Semantic roles in natural language processing and in linguistic theory

Mémoire de pré-doctorat

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# Contents

1 Introduction 3

2 Semantic roles in natural language processing 6
   2.1 Automatic labelling of semantic roles 7
      2.1.1 Training 7
      2.1.2 Predicting semantic roles 10
      2.1.3 Evaluation 13
   2.2 Resources for automatic labelling of semantic roles 14
      2.2.1 FrameNet 14
      2.2.2 The Proposition Bank (PropBank) 19
      2.2.3 VerbNet 22
      2.2.4 Comparing the resources 25
   2.3 Semantic role labelling using parallel corpora 28
      2.3.1 Parallel texts in Europarl 28
      2.3.2 Word alignment 29
      2.3.3 Projecting semantic role labels 32
      2.3.4 Cross-lingual parallelism and parallel corpora 34

3 Semantic roles and the structure of a phrase 38
   3.1 Traditional semantic roles 40
   3.2 Semantic roles as clusters of features 42
      3.2.1 Proto-roles 42
      3.2.2 The Theta System 45
   3.3 Predicate decomposition and semantic roles 49
3.3.1 Aspectual event analysis ........................................ 50
3.3.2 Causal event analysis ........................................... 51

3.4 Semantic roles in complex predicates ............................... 52
3.4.1 Lexical and syntactic account of complex predicates .... 53
3.4.2 Causative constructions ......................................... 58
3.4.3 Light verb constructions ......................................... 61

3.5 Causative constructions
and light verb constructions
in English, German, and Serbian .................................... 66
Chapter 1

Introduction

Automatic semantic analysis of sentences is necessary for developing an efficient human machine interface which can enable users to employ computers in activities such as different kinds of automatic booking, or search for information in texts and databases. For example, an automatic railway information system could use such an analysis to understand that from Geneva denotes the starting point and to Montreux the destination of the request in (1.1).

(1.1) What is the shortest connection from Geneva to Montreux?

An analysis which provides this information involves identifying semantic roles — semantic labels assigned to the constituents of a sentence. These labels are based on an analysis of the predicate-argument relations that hold between the constituents in the sentences, determining the predicate of the sentence (typically a verb) and the semantic type of the arguments it takes. This analysis results in an additional layer of linguistic representation, defining relations between the constituents in a sentence that cannot be defined by the rules of syntax only. It also enables a unified representation of sentences with different syntactic structures in the same language (1.2), as well as cross-linguistically (1.3).

(1.2) a [AGENT Mary] stopped [THEME the car].

b [THEME The car] stopped.

3
A successful automatic analysis of the predicate-argument structure of a sentence requires an approach that combines deep linguistic analysis with the methods developed in natural language processing. It makes use of extensive linguistic resources with annotated instances of predicates and semantic roles. Since developing such resources is a long and expensive process, they have been developed only for a few languages. The growing collections of parallel texts, on the other hand, bring an interest in trying to automatically transfer the annotation to other languages via parallel texts. However, the obstacle for automatic transfer of the annotation is the same as for automatic translation — the structural divergences between languages.

This study addresses the cross-linguistic divergences at the lexicon-syntax interface concerning predicate decomposition, namely the light verb constructions and the causative constructions, that affect the predicate-argument structure of sentences. Translation equivalents of these constructions involve divergent structures in different languages, including different number of predicates and different syntactic realizations of semantic roles. As a result, transferring linguistic annotation from one language to another for sentences that contain these constructions becomes a challenging task.

In the following two chapters, we first review the methods applied in automatic labelling of semantic roles including the methods that use parallel texts. Then we take a closer look into linguistic background of assignment of semantic roles, focusing on the issues concerning the relation between semantic roles and syntactic structure of a phrase and on the issues of semantic
role assignment in complex predicates (causative constructions and light verb constructions).
Chapter 2

Semantic roles in natural language processing

Automatic processing of semantic roles is a relatively new subject of studying. It relies strongly on the experience and results achieved in other domains of automatic text analysis such as morphological and syntactic analysis, which provide linguistic knowledge about the text that is necessary for this task. Advances in linguistic theory concerning the syntax-semantic interface, on the other hand, provided a theoretical framework for using the available morpho-syntactic knowledge in identifying the predicate-argument structure in a sentence.

