

# Approximating the disambiguation of some German nominalizations by use of weak structural, lexical and corpus information

## *Hacia la desambiguación de nominalizaciones en alemán a partir de información estructural, léxica y de corpus*

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**Resumen:** Entre el método clásico y simbólico de desambiguación de sentidos (*WSD*) que utiliza representaciones semánticas profundas de oraciones y textos, y el método estadístico que utiliza información relativa a la co-ocurrencia de palabras, existe una tendencia reciente a usar métodos híbridos. De manera similar a la llamada semántica *light-weight* (Marek, 2009), en este artículo se propone hacer uso de escasa información semántica. Describimos un modelo de aproximación sobre la base de *Flat Underspecified Discourse Representation Structures* (*FUDRSs*, cf. Eberle 2004) que valora conocimiento sobre estructura contextual, restricciones de semántica léxica e interpretaciones preferenciales. Presentamos una guía de anotación para la anotación por humanos de textos con los correspondientes indicadores. Mediante su uso, la fiabilidad de la herramienta que implementa el modelo puede ser testada con respecto a la precisión de anotación y a la predicción de desambiguación, y cómo ambas pueden ser mejoradas mediante el *bootstrapping* del conocimiento del sistema usando información de corpus. Para el corpus set de test considerado, la tasa de reconocimiento de la lectura preferida es del 80-90% (dependiendo de la compensación de errores de análisis sintáctico).

**Palabras clave:** información de corpus, desambiguación, representación semántica superficial, fiabilidad, anotación de corpus

**Abstract:** Between classical symbolic word sense disambiguation (*wsd*) using explicit deep semantic representations of sentences and texts and statistical *wsd* using word co-occurrence information, there is a recent tendency towards mediating methods. Similar to so-called *light-weight* semantics (Marek, 2009) we suggest to only make sparse use of semantic information. We describe an approximation model based upon *flat underspecified discourse representation structures* (*FUDRSs*, cf. Eberle, 2004) that weighs knowledge about context structure, lexical semantic restrictions and interpretation preferences. We give a catalogue of guidelines for human annotation of texts by corresponding indicators. Using this, the reliability of an analysis tool that implements the model can be tested with respect to annotation precision and disambiguation prediction and how both can be improved by bootstrapping the knowledge of the system using corpus information. For the balanced test corpus considered the recognition rate of the preferred reading is 80-90% (depending on the smoothing of parse errors).

**Keywords:** corpus information, disambiguation, shallow semantic representation, reliability, corpus annotation

## 1 Introduction

Deverbal nominalization via the affix *-ung* applied to the stem or root of the verb is a very frequent and productive derivation in German. Typically, such *-ung* nominalizations are

ambiguous. They may describe an event (*nach der Begradigung [e] des Rheins bei Mannheim* 'after the straightening of the Rhine near Mannheim'), a state (*während der Teilung [s] Deutschlands* 'during the partition of Germany') or an object (*die Übersetzung [o] des Romans verkauft sich gut* 'the translation of

the novel sells well'). These nominals are not always three-way ambiguous. According to the underlying verb semantics, there are three or two readings or only one. Of course, context disambiguates further. Hypotheses about the ambiguity of *-ung*-nominals and about disambiguating contextual constraints can be found in Ehrlich and Rapp (2000), Roß-deutscher (2007), Spranger and Heid (2007).

As the differences are relevant for the conception of corresponding nominalization theories, but also for topics like text interpretation and machine translation, automating disambiguation and keeping track of corresponding statistics about disambiguation preferences are important tasks. In order to optimize reliability and tractability of the targeted automatic disambiguation of *-ung* nominalizations in context, we suggested a method according to which deep semantic representations of the competing interpretations of the nominalizations are used in order to discriminate types of information which provide strong indications about preferred readings in context. Given the goal of automation, it is important that the corresponding criteria are easy to check (Eberle et al 2009a).

*Easy to check* means in this approach that an analysis system that can assign *flat underspecified discourse representation structures* (FUDRSs) to sentences on the basis of lexical semantic selection constraints can detect the presence of these indicators in the sentence with sufficient reliability (for FUDRSs see Eberle (2004), for the underlying (U)DRT Kamp (1981), Kamp and Reyle (1993)).

