Classification of "Inheritance" Relations: a Semi-automatic Approach

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Abstract. This study describes a semi-automatic approach to the classification of "inheritance" relations between morphologically related predicates.
Predicates, such as verbs and nouns subcategorizing for a subclause, are automatically extracted from text corpora and are classified accroding to their subcategorisation properties. For this purpose, we elaborate a semi-automatic knowledge-rich extraction and classification architecture. Our aim is also to compare subcategorisation properties of morphologically related predicates, i.e. verbs and deverbal nouns.
In this work, we concentrate exclusively on the predicates with sentential complements, such as *dass, ob* and *w*-clauses (that, if and wh-clauses) in German, although our methods can be applied for other complement types as well.

1 Introduction

This paper describes a semi-automatic approach to the analysis of subcategorisation properties of morphologically related predicates, such as verbs and nouns. We classify predicates according to their subcategorisation properties by means of extracting them from German corpora along with their complements. In this work, we concentrate exclusively on sentential complements, such as *dass, ob* and *w*-clauses, although our methods can be also applied for other types of complements.

It is usually assumpted that subcategorisation properties of nominalisations are taken over from their underlying verbs. However, our preliminary tests show that there exist different types of relations between them. Thus, our aim is to review the properties of morphologically related words and to analyse the phenomenon of "inheritance" of subcategorisation properties.

For this purpose, we elaborate a set of semi-automatic procedures, with the help of which we not only classify extracted units according to their subcategorisation properties, but also compare the properties of verbs and their nominalisations. Our aim is to serve NLP, especially such large symbolic grammar for deep processing as HPSG or LFG, which need detailed subcategorisation data for their lexicons and grammars.

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2 Data and Existing Approaches

As mentioned above, our interest targets verbs and their nominalisations. In this study, we focus only on two types of predicates: verbs and nominalisations which occur freely in a sentence. The same methods can be applied for the analysis of nominalisations within a support verb constructions, which is a task for our future work. Subcategorisation properties of verbs and nouns have been described in many linguistic and NLP studies. There exist various works on verb valency in NLP approaches (e.g. [1], [2], [3], [4], [5] and [6]). Most of them concentrate on English verbal predicates, but there exist studies for other languages as well, e.g. [7], [8], and [9] for German or [10] and [11] for Italian.

Nominalisations are also described in many studies, for instance, [12], [13], etc. for English, [14] and [15] for German nominalisations.

3 The Phenomenon of "Inheritance" in Subcategorisation

The phenomenon of "inheritance" of subcategorisation was mostly studied within the relationships of verbs and their nominalisations, deverbal nouns which are morphologically derived from verbs by affixation, and which often share much of their meaning with the base verbs. Many authors who analyze nominalsiations, e.g. [12], [14], [15], [13], mention correspondences between arguments of nominalisations and those of their underlying verbs, depending on the type of complements and the classes of verbs under analysis.

However, only a few lexical resources provide systematic correspondences between verbs and their nominalisations. For instance, [16] describes a computational lexicon of nominalisations NOMLEX which maps noun roles into the predicate-argument structure of their associated verbs. Another example is the analysis described in [17], where the authors use the PARC's text processing system for the process of mapping the predicate-argument structure of nominalisations and that of their base verbs.

In NOMLEX, we find two types of nominalisations depending on the ability to absorb the arguments of the base verb: VERB-NOM for those that appear with many or all verbal complements, and NOM-TYPE for those nominalsiations that can "inherit" only one of the arguments of the base verb. That shows that some deverbals only partially take over verbal valency patterns, thus, there are also non-correspondences in the predicate-argument structures of a nominalisation and its base verb.

Our preliminary extraction tests also show that there are both correspondences ("inheritance") and differences ("non-inheritance") in the subcategorisation of morphologically related predicates.

In many cases subcategorisation properties of deverbal nominal predicates are "inherited" from their base verbs (example (1)).

(1) – *begründen, dass/w-...* ("to justify that/wh-...")
vs. *Begründung, dass/w-...* ("justification that/wh-...")

– *befürchten, dass...* (" to fear that...")
  vs. *Befürchtung, dass...* ("fear that...")
– *erklären, dass/w-...* ("to explain that/wh-...")
  vs. *Erklärung, dass/w-...* ("explanation that/wh-...")