In automatic identification of semantic roles different methods of *machine learning* are applied to the specially structured linguistic data. The success of the processing depends both on the method that is used and on the design of the linguistic data that are presented as input to the system. In this chapter, we review the main aspects of the methods that have been used, with special reference to the linguistic resources.
2.1 Automatic labelling of semantic roles

The most widely used procedure for automatic labelling of semantic roles is the supervised machine learning technique defined in (Gildea and Jurafsky 2002). Approaches in supervised machine learning consist of two major steps. In the first step, the system is trained on the text where segments of texts are already correctly labelled (with semantic roles in this task). It reads the text (training input) and collects the knowledge about the occurrences of labels. In the second step, the system reads a new text for which the labels are to be automatically assigned (test input) and attempts to predict the correct label for every given segment of the text using the information available in the text and the knowledge acquired in training. The procedure usually also involves an evaluation of the performance of the system. In the following subsections, the three steps in automatic semantic role labelling are described in more detail.

2.1.1 Training

Systems for automatic labelling of semantic roles are trained on a corpus of texts that contains explicit labels describing which semantic role is assigned to which segment of the text. Three comprehensive resources which contain this information for English are described in Section 2.2. In the process of training, the system observes the occurrences of semantic roles and collects the data that are related to the occurrences. The data that the system needs to memorise are usually described as a set of features defined in advance. Different systems may use different features, but, as noted by Carreras and Márquez (2005), the systems tend to use similar sets of features.

The system developed by Gildea and Jurafsky (2002) is trained on 36,995 annotated sentences in FrameNet (see Section 2.2.1). The features that they define describe the syntactic and lexical conditions in which a particular semantic role occurs. They are based on the fact that there is a relation between the type of a semantic role and the syntactic form of the unit that
realizes it (see Section 3.1), so that the syntactic information can serve as an indicator for the semantic role. Six features are defined:

- **Phrase type** — reflects the fact that some semantic roles tend to be realized by one and others by another type of phrase. For example, the role GOAL in Table 2.2 tends to be realized by noun phrases, and the role PLACE is realized by prepositional phrases.

- **Governing category** — defines the grammatical function of the constituent that realizes a particular semantic role. It is based on the fact that some semantic roles are realized as the subject in a sentence, and others are realized as the direct object (see Section 3.1). The feature is defined so that it can only have two possible values: S and VP. If a constituent bearing a semantic role is governed by the node S in a syntactic tree, it is the subject of the sentence, if it is governed by the node VP, it means that it belongs to the verb phrase, which is the position of the object. The difference between the direct and the indirect object is not made.

- **Parse tree path** — defines the path in the syntactic tree which connects a given semantic role to its corresponding target word. The value of this feature is the sequence of nodes that form the path, starting with the category of the target word and ending with the phrase that realizes the role. The direction of moving from one node to another is marked with arrows. For example, the value of the feature for the ARG0 role in the example (2.2.2) below relating it to the verb paid would be: VB↑VP↑VP↑S↓SN. The string is regarded as an atomic value. The possible values for this feature are numerous, Gildea and Jurafsky (2002) count 2,978 different values in the training data).

---

1. We use the example from PropBank for convenience, the syntactic annotation used by Gildea and Jurafsky (2002) is the same as in the example.
2. The versions of the part-of-speech tag for verbs denoting their tense form (VBD for past, VBZ for 3rd person present, VBP for present, and VBN for past participle) were replaced by the general VB tag.
• **Position** — defines the position of the constituent bearing a semantic role relative to its corresponding target word, whether the constituent occurs before or after the target word. This is another way to describe the grammatical function of the constituent, since subjects tend to occur before and objects after the verb.

