

-ung Nominalizations of Verbs of Saying in German

Events and Propositions

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Abstract

-ung nominalizations of verbs of saying in German can be interpreted as events or propositions. There are context partners of such nominals which disambiguate the reading or suggest preferences. We consider a specific ambiguous constellation which is very frequent in German, where the nominal is the internal argument of a PP with *nach*. We detail the semantic representations of corresponding sentence types in the framework of Discourse Representation Theory and conclude from this an explanation of why some context partners suggest the one reading and some the other.

The findings are currently used in corpus analyses to test the relevance and coverage of the stipulated criteria and to optimize preference weights statistically. This shows a way to avoid deep semantic evaluation with respect to disambiguation and to replace it by a combination of shallow semantic interpretation (based upon selectional restrictions and semantic hierarchies) and data driven methods. We present some of the results.¹

1. Introduction

Typically, *-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*).

-ung nominals are not always three-way ambiguous. According to the underlying verb, there are three, two or only one reading. Of course, context disambiguates further. Hypotheses about ambiguity of *-ung*-nominals and about disambiguating contextual constraints can be found in [Ehrich and Rapp (2000), Roßdeutscher (2007), Spranger and Heid (2007), Eberle et al. (2008)].

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-ung nominalizations of verbs of saying (henceforth *NVS*) are particularly interesting because they relate to speech acts or, more generally, to *statements*, and to attitudes and reports about statements. For a number of computational applications it is important to know which of the different readings is present in a sentence and which context partners can disambiguate them (e.g. for Machine Translation, Text Mining etc.). Consider the following example taken from the *DeWaC corpus* (*Deutsches Web as Corpus*) [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 1. Wiederholungsprüfung muss nach Mitteilung des Prüfungsausschusses zum nächsten regulären Prüfungstermin abgelegt werden.*
According to the announcement of the examination board, the first retake of the examination must be passed by the next regular date of examination.

In (1.a), *Mitteilung/announcement* is obviously interpreted as an event: The first retake of the exam must occur **after** the event of announcing the results of the (first) examination. In contrast, in (1.b), it is interpreted as a proposition: the examination board states that retakes must be passed by a specific date.

Note that this reading also incorporates an announcement which is an event, but in this case this event plays another role: It is presupposed as the cause of the announcement as a propositional result. Its time is independent of the times of the retakes that the announcement as a proposition - the regulation - speaks about. Clearly, in (1.b), the definite description does not refer to this event but to the proposition, whereas in (1.a) it is the other way around.

What is the reason for this difference? Obviously, the different genitive complements play an important role. In (1.a) the complement introduces an agent and in (1.b) a theme. However, in many cases this difference has no relevant disambiguating effect (*die Mitteilung des Prüfungsergebnisses* is as ambiguous as *die Mitteilung des Prüfungsausschusses* is and may refer to an event or an object: a document or the content of a document, i.e. a proposition²). In cases like (1) the difference is rather triggered by the influence of the preposition *nach* -- which itself is ambiguous between a temporal reading

² The ambiguity between propositional and 'physical' reading is rather regular for -ung nominalizations of verbs of saying and other verbs having to do with creation and exchange of information. There are similar sortal phenomena with respect to specific nominalizations in other languages, e.g. the semantics of *-ment* and *-age* in French, cf. [Dubois (1972)]. There is work onto this topic in project B5 of SFB 732, cf. [Martin (2008), Uth (2008)] to which the study here is planned to link up against the background of a multilingual research standpoint.

(*after*) and a reading as *discourse relation (according to)* – and by the different constraints these readings impose on the argument of the corresponding PP and on the VP that this PP modifies.

We call the (1.a) reading of the PP with *nach* the *temporal reading* or *event reading* and the (1.b) reading the *propositional reading*.

In the next section we will have a closer look to these interpretation and specify the differences in the framework of Discourse Representation Theory [Kamp (1982), Kamp and Reyle (1993)]. In particular, we use suggestions from [Kamp (2002)] and [Eberle (2004)] for representing presuppositions and attitudinal states, in order to work out the details. In section 3, we deduce a number of (pragmatic) constraints from these differences and define contextual criteria that make one interpretation or the other possible or impossible, (more) likely or unlikely. In section 4, we sketch a corpus tool that we use for extracting references from corpora and testing the hypotheses about useful criteria and their relevance. We discuss some results and conclude with a brief outlook on current work and plans for the near future in section 5.

