The key role of semantics in the development of large-scale grammars of natural language

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Abstract

The aim of this paper is to show how large-scale (computational) grammars of natural language benefit from an organization of semantics which is based on Minimal Recursion Semantics (MRS; Copestake et al. (1999)). This we are doing by providing an account of valence alternations in German based on MRS, showing how such an account makes a computational grammar more efficient and less complicated for the grammar writer.

1 Introduction

The valence alternations in German that we focus on in this paper are the ones involving direct internal arguments (i.e., objects) and indirect prepositional complements: NP_k V NP_i [P NP_j] $\rightarrow$ NP_k V NP_j [P NP_i], where the indices denote referential identity.

Such alternation patterns in German characterize among others the behaviour of verbal predicates which participate in the so-called Locative Alternation phenomena.

2 Locative Alternation in German: Overview

2.1 The verbs *gießen* and *füllen*

Consider the following sentences in German:

(1) Peter goß die Blumen mit Wasser.
Peter poured the flowers.A with water
"Peter watered the flowers".

(2) Peter goß Wasser auf die Blumen.

(3) Peter füllte den Tank (mit Wasser).
Peter.N filled the tank.A (with water)
"Peter filled the tank (with water)".

(4) Peter füllte Wasser in den Tank.

(1)-(4) are examples of German predicates which participate in the so-called Locative alternation phenomena (see among others Dowty (1991), Rappaport and Levin (1988), Levin and Rapapport Hovav (1991)). Alternations in German with the locative verbs *füllen* (fill) and *gießen* (pour) are of the general form presented in Section (1). The main features of these verbs in German (English, Modern Greek, and some other languages) is that they are morphologically identical and that they involve two arguments: one denoting a *location* and one denoting the *locatum* (*die Blumen* (flowers)/*den Tank* (tank) and *Wasser* (water), respectively, in (1)-(4) above).

2.2 Removal Predicates

The *removal* predicates in German also take *locatum* and *location* arguments and they are distinguished in the following groups:

1. Predicates (like *leeren/entleeren* (empty)) which imply a change of state of the *location* argument when it is realized as the direct object of the verb:

   (5) Peter leerte den Tank.
   Peter.N emptied the tank.A
   "Peter emptied the tank".

   (6) Peter leerte das Wasser aus dem Tank.
   Peter emptied the water.A from the tank
   "Peter emptied the water from the tank".

2. Predicates which denote a contact with the *location*, as well as a change of location. These predicates may also specify the manner or the instrument related to the action of moving (*wischen* (wipe)). *wischen* does not admit a *von*-PP (of/from-PP) complement when its *location* argument is realized as the direct object (example (7)). In this case *wischen* does *not* entail the existence of a *locatum* argument. For instance, the act of wiping a board does not necessarily result in wiping something off it.

   (7) *Peter wischte die Tafel von Kreide.
   Peter.N wiped the board.A from chalk
   "*Peter wiped the board of chalk".

   (8) Peter wischte die Kreide von der Tafel.
   Peter.N wiped the chalk.A from the board
   "Peter wiped the chalk from the board".

3. *säubern* (trim) is different than *wischen* (wipe), though, in the sense that "trimming an object" necessarily means "trimming something off this object":

   (9) Peter säuberte den Busch von trockenen
   Peter.N trimmed the bush.A of dry
   Ästen.
   branches
   "Peter trimmed the bush of dry branches".

2.3 Impingement Predicates

A typical impingement verb in German is *schlagen* (hit). According to Dowty (1991), the verb *hit* (in English) does not imply any change of state for any of its arguments which may surface syntactically as direct object. The same semantic entailments also hold for the German verb *schlagen*. *schlagen* is an assymetric predicate in that when the *location* argument is realized as the direct object of the predicate the *locatum* argument is optional, but when the *locatum* argument is realized as the direct object all arguments are obligatory.

(10) Peter schlägt den Gong (mit dem Klöppel).
Peter.N hits the gong.A (with the clapper)
"Peter hits the gong with the clapper".