• **Voice** — marking whether the verb is used as passive or active. This feature is needed to capture the systematic alternation of the relation between the grammatical function and semantic role of a constituent. While AGENT is the subject and PATIENT is the object in typical realizations, the reverse is true if the passive transformation takes place.

• **Head word** — describes the relation between the lexical content of a constituent and the semantic role that it bears. The value of this feature is the lexical item that heads the constituent. For example, if a sentence contains two assigned semantic roles, **SPEAKER** and **TOPIC**, the constituent which is headed by *Bill*, *brother*, or *he* is more likely to be the **SPEAKER**, while the constituent headed by *proposal*, *story*, or *question* is more likely to be the **TOPIC**.

Three of the listed features, *path*, *government*, and *position* are different indicators of the grammatical function of the constituents. Gildea and Jurafsky (2002) compare performances of the system using only one, as well as only two of the features at the time, with the performance using the whole set. They find that using both the position and either of the other two feature is redundant. On the other hand, including any of these features is necessary.

More recent systems use more features. In addition to the *government* feature, for instance, the information about the siblings of the constituent in the tree is collected. Also, information about the subcategorization frame or syntactic pattern of the verb is often used (Carreras and Márquez 2005).
2.1.2 Predicting semantic roles

When predicting the correct semantic role for a string of words (usually representing a constituent of a sentence) the system observes the values of the defined features in the test data and calculates the probability that each of the possible roles occurs in the given conditions. The role that is most likely to occur in the given conditions is assigned to the constituent.

The probability that is calculated for each possible role is formulated in the following way (Gildea and Jurafsky 2002):

$$P(r|h, pt, gov, position, voice, t)$$

(2.1)

What is the probability that a particular constituent bears a particular semantic role knowing that the head of the constituent is $h$, the path between the constituent and the target word is $pt$, the category governing the constituent is $gov$, the position of the constituent relative to the target verb is $position$, the voice of the target verb is $voice$, and the target verb is $t$?\(^3\)

An important issue in the task of automatic semantic role labelling is the estimation of the probability. One could assume that the role which occurs most frequently with a given combination of values of the features in the training data is the role that is most likely to occur with the same features in the test data too. In this case the probability could be calculated as the relative frequency of the observations: the number of times the role occurs with the combination of features out of all the occurrences of the combination of features in question:

$$P(r|h, pt, gov, position, voice, t) = \frac{\#(r, h, pt, gov, position, voice, t)}{\#(h, pt, gov, position, voice, t)}$$

(2.2)

The problem with this approach is that some features can have many different values (e.g. the value of the feature head word can be any word in

\(^3\)Note that the test input has to be a text with annotated syntactic structure.
the language), which results in a large number of possible combinations of the values. Many of the combinations will not occur in the training data, even if complex and comprehensive resources such as those described in Section 2.2 are used. Thus, the set of features has to be divided into subsets that occur enough times in the training data. The values for each subset are then considered for each possible semantic role and the decision on the most probable role is made by combining the information.

Different systems apply different machine learning methods to estimate the probabilities. Gildea and Jurafsky (2002) divide the set of features into 8 subsets:

\[
\begin{align*}
P(r|t), & \quad P(r|pt, position, voice, t), \\
P(r|pt, t), & \quad P(r|h), \\
P(r|pt, gov, t), & \quad P(r|h, t), \\
P(r|pt, position, voice), & \quad P(r|h, pt, t).
\end{align*}
\]

They explore several methods of combining the information based on the subsets achieving the best results by combining linear interpolation with the back-off method. Linear interpolation provides the average value of the probabilities based on the subsets of features. It is calculated in the following way:

\[
P(r|\text{constituent}) = \lambda_1 P(r|t) + \lambda_2 P(r|pt, t) + \\
\lambda_3 P(r|pt, gov, t) + \lambda_4 P(r|pt, position, voice) + \\
\lambda_5 P(r|pt, position, voice, t) + \lambda_6 P(r|h) + \\
\lambda_7 P(r|h, t) + \lambda_8 P(r|h, pt, t)
\]

where \(\lambda_i\) represents interpolation weight of each of the probabilities and \(\Sigma_i \lambda_i = 1\).

