An LFG Grammar Checker for CALL

Christian Fortmann, Martin Forst
Institute for Natural Language Processing
{fortmann|forst}@ims.uni-stuttgart.de

Abstract

In this paper we present the possibilities of modifying an existing broad-coverage LFG for German in such a way that it can be used as a grammar checker in L2 learning that not only states whether or not the learner's input is grammatical, but also provides crucial information necessary for generating helpful feedback as to what has to be corrected. The necessary modifications, which consist basically in anticipating malrules, are exemplified with a number of notorious systematic errors L2 learners of German typically commit, such as the non-compliance of constraints on verb placement, the use of pragmatically inadequate constituent orders and agreement violations. At present, the modified grammar covers the most frequent error types of L2 learners. However, more corpus work is needed for extension and evaluation.

1. Introduction

Grammar acquisition is a fundamental part of second language learning. A comprehensive CALL program for L2 learning must therefore be equipped with a grammar component which supports and guides the learner's activities. CALL is subject to the general conditions of L2 learning as well as to specific conditions due to the technical device.
L2 learning does not proceed in an unconscious and spontaneous way, but is a process of conscious rule learning. As the learners already have acquired an L1 language (or even another L2 language), the grammar of the native language interferes. Learners often hypothesize grammatical generalizations which are incorrect with respect to the language to be learned, giving rise to systematic errors (cf. [1], [2], [3], [4]). On the other hand, CALL is learner-oriented; communication with a competent speaker of the target language gets less important.
The grammar component must provide the learner with information about the grammatical structure of the target language. It must also be able to recognize wrong grammatical generalizations from ungrammatical learner utterances and give suitable responses that enable the learner to revise them. The latter requirement cannot be met by a grammaticality judgement alone. Instead a precise structural analysis of ungrammatical input is necessary to identify the specific type of error.
Furthermore grammatical evaluation should distinguish between strictly ungrammatical and marked constructions that are restricted for pragmatical reasons.

1.1 Typical Errors in L2 Acquisition of German

In the field of German as a foreign language education a couple of typical error types are well attested. Sentential *word order* is one obstacle for L2 learners. Typical errors with respect to word order in main clauses are shown in (1).

(1) a. more than one constituent before the finite verb:
**Peter heute den Kuchen* hat gegessen
Peter today the cake has eaten
b. more than one verb form in V2-position:
*Peter *hat gegessen* heute den Kuchen
Peter has eaten today the cake
c. German as an SVO-language:
*heute hat *Peter gegessen* den Kuchen
today has Peter eaten the cake

Apart from the strictly ungrammatical word orders, marked word orders (object preceding subject; a full NP preceding a pronominal NP; an indefinite NP preceding a definite NPs etc.) are a typical problem for L2 learners of German as well.

(2) a. #heute hat den Kuchen Peter gegessen
today has the cake Peter eaten
b. #heute hat Anna Otto es gegeben.
today has Anna Otto it given
c. #heute hat Anna einem Mann den Hut gegeben.
today has Anna a man the hat given.

German word order being highly sensitive to information structure, these sentences are not strictly ungrammatical, but often inadequate in a given context. We thus decided to highlight the fact that a certain word order is marked to the L2 learner, so that she can check whether she chose it intentionally or whether she prefers changing it.
Another error type comprises subject verb agreement and the declension of determiners, adjectives and nouns within NPs.

(3) a. subject-verb-agreement:
*Otto sieh*st* Anna.
Otto see-2sg Anna
b. agreement within an NP:
*d*er* klein*es* Blume
the-masc small-neutr flower-fem

1.2 A Modified LFG as a Grammar Checker

For the purpose of developing a CALL grammar checker, a large-scale Lexical Functional Grammar (LFG), implemented in the XLE grammar development platform (cf. [5], [6]), has been supplemented with rule components for analyses of ungrammatical and marked input.
LFG provides for at least two structural representations of a sentence (cf. [7]). C(onstituent)-Structure encodes linear and hierarchical constituent order; F(unctional)-Structure represents functional relations and grammatical features by means of attribute value matrices. The mapping of C- to F-structure is mediated by functional annotation of C-structure nodes. Given a choice of lexical items, different C-structures may be associated with a unique F-structure, if word order variation is possible. A third representation called o-structure is used for ambiguity reduction and robustness (cf. [8]).