(11) Peter schlägt den Klöppel gegen den Gong.
Peter.N hits the clapper.A against the gong
"Peter hits the clapper against the gong".

(12) *Peter schlägt den Klöppel.

For verbs in the *schlagen* (hit) subclass of German, the *mit* (with) alternant (example (10)) entails that one of the arguments (i.e., the *locatum*) is understood as the instrument ("means") which is used by the actor in order to perform the action denoted by the verb. The "*gegen*" (against) alternant (see example (11)), on the other hand, entails that the *locatum* undergoes directed motion.

3 Locative Alternation in German: The Analysis

The account we suggest here for locative alternation in German (see examples in Section (2) above) follows the proposal of Koenig and Davis (2000) for valence alternations, including locative alternation in English. Their analysis is based on a minimal recursion approach to semantic representation and is formalized using the Minimal Recursion Semantics (MRS) framework of Copestake et al. (1999). In brief, Minimal Recursion Semantics is a framework for computational semantics, in which the meaning of expressions is represented as a flat bag of Elementary Predications (or EPs) encoded as values of a LISZT attribute. The denotation of this bag is equivalent to the logical conjunction of its members. Scope relations between EPs are represented as explicit relations among EPs. Such scope relations can also be underspecified. The assumption of current MRS is that each lexical item (other than those with empty EP bags) has a single distinguished main EP, which is referred to as the *KEY* EP. All other EPs share a label with the KEY EP. According to Koenig and Davis (2000), for situation-denoting EPs, which are also most interesting for our purposes here, the following generalizations hold: (i) EPs do not encode recursively embedded state-of-affairs (SOAs); (ii) EPs can have one, two, or three arguments; (iii) if an EP has three arguments, then one of them is a state-of-affairs, and another is an undergoer coindexed with an argument of the embedded state-of-affairs. Finally, as far as direct arguments are concerned, in Koenig and Davis (2000) these are predicted to link off the value of the KEY attribute.

3.1 The verbs *gießen* and *füllen*

Following the *lexical list hypothesis* of Koenig and Davis (2000), according to which lexical items in-

clude more than one EPs in their semantic content, but lexically they select only one of these EPs as their KEY, we propose that the semantic properties of the arguments of the verb *gießen* (water) in example (1) of Section (2.1) above are captured by the following semantic type:

(13) CONTENT value of $gießen_{\text{mit}}$

$$\left[\begin{array}{l}\text{KEY } \boxed{3}\left[\begin{array}{l}gießen\text{-}ch\text{-}of\text{-}st\text{-}rel\\ \text{ACT } \boxed{1}(Peter)\\ \text{UND } \boxed{2}(die\ Blumen)\\ \text{SOA}\left[\begin{array}{l}ch\text{-}of\text{-}st\text{-}rel\\ \text{UND } \boxed{2}\end{array}\right]\end{array}\right]\\ \text{LISZT } \langle \boxed{3}, \left[\begin{array}{l}mit\text{-}rel\\ \text{ACT } \boxed{1}\\ \text{UND } \boxed{4}\\ \text{SOA } \boxed{3}\end{array}\right], \left[\begin{array}{l}gießen\text{-}ch\text{-}of\text{-}loc\text{-}rel\\ \text{ACT } \boxed{1}\\ \text{UND } \boxed{4}(Wasser)\\ \text{SOA}\left[\begin{array}{l}ch\text{-}of\text{-}loc\text{-}rel\\ \text{FIG } \boxed{4}\end{array}\right]\end{array}\right]\rangle\end{array}\right]$$

(13) above captures that the *mit* (with) alternant of the German locative verb *gießen* (example (1)) denotes situations that must be both changes of state and changes of location.