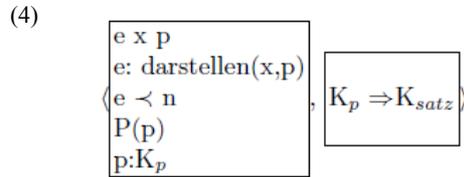
2. Two different readings of German PPs with *nach* and –ung nominalizations of verbs of saying

2.1. Propositional reading

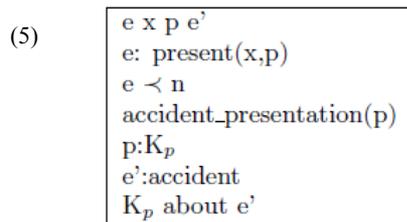
If the recipient interprets the PP according to what we called the propositional reading he or she takes the remaining sentence (the modified clause) as a description of the content of the internal argument of the PP or as a logical consequence of it. Compare example (2) and its schematical abstraction (3)

- (2) a) *Nach Pierre's Darstellung des Unfalls, war der Fahrer betrunken.*
According to Pierre's presentation of the accident the driver was drunk.
- b) *Nach Pierre's Darstellung des Unfalls, musste der Fahrer betrunken gewesen sein.*
According to Pierre's presentation the driver must have been drunk.
- (3) *Nach X's Darstellung (NVS) von P, SATZ*
According to X's presentation (NVS) of P, CLAUSE

In (2.a), the state of being drunk is part of the story of the accident as presented by Pierre, in (2.b) the speaker of the text presents it as a consequence to be deducible from the story as presented by Pierre. (3) sketches this interpretation schema. We represent the corresponding *Discourse Representation Structure* (DRS) (cf. [Kamp and Reyle (1993)]) as follows:



(4) is a pair of DRSs where the first DRS describes the presuppositions associated with the assertions represented by the second DRS. According to this structure, the recipient of (3) presupposes the existence of an event *e* of *darstellen/presenting s.th.* (or more generally an event underlying an NVS) produced by *x* and relating to a propositional content *K_p* that is referred to by *p*, where *e* is in the past of the contextual *now* (*n*) and where *P* is the characterization of the presented proposition, the theme, as is known from the text. According to this, we obtain the following presupposition for example (2):



Note that the existence of the accident can be presupposed in (2), as it is introduced by definite description. Therefore, independently of Pierre's presentation, the reader can presuppose a corresponding event *e'*. The statement *K_p about e'* shall indicate that the presentation *K_p* contains statements about properties of *e'*. Given the information of (5), or (4) respectively, nothing else is known about it, except for what the main clause reports about it. Technically, we model this by using *K_p* as a DRS variable and by relating it to the representation of the main clause, *K_{sent}*, as a prerequisite of the truth of the corresponding assertion (represented by *K_p ⇒ K_{sent}* in (4)). According to this, the more information *K_{sent}* introduces about the theme of the presentation, the more *K_p* gets shape, via abductive deduction of conditions that support *K_{sent}*. For instance, in (2.b) we learn that during the development of the accident there must have happened things legitimating the assumption that the driver was drunk.

The propositional reading as represented here doesn't predict any restriction about *K_{sent}* other than that it is about the theme of the presentation event *e*. In particular there is no sortal restriction deducible or to expect with respect to the main clause event (in the wide sense of *temporal unit*). In (2.a)

it is a *state*, in (2.b) it is a specific state, a modal state. (6) presents further examples including events (in the narrow sense) and processes.

(6) *Nach Pierre's Beschreibung*

According to/after Pierre's description

(i) *der Ereignisse* / (ii) *des Sachverhalts* / (iii) *des Problems*

(i) of the incidents / (ii) the facts (iii) of the problem

a) *hatte Freddy Pia heimlich einen Zettel zugesteckt* (*e @ event*)

Freddy had slipped a piece of paper to Pia in secret

b) *hatte es gestern geregnet* (*e @ process*)

it had rained yesterday

c) *war die Frau gut ansprechbar* (*e @ state*)

the woman was satisfactorily responsive.

d) *war es möglich, dass Z* (*q @ prop*)

it was possible that Z

All combinations between (a)-(d) and (i) and (ii) are easily understandable in the sense of the propositional reading. (iii) exemplifies that the description of P (in the sense of the schematic representation (4)) has an important influence of what statements are acceptable in the main clause without hindering this reading or making it very unlikely: statements like (a) and (b) are relatively unexpected parts or consequences of a *problem*, they are quite natural parts or consequences of a series of *incidents* or some unspecified *facts*. However, the character of P doesn't show an impact on the Aktionsart of the main clause. In this respect, all possibilities are equally acceptable (or unacceptable). This means, the description of the theme P may restrict the acceptability of the propositional reading: the more it specifies K_p the more the topics of the main clause, represented by K_{sent} , are restricted, via the relation $K_p \Rightarrow K_{sent}$. On the other hand, provided the topic of K_{sent} is acceptable, the characteristics of the described event in terms of Aktionsart and similar structural properties don't play a role.