It can be noted that not all subsets include the same number of features. By including more features, the subset \((pt, position, voice, t)\), for instance, defines more specific conditions than the subset \((t)\). The back-off method
enables combining the more specific features, that provide more information, when they are available and turning to the more general features only if the specific features are not available. The values for the most specific subsets \((pt, position, voice, t)\), \((pt, gov, t)\), \((h, pt, t)\) are considered first. If the probability cannot be estimated for any of them, it is replaced by its corresponding less specific subset. For example, \((pt, position, voice, t)\) is replaced by \((pt, position, t)\), \((pt, gov, t)\) by \((pt, t)\), \((h, pt, t)\) by \((h, t)\) and so on.

A range of different methods, including those based on maximum entropy, support vector machines, decision tree learning and others, have been applied in more recent systems (Carreras and Márquez 2005). Reviewing these methods, however, would exceed the scope of this work.

The described steps can only be applied if the constituent that bears a particular semantic role is already identified. Since this information is not provided in the text with syntactic annotation, which is usually the input for the systems for automatic labelling of semantic roles, the systems need to identify the relevant constituents first and then label them with the correct semantic role.

The methods used for labelling semantic roles can be used for identifying the relevant constituents too. The estimated probability in this case is the probability that a constituent bears any semantic role in given conditions, described by a reduced set of features. Gildea and Jurafsky (2002) use the information on the head word (feature \(h\)), target word \(t\) and the path between them. Since the information on the target word is not contained in the syntactic annotation, most of the systems use resources where this information is manually added (see Section 2.2). However, Merlo and Musillo (2008) show that this information can also be predicted on the basis of syntactic annotation, with comparable results, using additional features that encode relevant syntactic phenomena. One of these features describes whether another verb intervenes between a constituent and its potential target verb (the minimality conditions). The other feature marks if the constituent is realized outside of an verb phrase, either as the subject of a sentence or an extracted


<table>
<thead>
<tr>
<th></th>
<th>Predicted 1</th>
<th>Predicted 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>True 1</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>True 0</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

Table 2.1: Precision and recall matrix

constituent locality constraints.

2.1.3 Evaluation

The performance of the systems for automatic labelling of semantic roles are usually evaluated in comparison with a gold standard, an annotation provided by human experts. The existing manually annotated resources are, thus, usually divided into two parts. One part is used for training and the other for testing.

Assuming that the labels in the gold standard are correct, the labels assigned by the system are correct if they are identical to the labels in the gold standard. The most commonly used measure to expresses the similarity between the labels provided by the system and the gold standard is the $F_1$ measure. It is the harmonic mean of two measures: precision ($p$) and recall ($r$):

$$F_1 = \frac{2 \cdot (p \cdot r)}{p + r} \quad (2.4)$$

Precision shows how many of the assigned labels are correct ($p = A/(A + C)$ in the matrix in Table 2.1). Recall shows how many of the labels that exist in the gold standard the system succeeds in assigning ($r = A/(A + B)$). The best performing systems achieve an $F$-score over 80% (Màrquez et al. 2008)

Since a number of the automatically assigned labels can be identical to the gold standard labels due to chance the success of the system is usually
defined as an improvement relative to the baseline — the result that would be achieved by chance, or by a very simple technique.

2.2 Resources for automatic labelling of semantic roles

Samples of sentences containing correctly marked instances of semantic roles are necessary both for training and evaluation of the systems for automatic labelling of semantic roles. Three big projects are concerned with providing extensive descriptions of the predicate-argument relations for English words. They are described in the following subsections, starting with the most comprehensive one, FrameNet, followed by PropBank and VerbNet.