But there are also cases where subcategorisation of a nominalisation differs from that of its base verb (cf. (2))

(2) – *vorstellen, dass/w-...* ("to think that/wh-...")
  vs. *die Vorstellung, dass/*w-...* ("idea that/*wh-...")
– *vermuten, dass/w-...* ("to suppose that/wh-...")
  vs. *die Vermutung, dass/*w-...* ("supposition that/*wh-...")

All the above mentioned cases should be analysed and considered in the mapping rules for predicate-argument structure. Linking the predicate-argument structure of such deverbals like in (2), with the predicate-argument structure of their base elements, we should take into account that subcategorisation properties of verbs underlying deverbals in these cases can not be just transferred and reapplied.

4 Methods and Tools

4.1 Input and Context

For this study, we use a corpus of German texts consisting of newspaper texts from Germany which include extracts (1992–2000) from *die tageszeitung* ('taz', 111M), *Frankfurter Rundschau* ('FR', 40M), *Frankfurter Allgemeine Zeitung* ('FAZ', 71M).

All corpora are pre-processed: sentence-tokenised, tagged for part-of-speech, lemmatised and partially chunked[1]. Extraction queries in the form of regular expressions rely on the Stuttgart CorpusWorkBench (CWB, [22]). As extraction context for verbal predicates, we chose German verb-final clauses (VL) (in this case, the subcategorised subclause usually follows the verb, cf. Table 1) and passive sentences (where we have a regular sequence of elements, and the subclause follows the 2nd part of the verb, cf. Table 2).

Table 1. *Dass*-clause after a verb in VL

main clause		**subclause**
	verb	
DE: *Wenn sie*	*erfahren,*	*dass John Miller große Mengen Alkohol kauft...*
EN: "If they"	"found out"	"that John Miller buys much alcohol..."

[1] For annotations we used the Tokeniser of [18], Tree-Tagger described in [19] and [20] and YAC-Chunker [21]

Table 2. *Dass*-clause after a verb in passive

	main clause			**subclause**
	verb: 1st part		**verb: 2nd part**	
DE: *Es*	*muss*	*heute*	*gesagt werden,*	dass der Nikolaus ein Türke ist.
EN: "It"	"should be"	"today"	"told"	"that Santa Claus is Turk."

Nominalisations are extracted in Vorfeld construction (VF), a clause initial position before the finite verb in German declaratives. If a noun in VF is followed by a subclause, this subclause can only be subcategorised by the noun (see Table 3).

Table 3. *W*-clause after a noun in VF

main clause: 1st part noun phrase	**subclause**	**main clause: 2nd part the rest**
DE: *Die Erklärungsversuche,*	*warum der Teufel sich an X heranmacht*	*sind auf der Glatze gedrehte Locken.*
EN: "The explanation attempts",	"why the devil chats up X"	"are as futile as giving a bald man a comb."

4.2 Extraction and Classification Architecture

Extraction and Classification of Nominalisations. We automatically extract predicates from text corpora classifying them according to their subcategorisation properties. The extraction steps proceed from the general to the specific.

For the extraction and classification of "inheritance" relations, we start with the analysis of nominalsations, extracted in VF. They are classified into the three groups shown in Table 4.

Table 4. Classification of nominalisations extracted in VF

type	**subcategorisation properties**
N1	nominalisations that subcategorise only for a *dass*-clause
N2	nominalisations that can take all the three sentential complements
N3	nominalisations with which a *dass*-clause was not found

Extraction and Classification of Base Verbs. With the help of morphological tools, e.g. SMOR, [23], we get a list of base verbs underlying the nominalisations extracted in Vorfeld constructions.

Table 5. Nominalisation-verb pairs after SMOR analysis

nouns vs. verbs	**translation**
Ankündigung – ankündigen	"announcement" – "to announce"
Bedingung – bedingen	"condition" – "to condition"
Befürchtung – befürchten	"fear" – "to fear"
Erwartung – erwarten	"expectation" – "to expect"
Entscheidung – entscheiden	"decision" – "to decide"
Erklärung – erklären	"explanation" – "to explain"
Darstellung – darstellen	"presentation" – "to present"
Vermutung – vermuten	"assumption" – "to assumpt"
Vorstellung – vorstellen	"idea" – "to think"

The generated list of base verbs is integrated into the query for verb extraction. We lexically specify the constraints for the verbal predicate extraction (line 3 in Fig. 1) adding the generated base verbs list $base_verbs (line 3b.).