2.2. Temporal Reading

As said in the introduction, by *temporal reading* we mean that the preposition *nach* is interpreted as temporal relation and that the contribution of the PP consists of asserting that the event of the modified clause follows the event described by the internal argument of the PP, i.e. the nominalization. The corresponding sentence schema is as in (7). We represent it as in (8):

- (7) *Nach X's Darstellung (NVS) von P, SATZ*
After X's presentation (NVS) of P, CLAUSE

$$(8) \quad \left(\begin{array}{l} e \times p \\ e: \text{darstellen}(x,p) \\ e \prec n \\ P(p) \\ p:K_p \end{array} \right), \quad \left(\begin{array}{l} \langle e', K_{\text{clause}} \rangle \\ \cup \\ \left(\begin{array}{l} e \prec e' \end{array} \right) \end{array} \right)$$

In contrast to (4), the schema of (8) relates the events of the PP and the modified clause to each other, not the corresponding propositions and the type of relation is temporal, not a kind of logic condition.

The PP in (6.a) can easily be interpreted according to this schema, independently of the description of the theme ((i)-(iii)), also (6,b), but in a less obvious way. The temporal modification *gestern/yesterday* makes this interpretation a bit hard. If *gestern* is replaced by *plötzlich/suddenly* or some similar adverbial, it is much more prominent. In (6.3) it is very hard to get the temporal reading, with (6.4) it is no problem. What are the reasons for the differences?

If *nach* is interpreted as in (8), the event of the PP is taken as a reference event of the eventuality/temporal unit of the modified clause, where this eventuality is localized in an interval starting at the end of the event described by the PP. (We omitted the introduction of a corresponding interval t in (8), with e starts t , $e' \subset t$, for the sake of simplicity, and settled for the statement $e \prec e'$ that can be concluded from this³).

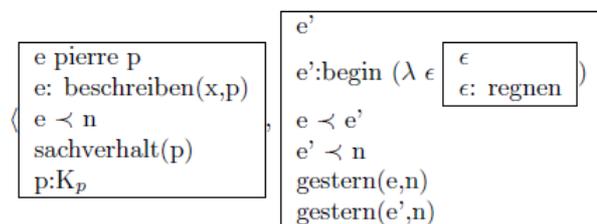
This temporal modification schema obviously fits best with eventualities that have clear limits with respect to temporal extension, i.e. with events in the narrow sense (accomplishments and achievements). The corresponding regularity has often been observed (with respect to German for instance in [Bäuerle (1988), Eberle (1991), Herweg (1990)]). Part of this regularity is that processes and states are also acceptable however, provided they can be *reinterpreted* as events (by some regular meaning shift, to an inchoative reading for instance)⁴, the more, the more the reinterpretation is conventional and therefore easy to obtain. For the process in (6.2) and the state in (6.4), inchoative reinterpretation is very natural: the corresponding state or process **began** after Pierre's describing something, in the case of (6.4) maybe because

³ It can be argued that in order to do justice to the semantics of tenses and to take into account a number of temporal discourse phenomena a detailed study cannot omit the introduction of such localization times (cf. [Kamp (1981b), Kamp and Rohrer (1983), Eberle (2004)]). However, the topic of the study here is not to present a detailed account of temporal relations in texts, but to contrast a specific temporal reading against another non-temporal reading.

⁴ Compare [Eberle (1991), Egg and Herweg (1994)] for corresponding regularities in German.

the describing event is the **cause** of the state of the main clause, as the description may have provided new information to the hearers that made clear how Z could be the case or could be realized. (9) gives a representation of (6.2) (variant (ii)) under the assumption of this inchoative reinterpretation. According to the notation of [Eberle (1991)], it uses an Aktionsart operator *begin* that (in terms of type theory) maps event predicates onto event predicates (in the wide sense).