Ungrammatical input like the sample sentences in (1)–(3) is parsed with malrules. The resulting C-structures are mapped onto F-structures identical with those that are projected from their grammatical counterparts except for a specific feature *DAF-UNGRAM*. The value of this feature is defined depending on the error as *Vorfeld*, *SVPersAgr* etc.. Since more than one error may occur in a sentence, the value of the *DAF-UNGRAM* feature is defined as a set. The F-structure representation of a sentence with marked word order encloses the feature *DAF-MARKED* to which a value is assigned that specifies the marked construction.

2. Ungrammatical Word Order in LFG

Although German is generally known as a free word order language, the placement of verbs in a German sentence is subject to certain strict constraints. One such constraint states that there can only appear one constituent before the inflected verb (V2). L2 learners of German, however, often do not respect this constraint, especially when it is contrary to word order constraints in their native language. When grammar is modified in order to cope with ill-formed input such as sample sentence (1a), its context-free rules have to be extended so that a C-structure can be built.

Consider the following rule. Initially, it states that a German CP consists of exactly one constituent of any kind (XP) followed by a C'-projection (Cbar). Additional prefield constituents are then allowed by means of rule extension.

```
CP →  XP: (↑TOPIC)=↓
          (↑XCOMP* {SUBJ|OBJ|...})=↓;
      XP*: (?XCOMP* {SUBJ|OBJ|...})=?
           Vorfeld ∈ (?DAF-UNGRAM)
           DAFUngram ∈ o::*;
      Cbar: ↑=↓.
```

This extension allows any number of constituents of any kind to appear in addition to the normal prefield constituent and assigns them one of the grammatical functions in the functional uncertainty equation. The projection of *Vorfeld* as a value of the F-structure feature *DAF-UNGRAM* allows to keep track of the kind of mistake and is essential for giving feedback to the learner. In order to prevent the rule from being applied when a grammatical analysis is possible, each additional prefield constituent projects the dispreference OT mark *DAFUngram* into the so-called o-structure.

The C- and F-structures resulting from parsing sample sentence (1a) with the extended rule are shown in figures 1 and 2.

The C-structure does not look particular in any way, apart from the fact that there are several constituents in the prefield, a constellation that could not be parsed by the initial LFG. The F-structure also looks pretty close to the one we would get for the grammatical counterpart of the sentence, the only difference being the feature *DAF-UNGRAM*, which encodes that the problem consists in multiple constituents in the prefield (*Vorfeld*).

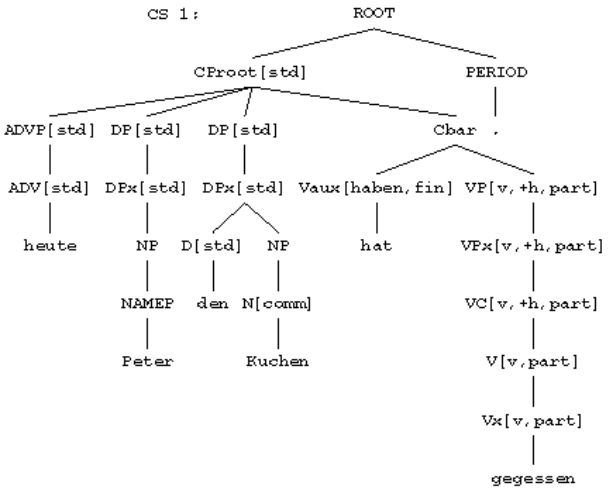

Figure 1: C-structure associated to sentence (1a)

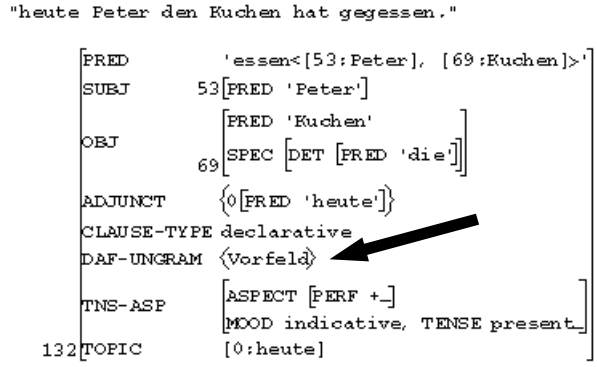

Figure 2: F-structure associated to sentence (1a)

3. Marked Word Order in LFG

Another difficulty for L2 learners of German are marked word orders in the midfield. This difficulty is due to the fact that on the one hand, the linear order of arguments and modifiers is free in the sense that almost any order can be observed and often two (or even more) alternatives are acceptable, but that on the other hand it is not random. Rather it is determined by both syntactic and information-structural constraints, which can sometimes even be contradictory. This complex situation makes it difficult both to state clear rules regarding constituent order in the midfield (which is reflected in its insufficient or even incorrect description in the relevant literature) and to learn practically how syntax and information structure interact here.