Query building blocks	**comments**	**matching sentence**	**translation**
1. [pos="KOU.*|PREL.*|PW.*"]	conj., relat. or inter. pronoun	*weil*	"because"
2. [pos!="V.*FIN"&word!=",|-"]*	optional, no fin. verbs or punctuation	*nicht mehr die Parlamentarier selbst künftig darüber*	"in the future not even the parlament members themselves"
3a. <vc>...	verb		
3b. [lemma=RE($base_verbs)]	complex	*entscheiden*	"deside"
3c. ...</vc>		*sollen*	"must"
4. ","	comma	,	,
5. [(pos="PW.*") | (word="ob") | (word="dass")]	rel. pronoun or conj. "ob" or conj. "daß"	*wieviel*	"how much"
6. [pos!="V.*FIN"]*	optional, no fin. verbs	*Geld sie*	"money they"
7. [pos="V.FIN*"]	fin. verb	*bekommen*	"become"
8. [pos="$."]	sent. end	.	.
9. within s;	within a sent.	sentence context	

Fig. 1. Query for base verbs in VL subcategorizing for a *dass/ob/w*-clause

The system searches for base verbs subcategorising for all three complement types (*dass, ob* and *w*-clauses). The list of extracted verbs (with frequency data) is used for the subsequent comparison of subcategorisation properties of the extracted verbs and those of their nominalisations. Base verbs are also classified

into three groups according to their subcategorisation properties, as seen in Table 6.

Table 6. Classification of base verbs

type	subcategorisation properties
V1	verbs that subcategorise only for a *dass*-clause
V2	verbs that can take all the three sentential complements
V3	verbs with which a *dass*-clause was not found

Classification and description of Subcategorisation Relations. We analyse the relations between the subcategorisation properties of verbs and those of their nominalisations as it is shown in Table 7.

Table 7. relations between verbs and their nominalisatons

relations	description of subcategorisation relations
V1N1	nominalisation and its underlying verb subcategorise only for a *dass*-clause.
V2N1	the base verb has all three (or two) complement types but the nominalisation has only a *dass*-clause (the loss of *ob, w*-clauses).
V3N1	the base verb has no *dass*-clause but its nominalisation has a subcategorised *dass*-clause.
V1N2	the base verb has only a *dass*-clause (found in corpora), but its nominalisation has all three (or two) complement types.
V2N2	the base verb has all three (or two) complement types, so does its nominalisation (V1N1 and V2N2 – similar relations).
V3N2	the base verb has no *dass*-clause, but its nominalisation has all three (or two) complement types.
V1N3	the base verb has only a *dass*-clause, but its nominalisation doesn't have any *dass*-clause.
V2N3	the base verb has all three (or two) complement types (including the *dass*-clause), but the nominalisation has no *dass*-clause.
V3N3	the base verb does not have a *dass*-clause, neither does its nominalisation (V1N1 and V3N2 – similar relations).

Classification of "Inheritance" Relations. We classify the relations between the subcategorisation properties of nominalisations and those of their base verbs described above into the three following groups:

R1 subcategorisation properties are "inherited" from the verb (V1N1, V2N2, V3N3):
entscheiden, dass/ob/w- ("to decide that/if/wh-")
vs. *Entscheidung, dass/ob/w-* ("decision that/if/wh-")

R2 subcategorisation properties are "inherited" with the loss of clauses by the nominalisation:
- loss of *ob/w*-clauses (V2N1):
  ankündigen, dass/w- ("to announce that/wh-")
  vs. *Ankündigung, dass* ("announcement that")
- loss of *dass*-clauses (V2N3, V1N3):
  ermitteln, dass/ob/w- ("to investigate that/if/wh-")
  vs. *Ermittlung (darüber), ob* ("investigation (about) if")