(9)



According to (9), *gestern* provides a location time to the main clause event e' as well as to the event of the PP. This is a possible interpretation, but not the only (temporal) one. We come back to this detail in section 3.3. The main clause event e' , here, is an achievement built by reinterpretation via *begin* from the process type introduced by *regnen*. With regard to (6.3) this type of interpretation is not likely. On the one hand, *being satisfactorily responsive* is not a type of state that starts out of the blue. Different from *regnen*, a normal, unmarked text should legitimate a corresponding inchoative reinterpretation by presenting reasons explaining why the state started right now, and there is no such explanation in (6.3). Other regular types of reinterpretation, for instance the perspective of perceiving a process not as ongoing but as a closed, temporally limited entity (as often triggered by accompanying adverbials of duration) seem to be out for similar reasons: compare the corresponding *Nach Pierres Beschreibung des Sachverhalts war die Frau minutenlang ansprechbar* (. the woman was responsive for minutes) where it is unclear why Pierre's utterance should have an impact on the state of responsiveness of some woman in question. Note that we do not argue that this reading is unacceptable. We only mean that the normal case of the temporal schema (8) is the one where the main clause eventuality e' is an event in the narrow sense and that in case where the main clause doesn't meet this precondition, it depends on how natural some reinterpretation is against the background of the information provided by the context, whether this reading is acceptable or not. In (6.3), the sentence taken in isolation doesn't provide sufficient information in this respect. In (6.2), there is no need for corresponding additional information besides the knowledge that author and recipient share about weather conditions and how we usually present them in texts. (6.4) is like (6.2) in this respect. Author and recipient know that *being*

(6.2) in this respect. Author and recipient know that *being possible* is, or can be, a logical (modal) attitude where such attitudes are often presented in texts as consequences of some previous actions. This explains why the temporal reading of (6.4) proves the same effortless acceptability as (6.2).

3. Indicators of the temporal and of the propositional reading

Generally, disambiguation is a hard problem. Besides linguistic knowledge, well-founded decisions typically presuppose broad coverage of world knowledge. This is a principal problem. Even when restricting to specific phenomena, as in the study which is reported here, if not in principal, there is a problem of cost. In order to cover all types of occurrences, mostly a fine-grained semantic analysis of the context is needed and must be backed by a detailed data base of suitable world knowledge. Often this is not tractable. Therefore we suggest to abstain from aiming at complete and reliable disambiguation and to settle for only approximating the readings which are contextually most likely or appropriate, by finding and optimizing a tradeoff between cost and reliability of the suggested interpretation. In the framework of the reported project such approximations are used in order to test hypotheses about regularities of nominalization against relatively large corpora (like DeWaC), other applications are Machine Translation or text classification.

The type of approximation that we suggest here is similar in some respects to so called *light-weighted semantics* (cf. [Marek (2009) for a recent approach]). The approximation bases upon shallow semantic representation of the text and sparse semantic knowledge which consists of semantic knowledge from the syntax-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. Details of the corresponding technical analysis and of the evaluation setting are given in the next section. Here, we concentrate on the identification of context partners of the nominalizations considered that give indications about which reading is more appropriate in the given context against the background of the semantic knowledge available and the characteristics of the adversative readings as can be derived from the representation schemes that we developed in the last section.

Provided semantic background knowledge as described, there are two types of indicators: contextual elements that clearly disambiguate the contribution of the PP via precise selectional restrictions and others that only give hints about which reading should be preferred. We call the first class of indicators *hard criteria*, the second *soft criteria*.

3.1. 'Hard' criteria: Selectional restrictions

When analysing the different readings of the considered type of PP in the last section, we implicitly assumed that the temporal interpretation of *nach* co-occurs with the reading of NVS as event -- and correspondingly with respect to the conditional reading of the preposition and the proposition reading of the nominalization. If this is true, candidates for 'hard' indicators are, of course, the modifiers of the nominalization, but also the modifiers of the preposition (or of the PP as a whole). Both types of elements may definitely disambiguate their argument via a corresponding precise semantic selection constraint and, by this, indirectly, the second ambiguous element too. Compare the examples of (10) – which are taken from DeWaC -- for this:

(10)

a) . . . *oder legt er diese nach erfolgter Meldung aus von ihm zu vertretenden Gründen nicht ab, so gilt die Wiederholungsprüfung als abgelegt und nicht bestanden.*

...otherwise if, the announcement having been carried out, he doesn't pass the retake for reasons he is responsible of, then this retake is regarded to be taken and not passed.

b) *Bei der Anfahrt zum Besteller darf der Fahrpreisanzeiger erst nach Meldung des Fahrers beim Besteller eingeschaltet werden.*

When driving to the customer, the fare schedule must be turned on only after announcing the driver to the customer

c) *Sollten Sie . . . einverstanden sein, haben Sie das Recht, der Änderung innerhalb eines Monats nach Mitteilung zu widersprechen.*

If you agree you obtain the right to object to the change during a month after announcement.