Given the situation that – to our knowledge, at least – no NLP system models information structure reliably, the following approach has been chosen: Potentially marked word orders are identified by the grammar, and the learner is informed as to why her utterance might be marked and in what kind of contexts this sort of word order is (or is not) appropriate. (Technical details of how the information provided by the grammar is further processed by the learning environment are still to be determined.) This gives her the possibility to reconsider whether she wishes to stick to the construction or adapt it.

The information concerning potentially marked word orders is obtained via additional F-structural annotations involving head-precedence. As an example, consider the following rule, with the additional annotations in bold face.

```
CP →  XP: (↑TOPIC)=↓
          (↑XCOMP*{SUBJ|OBJ|...})=↓;
      XP*: (↑XCOMP* {SUBJ|OBJ|...})=↓
           Vorfeld ∈ (↑DAF-UNGRAM)
           DAFUngram ∈ o::*;
      Cbar: ↑=↓
            {(?OBJ) <h (?SUBJ)
        ObjBeforeSubj ∈ (?DAF-MARKED)
        DAFMarked ∈ o::*
            |(?SUBJ) <h (?OBJ)
            |... }.
```

In the first disjunct, it is required that the object precede the subject of the clause and if this is the case, *ObjBeforeSubj* is projected into the F-structure as a value of the feature *DAF-MARKED*. In addition, the OT mark *DAFMarked* is projected into the o-structure in order to prevent such an analysis in cases where a less marked analysis is possible. The other disjuncts cover all other settings, whether marked or not.
A sentence where the above annotations contribute additional F-structure information is (2a). The F-structure associated to it is displayed in figure 3.

"heute hat den Kuchen Peter gegessen."

```
[PRED          'essen<[134:Peter], [71:Kuchen]>'
 OBJ        71 [PRED 'Kuchen'
                SPEC [DET [PRED 'die']]]
 SUBJ      134 [PRED 'Peter']
 ADJUNCT       {0[PRED 'heute']}
 CLAUSE-TYPE declarative
 DAF-MARKED    {MFObjBeforeSubj}
 TNS-ASP       [ASPECT [PERF +]
                MOOD indicative, TENSE present]
  53 TOPIC     [0:heute]]
```

Figure 3: F-structure associated to sentence (2a)

The fact that the order of constituents in the midfield is relatively strongly marked is expressed in the value *MFObjBeforeSubj* of the feature *DAF-MARKED*. The F-structure thus contains the information that is necessary to ask the learner to reconsider her choice in order to make sure that the marked construction has not been used unintentionally.

4. Agreement Correction in LFG

Agreement is another phenomenon that is notoriously difficult for learners of German as a foreign language. In LFG it is treated in terms of unification, i.e. on the level of F-structure. For the process of parsing erroneous input, this means that agreement has no repercussions whatsoever on the construction of C-structures and is purely dealt with in the process of finding well-formed F-structures corresponding to the context free trees. When modifying an existing LFG, one thus has to add some annotations in the existing rules and lexicon entries, but nothing fundamentally new is needed.
Consider the following – so-called sublexical – rule, which collects the output of a finite-state morphology for verb forms as Vs and projects their F-structure.

```
V →   V-S: ↑=↓;
      V-T: ↑=↓;
      Pers-F: {(↑SUBJ)=↓ | ?=?
            SVPersAgr ∈ (?DAF-UNGRAM)
            DAFUngram ∈ o::*;}
      Num-F: ...
```

The person information given for a finite verb form is normally projected into the subject of the verb, where it must unify with the person information that is projected there from another lexical entry, e.g. of a subject pronoun. Alternatively, i.e. for the cases where subject-verb agreement is not respected, we introduce the possibility of not projecting the person information onto the F-structure of the clause, penalizing this solution by means of the OT mark *DAFUngram* and marking the error in the F-structure by means of the feature *DAF-UNGRAM* and its value *SVPersAgr*.
An example for a sentence where the agreement in person between a verb and its subject is violated (besides ungrammatical word order) is:

(4) Heute Otto siehst Anna.
today Otto see-2sg Anna

The F-structure associated to this sentence is given in figure 4.
The agreement violation is marked as a value of the feature *DAF-UNGRAM*. Since several errors can occur simultaneously in the same clause, it was decided to make this feature set-valued, which is unproblematic since the function of this feature is rather one of bookkeeping than of insuring well-formedness via unification. E.g. the present sentence, apart from being ill-formed due to the violation of subject-verb-agreement, also contains multiple constituents in the prefield, so that *Vorfeld* appears alongside *SVPersAgreement* as a value of *DAF-UNGRAM*.