The locative alternant of the verb *gießen* (example (2) of Section (2.1)) denotes only a simple change of location. This is captured by the following semantic type:

(14) CONTENT value of $gießen_{\text{loc}}$

$$\left[\begin{array}{l}\text{KEY } \boxed{5}\left[\begin{array}{l}gießen\text{-}ch\text{-}of\text{-}loc\text{-}rel\\ \text{ACT } \boxed{1}(Peter)\\ \text{UND } \boxed{4}(Wasser)\\ \text{SOA}\left[\begin{array}{l}ch\text{-}of\text{-}loc\text{-}rel\\ \text{FIG } \boxed{4}\end{array}\right]\end{array}\right]\\ \text{LISZT } \langle \boxed{5} \rangle\end{array}\right]$$

The analysis presented above holds also for both alternants of the verb *füllen* (fill; examples (3) and (4) in Section (2.1)). One clarification is due here concerning the *mit* (with) alternant of the verb *füllen* (example (3) of Section (2.1)), where the PP (*mit Wasser*) appears to be optional: we assume that the PP carries existential import, even when it is not syntactically overt.

3.2 Removal Predicates

In the spirit of the MRS-based analysis for the German verbs *gießen* and *füllen* that we have presented above, we propose that the semantic properties of the arguments of one of the most representative verbs of the *removal predicates* class in German, the verb *wischen* (wipe), which denotes a change of location, when a *locatum* argument is realized as its direct object (see example (8) in Section (2.2)), are captured by the following type:

(15) CONTENT value of $wischen_{\text{loc}}$

$$\left[\begin{array}{l}\text{KEY } \boxed{5}\left[\begin{array}{l}wischen\text{-}ch\text{-}of\text{-}loc\text{-}rel\\ \text{ACT } \boxed{1}(Peter)\\ \text{UND } \boxed{4}(die\ Kreide)\\ \text{SOA}\left[\begin{array}{l}ch\text{-}of\text{-}loc\text{-}rel\\ \text{FIG } \boxed{4}\end{array}\right]\end{array}\right]\\ \text{LISZT } \langle \boxed{5} \rangle\end{array}\right]$$

säubern (trim; see example (9) in Section (2.2) and (16) below) is different than *wischen*:

(16) CONTENT value of $säubern_{\text{von}}$

$$\left[\begin{array}{l}\text{KEY } \boxed{3}\left[\begin{array}{l}säubern\text{-}ch\text{-}of\text{-}st\text{-}rel\\ \text{ACT } \boxed{1}(Peter)\\ \text{UND } \boxed{2}(den\ Busch)\\ \text{SOA}\left[\begin{array}{l}ch\text{-}of\text{-}st\text{-}rel\\ \text{UND } \boxed{2}\end{array}\right]\end{array}\right]\\ \text{LISZT } \langle \boxed{3}, \left[\begin{array}{l}von\text{-}rel\\ \text{ACT } \boxed{1}\\ \text{UND } \boxed{4}\\ \text{SOA } \boxed{3}\end{array}\right], \left[\begin{array}{l}säubern\text{-}ch\text{-}of\text{-}loc\text{-}rel\\ \text{ACT } \boxed{1}\\ \text{UND } \boxed{4}(Ästen)\\ \text{SOA}\left[\begin{array}{l}ch\text{-}of\text{-}loc\text{-}rel\\ \text{FIG } \boxed{4}\end{array}\right]\end{array}\right]\rangle\end{array}\right]$$

That is, as (16) above captures, in German trimming necessarily results in trimming something off something else; in the case of example (9) above trimming the bush results in trimming the dry branches off the bush. And this is what the semantic type in (16) captures.

3.3 Impingement Predicates

In order to capture the semantic properties of the arguments of the most representative verb of the *impingement predicates* class in German, the verb *schlagen* (hit) in examples (10)-(12) above, we propose the semantic types in (17) and (18), which are in the spirit of the MRS-based analysis that we have presented for the verbs *gießen* and *füllen* and for the *removal* predicates in German.

(17) and (18) capture that the German impingement verb *schlagen* (hit) is an assymetric predicate in that when the *location* argument is realized as the direct object of the predicate the *locatum* argument might be optional (see SOA $\boxed{5}$ in (18)), but when the *locatum* argument is realized as the direct object all arguments are obligatory

(see (17)). (17) and (18) also capture that the *mit* (with) alternant of the German impingement verb *schlagen* (hit) (see example (10)) entails that one of the verbal arguments, i.e., the *locatum*, is understood as the instrument which is used by the actor in order to perform the action denoted by the verb, while the other alternant (see example (11)) entails that the *locatum* undergoes directed motion; it is moved by the actor into contact with the location.