In (10.a) the participle *erfolgt/carried out (made)* disambiguates *Meldung/announcement* via adjectival modification, where it inherits its disambiguating force from the underlying verb *erfolgen* which presupposes a direct object which is of type temporal. As a consequence of this, *nach* is to be read as temporal relation and the entire PP according to (8). In (10.b), the focus adverb *erst* applies to the preposition (or to be precise, relates the pair ⟨PP,main clause⟩ to a range of corresponding alternatives). It applies to temporal entities only. So, here, the preposition is disambiguated first and the disambiguation of the nominalization follows as a consequence. (10.c) is similar to (10.b): *innerhalb eines Monats/during a month* presupposes a temporal argument.

With regard to automatic extraction and sortal evaluation of references in corpora, this means that all instances of P- (or PP-)modifiers and of N-modifiers must be classified in this respect (as a 'hard' indicator for the one or the other reading or as being unspecific in this respect), in order to being able to undertake frequency analyses about the considered readings and for identifying interesting occurrences. In connection with the considered phenomena an interesting reference is for instance a sentence with P- and N-modifier that predict a sortal conflict (instances of so called *semantic paradoxes*, cf. [Brandtner and von Heusinger]). An example is (11):

(11) (?) *Erst nach vorliegender Meldung zur Prüfung, darf an der Klausur teilgenommen werden*

The test may be written, only after present notification for examination

Most paradoxal sentences that we found in DeWaC are similar to (11): When looking carefully at it, the sentence is incorrect. However it appears to be acceptable as it is intuitively perceived as a shortening of a longer, correct sentence (which, here, would be something like: *Erst nachdem die Meldung.. vorliegt... / only after the notification is presented...*). According to our findings such conflicting cases (as can be extracted with the means at hand) are seldom.

3.2. 'Soft' criteria: Conventions connected to the use of PPs with *nach* and *NVS*

By 'soft' criteria we mean contextual elements which give hints about what reading seems to be preferred or unlikely. In section 2, we mentioned *Aktionsart* as a first example of a corresponding criterion: From the differences between the reading schemes (4) and (8) we derived, that the more effort has to be invested to interpret the main clause eventuality as an event, the more the temporal reading of the PP seems unlikely. In order to weight 'likelihood' or 'acceptability' in this sense, we use a range of preference values from -3 to +3, in turn standing for intuitive assessments like *nearly impossible*, *(very) unlikely*, *not favoured*, *neutral*, *favoured*, *(very) likely*, *nearly sure*.

Using this range, we define the *Aktionsart* criterion as follows:

Criterion	Reading	Eventuality of the modified clause			
		Event	Process	State 'historical' 'stage level',..	State 'non- historical' modal...
Aktionsart					
	temporal	+1	0	0	-2
	proposi-	0	0	+1	+2

	tional				
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According to this, we slightly prefer the temporal reading if the eventuality of the modified clause is an event, we slightly prefer the propositional reading in the presence of states like *being windy, dry, hungry*, we strongly prefer the propositional reading in the presence of states like *being possible that, being unlikely that, not being the case that*. We call the first class *historical states* (subsuming stage-level predications and other states that can be assumed to be 'short' in a sense), and the second class *non-historical states* (subsuming modals and exclusions of events etc., i.e. states that can be expected to be long lasting).

We currently use and evaluate 8 criterions in total, next to the Aktionsart criterion these are the following

- temporal modification
- spatial modification
- tense
- determination
- theme
- agent
- frame

As Aktionsart, the first three criteria relate to the modified clause: they evaluate the existence or non-existence of (additional) temporal or spatial modifications and the tense of the modified eventuality. The criteria *determination, theme* and *agent* relate to the nominalization and evaluate the type of determination and the existence or non-existence of a theme or an agent and properties of such roles. The criterion *frame* evaluates the semantic relation between the event types introduced by the internal argument of the PP and the modified clause. All criteria are derived from the differences between the two interpretation schemes (4) and (8) and from default regularities that seem to be connected to them when used according to convention. There are many other criteria that could be extracted from the considered differences. However, as we want to approximate correct disambiguations automatically, only such hints can be considered that can be found and evaluated by an analysis system that is informed in the limits of what we described in the beginning of this section (i.e. type and selection knowledge from the syntax-semantics interface).

In the following we illustrate two further criteria from this list. We give a sketchy presentation of the remaining criteria at the end of this section.⁵

3.3. Criteria relating to the modified clause: additional temporal modification

According to the temporal reading, the PP introduces a reference time t for the event of the modified clause. Assertion of a second reference time t' would be surprising therefore, unless it contributes a specification of the first. The problem here is to decide whether this is the case or not.

(12) gives some motivating examples.

(12)

(a) *Nach Pierre's Ausführungen, am Mittwoch, sprach Pia mit Claude.*

After/according to Pierre's exposition – Wednesday - Pia talked to Claude.