2.2.1 FrameNet

FrameNet is an electronic resource and a framework for explicit description of the lexical semantics of words. It is intended to be used by lexicographers, but also by systems for natural languages processing (Baker et al. 1998). It consists of three interrelated databases:

a. Frame database, the core component describing semantic frames that can be expressed by lexical units.

b. Annotated example sentences, sentences extracted from the British National Corpus (Burnard 2007) with manually annotated frames and frame elements that are described in the Frame database.

c. Lexicon, a list of lexical units described in terms of short dictionary definitions and detailed morpho-syntactic specifications of the units that can realize their arguments in a sentence.

The frame database (946 frames) contains descriptions of frames or scenes that can be denoted by predicating lexical units (Fillmore 1982), such as verbs, adjectives, prepositions, nouns. Each scene involves one or
more participants that are denoted by the lexical units which combine with
the predicating units. The predicating units are referred to as “targets”, and
the units that they combine with as “frame elements”. One frame can be
realized in its “core” version including “core” frame elements, or it can be
realized as a particular variation, including additional frame elements that
are specific for the variation. For example, the target unit for the frame
Accomplishment can be one of the verbs accomplish, achieve, bring about, or
one of the nouns accomplishment, achievement. The core frame elements for
this frame are:

a. AGENT: The conscious entity, generally a person, that performs the
intentional act that fulfills the GOAL.

b. GOAL: The state or action that the AGENT has wished to participate
in.

The definition of the frame itself specifies the interaction between the core
frame elements:

After a period in which the AGENT has been working on a GOAL,
the AGENT manages to attain it. The GOAL may be a desired
state, or be conceptualized as an event.

For the non-core realizations, only the additional frame elements are de-

dined.

The frames are organized into a network by means of one or more frame-

to-frame relations that are defined as attributes of frames.\footnote{Not all frames could be related to other frames.} Defining the
relations enables grouping related frames according to different criteria, so
that the annotation can be used with different levels of granularity. There
are six types of relations that can be defined:

- Inherits From / Is Inherited By: relates an abstract to a more specified
  frame with the same meaning, e.g. Activity (no lexical units) inherits
  from Process (lexical unit process.n) and it is inherited by Apply heat
Subframe of / Has Subframes: if an event denoted by a frame can be divided into smaller parts, this relation holds between the frames that denote the parts and the one that denotes the whole event, e.g. Activity has subframes: Activity abandoned state, Activity done state (lexical units done.a, finished.a, through.a), Activity finish (lexical units complete.v, completion.n, ...), Activity ongoing (lexical units carry on.v, continue.v, keep on.v, ...), Activity pause (lexical units freeze.n, freeze.v, pause.n, take break.v, ...), Activity paused state, Activity prepare, Activity ready state (lexical units prepared.a, ready.a, set.a), Activity resume (lexical units renew.v, restart.v, resume.v), Activity start (lexical units begin.v, beginner.n, commence.v, enter.v, initiate.v, ...), Activity stop (lexical units quit.v, stop.v, terminate.v, ...).

Precedes / Is Preceded by: holds between the frames that denote different parts of the same event, e.g. Activity pause precedes Activity paused state and is preceded by Activity ongoing.

Uses / Is Used By: connects the frames that share some elements, e.g. Accomplishment (lexical units accomplish.v, accomplishment.n, achieve.v, achievement.n, bring about.v) uses Intentionally act (lexical units act.n, act.v, action.n, activity.n, carry out.v, ...).

Perspective on / Is perspectivized in: holds between the frames that express different perspectives on the same event, e.g. Giving (lexical units gift.n, gift.v, give.v, give out.v, hand in.v, hand.v, ...) is a perspective on Transfer (lexical units transfer.n, transfer.v), Transfer can also be perspectivized in Receiving (lexical units accept.v, receipt.n, receive.v).