The usefulness of a disambiguation criterion is evaluated under two aspects: firstly, the reliability of automatic detectability on the basis of a specific state of the analysis system used and, secondly, discriminating power with respect to the disambiguation task in question.

The suggested shallow semantics approach is preferred over the classical symbolic approach using deep semantic representations and inferences in the sense of theorem provers (e.g. Herzog et al., 1991) because of cost and tractability. It is preferred over purely statistical evaluations of word co-occurrence information and meaning vectors (e.g., SemEval, 2010), because generally the considered cases are sparse, so that it is nearly

impossible to reliably detect them on the basis of this information alone.

In technical respects, the approach shows similarities to suggestions like Peris et al. (2009), from the discourse representation perspective, the conception of criteria on the basis of (pragmatic) default assumptions about the meaning of utterances has a Gricean background (Grice, 1975).

An important subclass of *-ung* nominalizations are the nominalizations of *verbs of saying* (*NVS*). Among other things they are interesting because they can relate to speech acts or, more generally, to *statements*, and to attitudes and reports about statements. Particularly interesting is the occurrence as internal argument of a prepositional phrase with *nach*, as the readings of such PPs are semantically related to each other in a very subtle way.

In this paper we report about the application of the disambiguation approximation model to the task of differentiating between the readings of such PPs. As described in (Eberle 2009, Eberle et al 2009b), these PPs have two types of readings (when used as adjoint modifiers of the verb); compare the following pair of examples which are taken from the *DeWaC* corpus (cf. Baroni and Kilgarriff (2006)):

- (1) a) *Die 1. Wiederholungsprüfung muss nach Mitteilung des Prüfungsergebnisses zum nächsten regulären Prüfungstermin abgelegt werden.*

The first retake of the examination must be passed by the next regular date of examination **after announcement** of the results of examination.

- b) *Die Preisverleihung erfolgt nach Mitteilung von Euronatur voraussichtlich im Juli 2003 in Ludwigsburg bei Stuttgart.*

**According to the announcement** of Euronatur, the presentation of prizes is expected to take place in July 2003 in Ludwigsburg near Stuttgart.

In (1.a), *nach Mitteilung* is interpreted as a *temporal modifier*: the retake must be passed **after the event of announcing** the examination results. In contrast, in (1.b), *nach Mitteilung* is interpreted as a modal restriction where the presentation of the prizes is described as a consequence or part of the

announcement of Euronatur (if the announcement is truthful, the presentation of the prizes happens at the place and time as mentioned). We call the first reading the *temporal reading* and the second the *propositional reading*, where, in the first case, the nominalization is understood as an event and in the second as a specific kind of *object*: a *proposition*. On the basis of detailed analyses of these readings using DRT's *Discourse Representation Structures (DRSs)* we developed a system of 8 criteria for the prediction of the preferred reading of the considered PP with *nach* and its nominalization in a specific context.

In the next section we sketch the criteria taken into account. These criteria have been evaluated with respect to a fragment of the mentioned DeWaC corpus consisting of 100 sentences that we have extracted manually from DeWaC, where our aim was to obtain a *balanced* test set, i.e. a set of sufficiently different sentences with respect to sentence structure, vocabulary and distribution of phenomena relating to the considered criteria.

According to the two aspects mentioned above we firstly tested the reliability of the analysis tool that we use with respect to determining the prediction constraints resulting from the criteria definitions. This has been done by comparing the classifications of the tool to human annotations that have been carried out on the basis of a set of annotation guidelines that accompanies the definition of the criteria (cf. sections 3 and 4). In section 5.1 we present the results of comparing the human annotation to the automatic classification and the consequences that can be drawn with respect to the formulation of criteria and to the degree of 'awareness' of the analysis tool.

Given reliable annotations, the usefulness of the criteria as disambiguation clues can be evaluated. We report in section 5.2 on the corresponding results with respect to the set of sentences considered. In section 6 we discuss the results and sketch plans to improve the suggested approximation model – with respect to the specific task described and with respect to the general task of approximating the human disambiguation of words with closely related meanings in context.