(b) *Nach Pierre's Ausführungen sprach Pia mit Claude am Mittwoch.*

After/according to Pierre's exposition –Pia talked to Claude - Wednesday.

(c) *Am Mittwoch sprach Pia mit Claude nach Pierre's Ausführungen.*

Wednesday - Pia talked to Claud - after/according to Pierre's exposition.

In (12.a) the supplementary PP *am Mittwoch* ist part of the *Vorfeld* as well als the PP with *nach*. This means that the two PPs must specify one single modification, i.e. *am Mittwoch* must be interpreted as apposition of the first PP. Therefore t and t' specify a single reference time t'' (where t and t'' are subintervals of t' and t precedes t''). Here, the supplementary modification disambiguates the contribution of the PP with *nach*. This is similar to (10c) – with respect to the semantic result, not with respect to syntactic composition. In (12.b) and (12.c) the PPs are separate and appear in different order. Here, it depends on whether the recipient is ready to accept the contributions as incremental specification of a unique reference time t'' where disambiguation is guided (weighted) by the conventions about scope order and resolution of temporal reference (in absence of prosodic information that could specify acceptability further). According to such conventions, in (12.b) it is more likely that the two PPs cooperate in specifying a joint reference time t'' than in (12.c). But in both examples it is not sure. (12.b) is structurally identical to (6.b). In section 2.2. we pointed out that the relatively unlikely temporal reading of (6.b) is significantly improved if the additional PP introduces some shorter reference time (for example *plötzlich/suddenly*, but also

⁵ A more complete description is currently compiled and remains to be published in a more comprehensive format.

um 3 Uhr/at 3 o'clock etc.) than a day. This means that next to the position in surface structure - which gives hints about scope and (anaphoric) reference – the quality of the introduced times is relevant as this provides information about how easily they combine and define a joint reference interval. In order to evaluate constraints and preferences in this respect, a (minimal) prerequisite is a fine-grained classifications of temporal units. As we lack such information at present we abstain from an ambitious formulation of a temporal reference criterion and specify the criterion as in the following, where *separate* means that the two PPs do not appear in neighboring position.

Criterion	Reading	Modified clause separate reference time	
		yes	no
temporal modification			
	temporal	-2	0
	propositional	+2	0

. Currently, we expose the criteria to corpus tests and use the results on the one hand to detail the definitions of the criteria and to adjust their significance (in terms of weights, compare section 4) on the other. As said in the beginning, detailing is guided by finding an optimal compromise between cost and disambiguation quality. We shortly sketch the other criteria relating to the modified clause in section 3.5.

3.4. Criteria relating to the nominalization (NVS): theme

According to our representation scheme (8), the propositional reading means that the modified VP specifies the theme of the announcing event introduced by the internal argument of the PP with *nach*. We already said that the more the PP itself provides information about this theme (and, by this, details K_p), the more the possibilities to add suitable information by the VP are restricted, as the VP information (K_{sent}) must accept K_p as a reasonable abductive justification. As it is hard to decide under which circumstances corresponding constraints are violated on the basis of the spare (light-weight) semantic information available, we model the theme criterion as coarse grained as the reference time criterion: we assume that the temporal reading is preferred if the PP provides a theme for NVS, unless the description of the theme is very high level and informs about the type of the theme only, but not about details of it. We define as follows:

Criterion	Reading	Nominalization 'substantial' theme
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		yes	no
theme			
	temporal	+2	0
	propositional	-2	0

Technically, '*substantial*' *theme* is interpreted as the class of all genitive attributes and PPs with *von* that, (a), modify NVS (or possibly modify NVS, compare the next section for this) and that, (b), can be identified as specifying *theme* (by their semantic type) and that, (c), are more specific than the types of the upper structure of the type *proposition* (i.e. that are more specific than *Ereignisse/Sachverhalt/Problem /incidents/facts /problem* etc.).

Though semantically superficial, the criterion seems to model sufficiently well human disambiguation conventions. Compare the following example (13) from DeWaC which clearly favors the temporal reading:

- (13) *Eine anderweitige zumutbare Ersatzmöglichkeit für die Kläger besteht auch nicht in der Geltendmachung von Ansprüchen gemäß §. . . nach Erklärung eines Widerrufs ihrer auf Abschluß der Darlehensverträge gerichteten Willenserklärungen (§1 Abs. 1 Haustür-WG).*

Also the assertion of claims in accordance with §. is not another reasonable possibility of replacement for the plaintiffs after the declaration of (after having declared) a revocation of their declaratons in favor of the conclusion of the loan contracts (..).