Is Causative of: e.g. Apply heat is causative of Absorb heat (lexical units bake.v, boil.v, cook.v, fry.v, ...).
The relations of inheritance, using, subframe, and perspective connect specific frames to the corresponding more general frames, but in different ways. The specific frame is a kind of the general frame in inheritance. Only a part of the specific frame is a kind of the general frame in using. A subframe is a part of another frame. The other two relations do not involve abstraction, they hold between the frames of the same level of specificity.

Frames and frame elements can also be classified into semantic types that are not based on the hierarchies described above, but that correspond to some ontologies that are commonly referred to (such as WordNet (Fellbaum 1998)). For example, frames are divided into non-lexical (e.g. Activity) and lexical (e.g. Accomplishment). Similarly, the frame element agent belongs to the type “sentient”, and theme belongs to the type “physical object”.

Annotated examples such as (2.5-2.9) are provided for most of the frame versions.

(2.5) [AGENT Iraq] had [TARGET achieved] [GOAL its programme objective of producing nuclear weapons].

(2.6) Perhaps [AGENT you] [TARGET achieved] [GOAL perfection] [MANNER too quickly].

(2.7) [AGENT He] has [DEGREE only partially] [TARGET achieved] [GOAL his objective].

(2.8) [GOAL These positive aspects of the Michigan law] may, however, have been [TARGET achieved] at the expense of simplicity .[AGENT CNI]

(2.9) A programme of national assessment began in May 1978 and concerned itself with [GOAL the standard] [TARGET achieved] [AGENT by 11 year olds].

The units of the lexicon are word senses (5161 fully described with another 5560 partially described units). The entries contain a short lexical
definition of the sense of the word, the frame that the unit realizes, as well as the list of the frame elements that can occur with it. They also contain two more pieces of information on frame elements: the specification of the syntactic form that each frame element can take and a list of possible combinations of the frame elements in a sentence. For example, the verb achieve realizes the frame Accomplishment. The frame elements that can occur with it are listed in Table 2.2.

The first row in Table 2.2 states that the frame element AGENT occurs with the verb achieve and that it can be realized as Constructional null instantiation (CNI), which is most often the case in passive sentences (2.8), or as a noun phrase external to the verb phrase headed by the target verb, which is most often the subject of a sentence (2.5-2.7), or as a prepositional phrase headed by the preposition by and realizing the grammatical function...
of dependent,\textsuperscript{5} or as a prepositional phrase headed by the preposition for with the same grammatical function. Possible syntactic realizations for the other frame elements are described in the same way.

Since not all frame elements can be combined with all the others in a sentence, the possible combinations of the frame elements are also listed. Some of the possible combinations for the verb achieve, those that correspond to the examples (2.5-2.7), are listed in Table 2.3. The original entry for this verb contains 19 combinations in total. Each of the combinations can have several versions depending on the type and grammatical function of the constituents that realize the frame elements.

### 2.2.2 The Proposition Bank (PropBank)

PropBank is a corpus of naturally occurring sentences with manually annotated syntactic structure and semantic roles. It is intended to be used for

\begin{table}[h]
\centering
\begin{tabular}{lll}
Agent & Goal & Manner \\
NP & NP & AVP \\
Ext & Obj & Dep \\
Agent & Degree & Goal \\
NP & AVP & GOAL \\
Ext & Dep & Obj \\
\end{tabular}
\caption{Some combinations of frame elements for the verb achieve.}
\end{table}

\textsuperscript{5}In the system of grammatical functions used in FrameNet, the standard distinction between a complement and a modifier is not made. They are both considered as dependent constituents — dependents. (Ruppenhofer et al. 2005)
developing systems for natural language understanding, that depend on semantic parsing, but also for quantitative analysis of syntactic alternations and transformations.

The corpus contains 2,499 articles (1 million words) published in the Wall Street Journal for which the syntactic structure was annotated in the The Penn Treebank Project (Marcus et al. 1994). The semantic roles were annotated in the PropBank project (Palmer et al. 2005). The labels for the semantic roles were attached to the corresponding nodes in the syntactic trees. An example of an annotated sentence is given in Figure 2.2.2. The added semantic annotation is placed between the "@" characters.