## 2 Criteria

The model for approximating disambiguation of PPs with *nach* and nominalizations of verbs of saying uses the following 8 morphosyntactic and semantic criteria that relate to the local context of the nominalization considered.

- **The agent criterion** takes into account whether or not the nominalization is assigned an agent that can be assumed to be a source or a distributor of news, instructions or messages. We assume that agents have this property if they are either institutions or else persons or groups of persons that are described by functions or professions that, by default, include communication as an essential component (like *Angeklagter* / 'accused', *Lehrer* / 'teacher', *Rechtsanwalt* / 'lawyer', etc).
- **The theme criterion** describes whether or not the nominalization is assigned a theme that gives information about the content of the announcement (like *die Mitteilung der Ergebnisse* / 'the announcement of the results', *die Mitteilung, dass es keine Überlebenden gibt* / 'the announcement that nobody has survived', etc.)
- **The determination criterion** considers the determiners or quantifiers, if any, of the nominal phrase that introduces the nominalization.
- **The frame criterion** evaluates whether the nominalization considered and *MVP* (the *verbal phrase* that is *modified* by the PP containing the nominalization) are similar in terms of semantic event classification or not. In this rough sense it verifies whether the two events (of the nominalization and of the verb) belong to the same event frame or script or not.<sup>1</sup>
- **The reference location criterion** takes into account whether MVP is assigned a spatial location or not.
- **The reference time criterion** takes into account whether MVP is assigned a (separate) temporal location or not.
- **The tense criterion** takes into account whether the event, state or process reported

<sup>1</sup> If for instance MVP is also a verb of saying, MVP may describe a (successive) reaction to the nominalization event acc. to a typical course of a *discussion* script or frame (cf. Hanks and McDermott (1986), Pustejovski (1995) a.o.).

by MVP is located at the textual now or in its past or future (or on a hypothetical time line).

- **The Aktionsart criterion** gives different preferences depending on whether MVP describes an event, a process or a specific state.

The first three criteria relate to the NP that introduces the nominalization considered, the last five criteria relate to MVP.<sup>2</sup>

As described in (Eberle et al 2009b), these criteria do not resolve the ambiguity of the considered nominalization, at least not in general, but they give important hints. They output preferences which - taken together - give a joint weighted vote with regard to disambiguation. Because of this, we call the instances of these criteria *weak indicators*. This vote is modified or suspended in the presence of other so-called *hard indicators*, which definitely disambiguate the nominalizations via specific sortal selections. These may be adjectives and other syntactic modifiers that apply sortal constraints to their arguments or other sentential elements that semantically modify the nominalizations in question.

For space reasons, section 3 and 4 will focus on the agent and the theme criterion only. However, this should give an idea about the general characteristics of the guidelines and corresponding technical definitions of the other criteria. The results reported in section 6 take all criteria into account.

### 3 Implementation

The approximation approach suggested is not free in defining criteria for disambiguation. The criteria must be such that the analysis tool used can check them. In our specific approach the tool assigns shallow semantic representations to the text on the basis of dependency grammar parses. The semantic knowledge it uses consists of knowledge from the syntax-

<sup>2</sup> The criteria are working hypotheses. We assume to change, modify or refine the criteria if this is suggested by use and tests. Some refinements can be foreseen by now. For instance, the fourth criterion *-frame-* might later be refined to refer to any relations between event types instead of requiring the nominalization to be of the same semantic category as MVP, including taking into account the different event arguments and the roles they play in more elaborate default scripts or event frames one wants to consider.

semantics interface only: in particular it uses knowledge about the semantic classification of lexemes, relations between the corresponding semantic types (subsumption hierarchy) and knowledge about semantic selectional restrictions. The system is a research prototype drawn from a commercial MT system. As this system was designed for unrestricted text translation, the language fragment considered is very large when compared to 'normal' research systems. We emphasize that this is true with respect to the semantic classification of the lexical item as well.<sup>3</sup>

Morphosyntactic knowledge is a preferred candidate for defining evaluation criteria, as its elements normally build a closed class so that we can assume that most of the relevant information is implemented and that corresponding forms can be detected in representations (modulo parse errors). The definition of criteria on this basis is critical only if semantic constraints are used as means of filtering. The tool we use makes use of such information. However, the constraints are restricted to selection restrictions on the basis of a semantic classification of the lexicon. We sketch how this type of knowledge is taken into account when modelling the difficult theme property and the even more difficult *communicating agent* property. We illustrate the relevant part only (in a variant of predicate logic; the original modelling is in *Prolog*).