(17) CONTENT value of $schlagen_{\mathrm{dmtc}}$[1,2]

$$\left[\begin{array}{ll} \mathrm{KEY}\ \boxed{7} & \left[\begin{array}{l} \textit{schlagen-directed\_motion\_to\_contact-rel} \\ \mathrm{ACT}\ \boxed{1}\,(\textit{Peter}) \\ \mathrm{UND}\ \boxed{4}\,(\textit{den Klöppel}) \\ \mathrm{SOA}\ \boxed{3}\ \left[\begin{array}{l} \textit{directed\_motion\_to\_contact-rel} \\ \mathrm{FIG}\ \boxed{4} \\ \mathrm{GRND}\ \boxed{8}\,(\textit{den Gong}) \end{array}\right] \end{array}\right] \\ \mathrm{LISZT}\ \langle \boxed{7}, \left[\begin{array}{ll} \textit{gegen-rel} & \\ \mathrm{ACT} & \boxed{1} \\ \mathrm{UND} & \boxed{8} \\ \mathrm{SOA} & \boxed{7} \end{array}\right] \rangle & \end{array}\right]$$

(18) CONTENT value of $schlagen_{\mathrm{mit}}$

$$\left[\begin{array}{ll} \mathrm{KEY}\ \boxed{5} & \left[\begin{array}{l} \textit{schlagen-rel} \\ \mathrm{ACT}\ \boxed{1}\,(\textit{Peter}) \\ \mathrm{UND}\ \boxed{3}\,(\textit{den Gong}) \end{array}\right] \\ \mathrm{LISZT}\ \langle \boxed{5}, \left[\begin{array}{l} \textit{mit-rel} \\ \mathrm{ACT}\ \boxed{1} \\ \mathrm{UND}\ \boxed{4}\,(\textit{Klöppel}) \\ \mathrm{SOA}\ \boxed{6}\ \left[\begin{array}{l} \textit{contact-rel} \\ \mathrm{ACT}\ \boxed{4} \\ \mathrm{UND}\ \boxed{3} \\ \mathrm{SOA}\ (\boxed{5}) \end{array}\right] \end{array}\right], \left[\begin{array}{l} \textit{schl-dmtc-rel} \\ \mathrm{ACT}\ \boxed{1} \\ \mathrm{UND}\ \boxed{4} \\ \mathrm{SOA}\ \left[\begin{array}{l} \textit{dmtc-rel} \\ \mathrm{FIG}\ \boxed{4} \\ \mathrm{GRND}\ \boxed{3} \end{array}\right] \end{array}\right] \rangle & \end{array}\right]$$

4 Conclusions and Outlook

As a final general comment we need to underline that the MRS-based analysis we have presented in Section (3) above allows for a linguistically motivated account of the syntactic properties of apparent semantic doublets (i.e., what we have called "valence alternants"), which avoids the processing load problems that are inseparable from (directional or even bi-directional à la Flickinger (1987)) lexical rule approaches to verbal alternations in particular and to development of (the lexicon of) large-scale computational grammars of natural language based on HPSG in general. As an immediate consequence, (the lexicon of) a large-scale computational grammar of German, like the one described in Müller and Kasper (2000), may become even more efficient, since it needs to depend on fewer or even no lexical rules at all, and thus less complicated for the grammar writer to maintain, as well as to develop further (NB: this is not incompatible at all with the ideas expressed in Copestake (2002) about the organization of the lexicon in an LKB grammar). Here we focussed on (some of) the theoretical assumptions upon which the achievement of such a goal can be based realistically. A presentation of the technical details of the LKB implementation of the grammar fragment that we have described above, which practically does not differ much from what we have presented in the types of Section (3), is not included here due to lack of space, but is available for the presentation of the paper.

[1] dmtc stands for directed_motion_to_contact.

[2] FIG(URE) denotes the moving entity (*locatum*); GRND (GROUND) denotes the contacted location.

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