R3 subcategorisation properties are "inherited" from the verb, but the nominalisation has additional subcategorisation properties of its own (V3N1, V1N2, V3N2):
darstellen, w- ("to present wh-")
vs. *Darstellung, dass/w-* ("the presentation that/wh-")

5 Results

5.1 Extraction Results and their Interpretation

Subcategorisation of deverbal nouns is "inherited" from their base verbs in most cases. Table 8 contains examples of R1 relation type. Subcategorisation properties of nominalisations *Bedingung* and *Befürchtung* which occur only with a *dass*-clause, as well as subcategorisation properties of the nominalisations *Entscheidung* and *Erklärung* which occur with all three complement types, correspond with subcategorisation properties of their base verbs *bedingen*, *befürchten*, *entscheiden* and *erklären*. Hence, subcategorisation of nominalisations is "inherited" from their base verbs.

Table 8. Examples of type R1 relations

predicate	**translation**	**subclause**		
		dass	*w-*	*ob*
bedingen	"to condition"	+	-	-
Bedingung	"condition"	+	-	-
befürchten	"to fear"	+	-	-
Befürchtung	"fear"	+	-	-
entscheiden	"to decide"	+	+	+
Entscheidung	"decision"	+	+	+
erklären	"to explain"	+	+	+
Erklärung	"explanation"	+	+	+

Table 9 shows cases when a nominalisation takes over only a part of the base verb's subcategorisation (R2 relation type). For instance, the verbs *ankündigen, erfahren* and *fordern* subcategorise for two or three sentential complements, whereas their deverbals *Ankündigung, Erfahrung* and *Forderung* occur only with a *dass*-clause.

Table 9. Examples of type R2 relations

predicate	**translation**	**subclause** *dass*	*w-*	*ob*
ankündigen	"to announce"	+	+	-
Ankündigung	"announcement"	+	-	-
erfahren	"to find out"	+	+	+
Erfahrung	"experience"	+	-	-
fordern	"to claim"	+	+	-
Forderung	"claim"	+	-	-

The R3 relations cases, when nominalisations get some additional properties are very seldom and sometimes difficult to detect.

In Table 10, we otline frequency data for some cases extracted in 'FR', 'FAZ' and 'taz'. The occurrence of nominalisations in VF subcategorising for *dass, ob* or *w*-clauses is compared with the occurrence of their base verbs in VL (see Sect. 4.1).

Table 10. Predicates extracted from German corpora (ca. 220M)

relations	**predicates**	**translation**	**TOTAL abs.**	*dass* **in%**	*w-* **in%**	*ob* **in%**
R1	*bedingen*	"to condition"	**100**	100,00	0	0
	Bedingung	"condition"	**85**	98,82	1,18	0
	fragen	"to ask"	**786**	0	97,33	2,67
	Frage	"question"	**1631**	0	26,98	73,02
R2	*erfahren*	"to find out	**4826**	80,90	14,67	4,43
	Erfahrung	"experience"	**124**	96,77	1,61	1,61
	vorstellen	"to think"	**100**	32,00	68,00	0
	Vorstellung	"idea"	**81**	100,00	0	0
	vermuten	"to assumpt"	**20**	70,00	30,00	0
	Vermutung	"assumption"	**76**	100,00	0	0
	regeln	"to settle"	**14**	42,86	57,14	0
	Regelung	"settlement"	**19**	100,00	0	0
R3	*beweisen*	"to evidence"	**65**	36,92	63,08	0
	Beweis	"evidence"	**65**	95,38	0	4,62
	darstellen	"to present"	**14**	0	100,00	0
	Darstellung	"presentation"	**9**	77,78	22,22	0

Table 10 reveals that the verb *bedingen* never occur with *w-* or *ob*-clauses. Neither does its nominalisation *Bedingung*. Both the deverbal noun *Frage* and its base verb *fragen* subcategorise for *w-* and *ob*-clauses, and never take a *dass*-clause as a complement.