In both cases, agent and theme, there are a number of (morpho)syntactic preconditions: the words in question must be nouns and must satisfy case constraints etc. (genitive noun left or right of the nominalization, etc.). The semantic restrictions are the following (compare examples (1.b) and (1.a)):

- **agent**  

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typical_message_source(WORD_ID,
                        WORD_SEMTYPE) ←
    typical_message_sources_w(WTMSs),
    typical_message_sources_t(TTMSs),
    sem_subsumed(WORD_ID,
                 WORD_SEMTYPE,
                 WTMSs, TTMSs).
typical_message_sources_t([inst,companyname]).
typical_message_sources_w(TMS_WORDLIST).

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<sup>33</sup> The system has been described in (Eberle et al 2008) and is made available to other research institutions by the owner (cf. <http://www.lingenio.de/English/Research/Research-Prototypes.htm>).

- **theme**  
 plausible\_theme(WORD\_ID,WORD\_SEMTYPE)  
 ← plausible\_themes\_w(WPTs),  
 plausible\_themes\_t(TPTs),  
 sem\_subsumed(WORD\_ID,  
 WORD\_SEMTYPE,  
 WPTs,TPTs).  
 plausible\_themes\_t([liv\human,cog,doc,  
 propos,situat]).  
 plausible\_themes\_w(PT\_WORDLIST).

The first rule says (together with the definition of *sem\_subsumed*, which we omit here) that a word introduces a (*communicating*) agent if its semantic type is a subtype of the classes *inst* (*institution*) or *companyname* or if the word is a member of TMS\_WORDLIST (*type message wordlist*).

Similarly, according to the second rule, a word is a *plausible theme* if it describes a *living being* (except *human* — as humans often are agents), a *cognitive object*, a *document*, a *proposition* or a *situation* or if it is a member of the list PT\_WORDLIST (*plausible theme wordlist*).

This illustrates that in both definitions we cannot (and do not) assume that the semantic classification of the lexicon entries that the analysis system is based on is fine-grained enough to exactly provide the specific classes that would be needed to satisfy the differentiation needs of the criteria (e.g. a class '*communicating agent*'). The strategy we follow is: a) to approximate these classes as precisely as possible by Boolean combinations of existing semantic types and, b), to collect words that satisfy the human understanding of the criterion from corpora with the goal of defining new semantic classes from their semantic union which then can refine the semantic classification of the tool lexicon. (Parts can be realized automatically and illustrate functions of the bootstrapping approach implemented).

A side effect of these word lists is that they show errors and insufficiencies of the existing typing with respect to the existing classes. For instance, *Euronatur* in (1.b) is an institution. If it is part of TMS\_WORDLIST this shows that it is currently insufficiently described in the lexicon (as *inst* objects are already TMS).

Comparing the annotation results of the tool to those of human annotators gives an evaluation of the tool's degree of information. The aim is to define the disambiguating criteria in such a way that the difference between human

and automatic annotation can be reduced to an insignificant level with low costs using modest evaluation corpora.

#### 4 Annotation guidelines

This section lists the guidelines for the agent and the theme criteria. Next to these and the other weak criteria described in section 2, there are also hard constraints from selectional restrictions that adverbials and adjectives provide for the nominalizations in question or verbs for the entire PPs with *nach*, which cannot be described in total here. This is postponed to a later and larger description of the approach.

##### 4.1 Weak criteria

###### Agent criterion.

1) Does the considered NP show a genitive phrase, a prepositional phrase or an adjective, which informs about the agent of the considered event of saying?

