Instrument(e')</td></tr> </table> | Instrument(ec) = Instrument(e') |
| ec    e'    e                    |                                                                                                               |               |                                  |   |                                                                               |                                 |
| ec: e' CAUSE <sub>heilen</sub> e |                                                                                                               |               |                                  |   |                                                                               |                                 |
| Instrument(ec) = Instrument(e')  |                                                                                                               |               |                                  |   |                                                                               |                                 |

|                                  |                                                                                                               |               |                                  |   |                                                                       |                         |
|----------------------------------|---------------------------------------------------------------------------------------------------------------|---------------|----------------------------------|---|-----------------------------------------------------------------------|-------------------------|
| (27'')                           | <table border="1"> <tr><td>ec    e'    e</td></tr> <tr><td>ec: e' CAUSE<sub>heilen</sub> e</td></tr> </table> | ec    e'    e | ec: e' CAUSE <sub>heilen</sub> e | ⇒ | <table border="1"> <tr><td>Causer(ec) = Causer(e')</td></tr> </table> | Causer(ec) = Causer(e') |
| ec    e'    e                    |                                                                                                               |               |                                  |   |                                                                       |                         |
| ec: e' CAUSE <sub>heilen</sub> e |                                                                                                               |               |                                  |   |                                                                       |                         |
| Causer(ec) = Causer(e')          |                                                                                                               |               |                                  |   |                                                                       |                         |

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