3.5. Other soft criteria

Currently we use and test five additional criteria: *tense*, *spatial modification*, *determination*, *agent* and *frame*. The first two criteria relate to the modified VP, where *tense* takes up regularities of using tense forms in narratives, similar to the Aktionsart criterion whereas spatial modification closely follows the argumentation of temporal modification about the effects of additional reference information. *Determination* and *agent* relate to NVS. They take into account the observation that bare singular and bare plural NPs are less suited to precisely identify reference objects – and therefore tend to favor propositional interpretations. Also as it seems, 'public' agents favor propositional interpretations. By 'public agent' we mean institutions and characterizations of persons that make us expect that announcement of information is an important feature of their social role. Examples are *Pressesprecher/press agent*, *Minister/minister*, *Rechtsanwalt/lawyer* etc. The criterion *frame* tries to exploit *frame knowledge* or *script knowledge* (in the sense of [Hanks and McDermott(1986)]) or *qualia knowledge* (in the sense of [Pustejovsky(1995)]) in order to determine whether NVS and VP may be interpreted as neighboring events in a story (following the plot of the frame, script, qualia structure) in a natural way. As with the other criteria, also here

the modeling must be coarse grained and must restrict itself to the knowledge available. At present, this means that we assume NVS and VP to be neighbors in a frame (and therefore favoring the temporal interpretation) if they share semantic type information to some extent. Loosely speaking, we prefer the temporal reading if VP is based upon a verb of saying also. Without going further into details here, we list the relevant coordinates of the sketched criteria as follows:

Criterion	Reading			
tense		Modified clause		
		present tense	other tense level	
	temporal	-1	+1	
	propositional	+1	-1	
spatial modification		Modified clause		
		reference loc.	no spatial mod.	
	temporal	-1	0	
	propositional	+1	0	
determination		Nominalization		
		no determiner	weak quantifier	other
	temporal	-2	-1	0
	propositional	+2	+1	0
agent		Nominalization		
		'public' agent	no such agent	
	temporal	-1	0	
	propositional	+1	0	
frame		Nominalization/Modified clause		
		Similar e Type	no such similarity	
	temporal	+1	0	
	propositional	-1	0	

4. Identifying and testing indicators in Corpus

Currently, the identified indicators are tested in a corpus study and their significance and weight is evaluated. For this purpose, we use a corpus tool that assigns *flat underspecified discourse representation structures* (FUDRSs, cf. [Eberle 2004]) to sentences⁶. It bases upon the Lingenio research prototype for the analysis of German [Lingenio (2009)]. Advantages of using this tool are the following: (1) As developed from software that underlies a commercial software system (the machine translation system translate, cf. <http://www.lingenio.de/English/Products/translation-software.htm>), the coverage of the system with respect to lexicon, syntactic phenomena, semantic typing is very large. (2) Analysing sentences into (encodings of) FUDRSs avoids unmotivated lexical and structural disambiguation as far as possible. With respect to the phenomena considered in this study, this means that (forced) disambiguation is restricted to the local representations that include the considered PPs and VPs – and is carried out only partially and only as far as is required by the specific task: When using the system for extracting possible indicators of the criteria considered above (for further lexical detailing), analysis cautiously avoids unmotivated choices in order not to erroneously rule out a context partner as a possible modifier of the considered subrepresentations and therefore as a possible indicator. When evaluating the relevance of specific readings or when trying to find sentences with marked uses of elements (like the paradoxal sentences, illustrated by (11)), it does such choices as far as is needed and reports about the interpretational consequences.

(15) shows the output of the system when applied to sentence (14) under the following modes:

- (i) Show underspecified representation.
- (ii) Compute possible sortal readings of the *-ung* nominalizations of the sentence.
- (iii) Extract possible modifiers and selectors of the nominalizations:

(14) *Beweisstücke müssen nach Bekanntmachung der Staatsanwaltschaft vorgelegt werden.*

- (a) Pieces of evidence must be presented to the prosecuting attorney's office after announcement.

⁶ The corresponding theory, FUDRT, is a modification and extension of UDRT ([Reyle (1993)]) that next to scope ambiguities takes into account lexical and several types of functional ambiguity also.

- (b) According to an announcement of the prosecuting attorney's office, pieces of evidence must be shown.