Yes	→	Continue with 2)
No	→	Stop
Unclear	→	Mark/extract corresponding phrase for later evaluation and stop (Mark&Stop)

2) Does the description stand for  
 a) an institution, including names of authorities and companies

Examples: *Polizei* / 'police', *Ministerium* / 'ministry', *Schule* / 'school', *Universität* / 'university', *Organisation* / 'organization', *Zeitung* / 'newspaper', *Finanzamt* / 'tax office', *IBM*, *BMBF* (*Federal Ministry of Education and Research*), etc.)

b) a person or group of persons described by a function (including temporary functions) or a profession where communication of information is an essential feature

Examples: (*Presse-*)*Sprecher* / 'press agent', 'speaker', *Verteidiger* / 'attorney', *Informant* / 'informant', *Professor* / 'professor', *Politiker* / 'politician' *Journalist* / 'journalist', etc.

c) a person, a group or an institution as in a) or b) which is indirectly described by an adjective (Example (1.b) satisfies this criterion via 2.a), viz. *Euronatur*).

Examples: *offiziell*, *behördlich* / 'official', *halbamtlich* / 'semiofficial', *staatlich* / 'governmental', *israelisch* / 'Israeli' etc.

Yes	→	Annotate: <i>agent criterion</i> ( <i>temporal reading: -1,</i> <i>propositional reading: +1</i> )
No	→	Stop
Unclear	→	Mark&Stop

N.B. b) doesn't subsume names of persons as the system doesn't classify last names according to the type system used in a)-c)<sup>4</sup>. At a later stage, we plan to infer sortal knowledge for person names by two additional system features:

(i) by anaphora resolution, through establishing anaphoric links to antecedents and propagating sort knowledge along these links.

(ii) by statistical named entity recognition and compilation of properties of entities that are identified.

Other names that are collected by human annotation via bootstrapping and TMS and other lists, like *Euronatur* in example (1.b) or *Südena* in example (3) below, obtain a permanent classification to be incorporated into the lexicon in the bootstrapping step (where the system supports the annotator by automatically extracting all relevant candidates for classification).

#### Theme criterion.

1) Does the considered NP show a genitive phrase, a prepositional phrase, an adjective or a subclause that informs about the theme of the considered event (Example (1.a) satisfies *theme*, viz. *Prüfungsergebnis*)?

Examples: *Mitteilung der Bewerberzahl* / 'notification of the number of applicants',  
*Aussagen zum Tathergang* / 'testimonies about the progression of events',  
*Täter-bezogenen Darstellungen* / 'presentations related to the perpetrator',  
*den Vorgang schildernde Darstellungen* / 'presentations outlining the process',  
*Mitteilung, dass die Kantine geschlossen bliebe* / 'announcement that the canteen remained closed' etc.).

Yes	→	Annotate: <i>theme criterion</i> ( <i>temporal reading: -2,</i> <i>propositional reading: +2</i> )
No	→	Stop
Unclear	→	Mark/extract corresponding phrase for later evaluation and stop (Mark&Stop)

<sup>4</sup> In contrast to institutions not all persons sharing the same name have the same properties, e.g. *being teacher*.

## 4.2 Hard criteria

Are there modifiers of the preposition *nach* or of the noun considered that disambiguate the temporal/propositional ambiguity definitely?

Examples: *kurz nach* / 'shortly after',  
*drei Stunden nach* / 'three hours after',  
*nach dreistündiger Mitteilung* / 'after an announcement of three hours',  
*nach zweifelhaften Darstellungen* / 'after doubtful representations', etc.)

Yes	→	Annotate: <i>indicator (Value)</i> (where <i>Value</i> is: <i>proposition</i> or <i>event</i> )
No	→	Stop
Unclear	→	Mark&Stop

A hard indicator is *vorliegend*, which excludes the temporal reading, as in example (2):

(2) *1995 wurden nach vorliegenden Meldungen 46 Todesurteile verhängt*  
According to all announcements at hand,  
46 death sentences have been imposed in  
1995.

## 5 Results

We annotated the considered test corpus consisting of 100 sentences from DeWaC manually and, independently of this, decided about the preferred reading of the PPs with *nach*. This has been done by several annotators. The tool did the corresponding annotation of criteria in a first pass and, on the basis of this, computed the preferred reading according to the weighting schema in a second pass.

### 5.1 Correctness of annotation

The first question to answer was: How satisfactorily do the guidelines render the formal definitions of the decision criteria used in the implementation and vice versa, i.e. what is the degree of agreement between the human annotations of the criteria and those of the tool?