The verb *erfahren* and its nominalisation *Erfahrung* show preferences for a *dass*-clause (in ca. 81% and ca. 97% of cases) as well. However, ca. 15% of the

verb occurrences are found with a *w*-clause, whereas only ca. 2% of its nominalisations occur with this complement type. The nomilnalisation *Erfahrung* seems to "inherit" only a *dass*-clause from the base verb. Further examples of "non-inheritance" are nominalisations *Vorstellung, Vermutung* and *Regelung*, which subcategorise only for a *dass*-clause, whereas their base verbs occur also with other complement types.

Subcategorisation of deverbals *Darstellung* and *Beweis* also differs from that of their base verbs *darstellen* and *beweisen*. The verb *darstellen* occurs only with a *w*-clause (100%) in our corpora, whereas its deverbal can subcategorise both for a *w*- and a *dass*-clause (22% and ca.78% respectively).

Ca. 95% of the occurrences of *Beweis* and only ca. 37% of occurrences of *beweisen* are found with a *dass*-clause. The verb *beweisen* shows preference for *w*-clauses (with 63%), whereas *Beweis* occurs with *ob*- and never with *w*-clauses in the analysed corpora.

5.2 Reasons for "non-inheritance"

One of the reasons for "non-inheritance" among nominalisations lies in their semantics. Most *ung*-nominalisations (e.g. *Erfahrung, Forderung, Vorstellung, Vermutung* ("experience, idea")) express a proposition, a fact, and the subcategorised *dass*-clause is their "content" (e.g. *Bedingung, Erfahrung, Vorstellung*). *W*- amd *ob*-clauses presuppose an open set of answers which doesn't correspond to the semantics of "fact"-nominalisations.

The meaning of "fact"-nominalisations can be introspectively tested with the help of deletion tests. A nominalisation in Vorfeld is deleted in front of its subcategorised subclause. If the complement clause can be used without the nominalisation, this nominalisation has a "fact"-reading (cf. (3a) and (3b)). Otherwise it has a "non-fact"-reading (cf. (4a) and (4b)).

(3a) *Für die Vermutung,* ***dass die Krawalle von rechts inszeniert worden seien****, spreche auch...*
("In the favour of the assumption **that the riots were organized by right-wingers** militates also...")
vs.

(3b) *Dafür,* ***dass die Krawalle von rechts inszeniert worden seien****, spreche auch...*
("In the favour of **that the riots were organized by right-wingers** militates also...")

(4a) *Die Überlegung,* ***ob Mullvorfahren von Afrika nach Lateinamerika über das Meer getrieben worden sein könnten****, ist hypothetisch.*
("The consideration **if the ancestors of moles floated from Africa to Latin America by sea** is hypothetic.")
vs.

(4b) ****Ob Mullvorfahren von Afrika nach Lateinamerika über das Meer getrieben worden sein könnten****, ist hypothetisch.*
("**If the ancestors of moles floated from Africa to Latin America by sea** is hypothetic.")

6 Treatment in NLP Lexicon Building

The phenomena described above should receive a specific treatment in NLP lexicon building. Classification of "inheritance" relations described in 4.2 limits the need for spelling out all subcategorisation properties of nominalisations.

Subcategorisation indications for nominalisations of all three relation types (from R1 to R3) should contain references to subcategorisation of the base verbs. A special note about the loss of certain properties should be included into the entry for R2 nominalisations, whereas entries for R3 nominalisations should contain a note about additional properties that the verb does not have.

7 Conclusion

Our experiments showed that although "inheritance" of subcategorisation properties from verbs to nominalisations is widespread, some morphologically derived predicates can have their own subccategorisation properties, which are not "inherited" from the verbs. These phenomena should receive a specific treatment in NLP lexicon building.

The system described above, allows us to extract and classify such cases semi-automatically according to their subcategorisation relations. It is possible to identify such cases automatically by means of extracting them from tokenised, pos-tagged and lemmatised text corpora.

Our future work will include extraction procedures on a larger corpora to achieve substantial coverage, and a deeper semantic analysis of nominalisations and possible reasons for the "non-inheritance" cases. We also intend to study contextual properties of predicates (e.g. polarity or modality) which can influence the subcategorisation properties of nominalisations. The future tests should include not only nominalisations that appear freely in a sentence but also support verb constructions which contain nominalisations, e.g. *unter Beweis stellen, in Erfahrung bringen*, etc.

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