"heute Otto siehst Anna."

```
[PRED          'sehen<[53:Otto], [104:Anna]>'
 SUBJ       53 [PRED 'Otto'
                NUM sg, PERS 3]
 OBJ       104 [PRED 'Anna'
                NUM sg, PERS 3]
 ADJUNCT       {0[PRED 'heute']}
 CLAUSE-TYPE declarative
 DAF-UNGRAM    {SVPersAgreement
                Vorfeld          }
 TNS-ASP       [MOOD indicative, TENSE present]
  69 TOPIC     [0:heute]]

 -1 [PERS 2]
```

Figure 4: F-structure associated to sentence (4)

The unconnected F-structure at the bottom of the figure displays the value of the feature *PERS* that could not be unified with the corresponding value in the main F-structure. It thus contains information about the exact nature of the agreement error, which can be useful for giving feedback to the learner.
Other agreement phenomena, such as agreement between determiners, adjectives and head nouns within NPs (cf. example (3b)), can be treated in a similar way, since all these phenomena are accounted for by means of unification.

Conclusions and outlook

Based on an implemented large-scale LFG/XLE grammar for German a prototypical grammar checker for the purposes of L2 teaching has been developed by adding malrule components. Since errors due to the interference of the first language grammar are systematic, grammatical analyses by anticipating malrules instead of a non anticipating procedure (as proposed e.g. in [9]) is well motivated.
Errors can be identified with respect to their type and strictly ungrammatical constructions can be differentiated from marked ones so that the grammar checker provides for the information that is indispensable for any revealing error evaluation given to the learner.
With the rule-based grammar checker it is in principle possible to parse unrestricted input (depending on the coverage of the grammar and the computational capacity of the machinery).
Further development of the gammar checker requires corpus work to specify the range of mistakes that must be detected by the enriched grammar. A corpus of (uncorrected) learner utterances is also required for the evaluation of the efficiency of the grammar checker. Still unresolved problems with respect to the grammar concern mistakes in orthography and morphologically incorrect word forms. Apart from this the grammar checker has to be integrated into a broader learning environment.

References

[1] Rüschoff, B. (2002) Computerunterstützte Lehr- und Lernmaterialien, Bausch/Christ/Krumm (eds.) *Handbuch Fremdsprachenunterricht*, Francke UTB

[2] Rüschoff, B., Ritter, M. (2001) Technology-Enhanced Language Learning: Construction of Knowledge and Template-Based Learning in the Foreign Language Classroom. In *Computer Assisted Language Learning*, 14: 219-232.

[3] Schlak, T., (2003). Die Auswahl grammatischer Lernziele: Linguistische, psycholinguistische und didaktische Perspektiven. In *Zeitschrift für interkulturellen Fremdsprachenunterricht*, 8 http://www.ualberta.ca/~german/ejournal/schlak4.htm

[4] Tschichold, C., (1999) Grammar Checking for CALL: Strategies for Improving Foreign Language Grammar Checkers. In Cameron, K. (ed.) *CALL: Media, Design and Applications*, Swets & Zeitlinger.

[5] Butt, M., King, T. H., Niño, M.-E., Segond, F. (1999). *A grammar writer's cookbook*, Stanford CSLI.

[6] Dipper, S. (2003). *Implemeting and Documenting Large-Scale Grammars – German LFG.* Ph.D. Thesis, IMS, University of Stuttgart, AIMS, Arbeitspapiere des Instituts für Maschinelle Sprachverarbeitung (AIMS), Volume 9, Number 1.

[7] Bresnan, J. (1982). *The Mental Representation of Grammatical Relations*, MIT Press, Cambridge Mass.

[8] Frank, A., King, T.H., Kuhn, J., Maxwell III, J. (1998). Optimality Theory Style Constraint Ranking in Large-Scale LFG Grammars. In Butt, M. and King, T.H. (eds.): *Proceedings of the LFG98 Conference,* CSLI Online Publications.

[9] Reuer, V. (2003). *PromisD - Ein Analyseverfahren zur antizipationsfreien Erkennung und Erklärung von grammatischen Fehlern in Sprachlehr-systemen*. Ph. D. Thesis, Humboldt-Universität zu Berlin.