(15)

```

--- German Slot Grammar (C) Copyright Lingenio 1999-2007 ---
Eingabe:
! : Beweisstücke müssen nach Bekanntmachung der Staatsanwaltschaft vorgelegt werden.
Dependence tree.
┌─── top          s<nüss, 488021>          ntu(ind:dc1:nuh,tf<pres,0,X1>,a):[[feinstellung0,modv,müss]]
├─── subj(n)      s<heuisstück,99827>      noun(cn,nom,pers3-pl-nt,[]):[[heuisstück,cohj,soc]]
├─── auxcomp(binf) s<leg,vorleg>          ntu(dep:inf:nuh,tf<inf,0,X2>,p):[[leg,vorleg]]
├─── vprep        s<nach,nachtentp>      prep([nach|dat],[nuh]):[[lprep,nach,nachtentp]]
├─── objjprep(dat) s<bekanntmachung,82581>      noun(cn,dat,pers3-sg-f,[]):[[bekanntmachung,propos_phys]]
├─── xnod         s<staatsanwaltschaft,660707> noun(cn,gen,pers3-sg-f,[]):[[coll,inst,staatsanwaltschaft]]
├─── ndet         s<der,d>              det(gen,pers3-sg-f,[def]):[[d,der]]
└─── obj(n)      empty                coref(1)

[<bekanntmachung,[e,o]>],h<?,vorleg,vprep<nachtentp>>],[xnod,6,staatsanwaltschaft]].
[<bekanntmachung,d<lag(6),det(e),akt(ev),te<pres>],[[e,-3],[p,4]],[]]].
! :

```

Figure 1: Underspecified analysis with (a) extraction and (b) sortal evaluation

4.2. Bootstrapping

Evaluation of possible 'light-weight' criteria for the (sortal) disambiguation of –ung nominalizations is done as follows: According to mode (iii), the tool extracts the relevant context partners of the nominalizations that maybe indicators of the different types of criteria (compare (a) in figure 1). If necessary their behaviour with respect to the considered phenomena is further specified and added to the corresponding lexical entries of the system (this mainly consists of adding Aktionsart information and more precise semantic typing and of correctng erroneous classifications). Then, in mode (iii), the tool computes the sortal outcome (compare (b) in figure 1) that is checked in a third step for adequacy.

Current tests use the weights as described in the last section. However, we intend to optimize the weights by making use of maximum optimization which is possible as the method that we use for the computation of preferences can be described as a maximum entropy model with linguistic features (compare [Och and Ney (2002)]):

$$(16) \quad L(\text{nach-PP}) = \operatorname{argmax}_{L_i} \left\{ \sum_{m=1}^8 \lambda_m h_m(L_i | (\text{nach-PP}, VP)) \right\}$$

(16) says that the reading of the PP with *nach* is that reading L_i (either the temporal reading or the propositional reading) which given PP and VP is

assigned the highest (higher) value by the sum of the weights λ of the (8) criteria h_m . The gold standard against which the results are checked consists of the preferences (a collection of) humans assign to the sentences of the corpus considered.

Note that there are two bootstrapping cycles: (1) Extracting and evaluating possible indicators improve the information state of the system with respect to the coverage and density of the light-weight semantic background knowledge the system uses. (2) Training the weighting improves the quality of judgements about significance and independence of the criteria considered (or others as may develop from testing the hypotheses and deepening the study).

4.3. Tests and results

Currently, we investigate a subset of some 10.000 sentences from DeWaC with sentences containing the considered NVS phenomena. We draw test sets from this subset which are optimally balanced with respect to the criteria considered (and to other ones) and sets which represent different degrees of semantic understanding that the system is able to show for the relevant indications (this means sets where the ratio of possible indicators to those elements which are sufficiently well known to the system is different). For a balanced subset of 100 sentences, where the relevant material is completely known to the system in this sense, we could show that it recognizes the preferred reading in over 80 % of the cases. A main problem that remains is 'noise' caused by erroneous syntactic analyses (that cannot be completely suppressed despite of using underspecification).

5. Conclusion

We investigated the use of German *-ung* nominalizations of verbs of saying in the context of PPs with *nach* and derived two different interpretation schemes, a so called temporal and a propositional reading. We represented these schemes in terms of Discourse Representation Theory and drew a number of criteria from them on the basis of pragmatic considerations (in line with [Grice (1975)]) about the conventional use of these interpretation schemes in context. We used these criteria to define a method for approximating the contextually most appropriate interpretation on the basis of flat underspecified discourse representation and specific light-weight semantic background knowledge. For a balanced test corpus of 100 sentences we could show that the system correctly determines the preferred reading in over 80% of the cases if it is maximally well informed with respect to the indicators contained in the corpus.

Next steps consist of specifying the set of criteria further and of adjusting the weighting by gradual extension of the test sets and bootstrapping of the knowledge available to the system. Also, we will try to find statistical interdependencies between the different criteria in order to discriminate criteria which are maximally independent of each other and criteria that are easy to check and of high quality with respect to disambiguating power. Finally, we will apply the method to a wider range of nominalizations in the sequel.

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