In total there were 9 criteria (the 8 'weak' criteria and the 'hard' selectional restriction criterion). We considered annotations of two independent human annotators (HA1, HA2). *Similarity* was defined as agreement with respect to all criteria (without preferring some criteria by specific weights), i.e. considering

the 100 sentences, 100% similarity would have been obtained by 900 agreements.

Grosso modo the overlap (a) between the human annotations themselves, (b) human annotation versus automatic annotation, is similar: **88,1 %** in case (a) and **89,7 %** in case (b).

The differences in (a), mainly, have to do with different syntactic interpretations of the sentences and with uncertainty about the property or influence of words, in particular with respect to the criteria of *determination*, *frame*, and *Aktionsart*. The following is an example. The relevant part of the corresponding sentence of the test corpus is shown in (3), the annotations in table 1:

- (3) *Bei den am 11. November in London beginnenden Besprechungen .. werden, nach Meldungen der Südena , nur .. die Vollmachten.. zur Erörterung stehen .*  
According to announcements of Südena, only the authorisations ... will be discussed during the meetings beginning on Nov 11 in London

HA1 and HA2 see a difference with respect to the Aktionsart of the MVP *zur Erörterung stehen* and with respect to the role this situation type plays with regard to the verb of *Meldung, melden/report*. While HA2 correctly seizes the abstract semantic proximity of the considered verb types, HA1 is oriented towards a more intuitive interpretation of *frame*. The second difference makes it clear that also the criterion Aktionsart needs a still more elaborate guideline with more examples. (Where HA2 classifies MVP as *historical*, i.e. as temporally limited, HA1 sees it as unlimited – *non-historical*). The difference with respect to the role of *in London* (reference space or not?) shows that experience with syntactic analysis is relevant also and caution with respect to inferred information: that *zur Erörterung stehen* will take place *in London* is not *given* but only *deducible* from knowledge about *beginning*), i.e. Rspace='-' is correct.

Annotation errors of the tool mainly come from erroneous syntactic analyses and from lack of information: The semantic classification of the verbs in the tool lexicon is not as detailed as the one of nouns, such that frequently information is missing for correct predictions about Aktionsart.

## 5.2 Results – correctness of prediction

For our balanced subset of 100 sentences, where the relevant material is completely known to the system in the sense described above, the tool recognizes the preferred reading in over **82%** of the cases. A main problem that remains is 'noise' caused by erroneous syntactic analyses. If the sentences are modified (or shortened to the relevant parts) such that the tool can compute the correct analysis, the tool recognizes in approximately **90%** of the sentences the reading that most of the human evaluators favoured.

## 6 Conclusions and future work

We presented a semantic analysis tool which disambiguates German PPs with *nach* and nominalizations of verbs of saying on the basis of a system of 9 types of indicators. For a balanced test corpus of 100 sentences its recall is 100 % and its precision over 80 %. A prerequisite for this is that the system is sufficiently aware of the semantic classification and selection restrictions of the relevant lexical material. The criteria use very weak knowledge however, so that we expect that the accuracy decreases only little when the system is applied to other corpora, particularly as the system is also able to bootstrap the semantic knowledge necessary for making informed decisions about the criteria (cf. Eberle et al 2008). Currently, we extend the investigation to some 10,000 sentences from DeWaC containing the same and similar phenomena. The interim results are promising. We plan to compare the method with available purely statistical methods of word sense disambiguation. Because of the fact that the data we focus on are not frequent and may appear in semantically similar texts and in close neighbourhood with different readings, we assume that the model turns out to be more appropriate for such phenomena.

When considering broader test suites we intend of course to optimize the criteria and their weights by usual statistical methods (the model can be described as a maximum entropy model with linguistic features; cf. Och and Ney 2002), thereby taking the integration of symbolic syntactic-semantic and statistical methods one step further.

Sent	Ann	CAgent	Theme	Det	Frame	Rspace	Rtime	Tense	Akt	Hard
3	HA1	+	-	no	-	+	+	F	nh	-
3	HA2	+	-	no	+	-	+	F	h	-

Table 1: Sentence annotations for example (3)

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