Only a limited set of labels was used for annotation. Verbs are marked with the label REL for relation and the participants in the situation denoted by the verb are marked with the labels ARG0 to ARG5 for the verb's arguments and with ARG-M for adjuncts.

The numbered labels represent semantic roles of a very general kind. The

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6 The annotation is slightly simplified.
labels ARG0 and ARG1 have approximately the same value with all verbs. They are used to mark instances of PROTO-AGENT (ARG0) and PROTO-PATIENT (ARG1) roles (see 3.2.1). The value of other indices varies across verbs. It depends on the meaning of the verb, on the type of the constituent that they are attached to, and on the number of roles present in a particular sentence. ARG3, for example, can mark the PURPOSE, as it is the case in 2.2.2, or it can mark a DIRECTION or some other role with other verbs. The indices are assigned according to the roles’ prominence in the sentence. More prominent are the roles that are more closely related to the verb.

The ARG-M can have different versions depending on the semantic type of the constituent: LOC denoting location, CAU for cause, EXT for extent, TMP for time, DIS for discourse connectives, PNC for purpose, ADV for general-purpose, MNR for manner, DIR for direction, NEG for negation marker, and MOD for modal verb. The last three labels do not correspond to adjuncts, but they are added to the set of labels for semantic annotation nevertheless, so that all the constituents that surround the verb could have a semantic label (Palmer et al. 2005). The labels for adjuncts are more specific than the labels for arguments. They do not depend on the presence of other roles in the sentence. They are mapped directly from the syntactic annotation.

For example, the verb pay in Figure 2.2.2 assigns three semantic roles to its arguments and one to an adjunct. ARG0 is attached to the noun phrase that it the subject of the sentence (NP-SUBJ: The Latin American nation) and it represents the (PROTO-)AGENT. ARG1 is attached to the direct object (NP: very little). ARG3 is attached to the prepositional phrase that denotes the purpose of the payment (PP: on its debt). The label for the adjunct (PP-TMP: since early last year), ARG-M-TMP, is mapped from the syntactic label for the corresponding phrase.

The annotated corpus is accompanied with a lexicon that specifies the interpretation of the roles for each verb in its different senses. The unit of the lexicon is a lemma (3300 verbs) containing one or more lexemes (4 500 verb senses). The interpretations for the numbered roles are given for each
| pay.01 | Arg0: payer or buyer  
|        | Arg1: money or attention  
|        | Arg2: person being paid, destination of attention  
|        | Arg3: commodity, paid for what  
| pay.02  
| (pay off) | Arg0: payer  
|        | Arg1: debt  
|        | Arg2: owed to whom, person paid  
| pay.03  
| (pay out) | Arg0: payer or buyer  
|        | Arg1: money or attention  
|        | Arg2: person being paid, destination of attention  
|        | Arg3: commodity, paid for what  
| pay.04  
|        | Arg1: thing succeeding or working out  
| pay.05  
| (pay off) | Arg1: thing succeeding or working out  
| pay.06  
| (pay down) | Arg0: payer  
|        | Arg1: debt  

Table 2.4: The PropBank lexicon entry for the verb *pay*.

The syntactic realizations of the roles are not explicitly described as in FrameNet, but they are illustrated with a number of annotated sentences, each representing a different syntactic realization of the role. These sentences are mostly drawn from the corpus. For some syntactic realizations that are not attested in the corpus, example sentences are constructed.

### 2.2.3 VerbNet

VerbNet is a database which is primarily concerned with classification of English verbs. The approach to classification is based on the framework proposed by Levin (1993). It takes into account two properties: a) the lex-
ical meaning of a verb and b) the kind of argument alternations that can be observed in the sentences formed with a particular verb. Typical examples of alternations of arguments that can be a basis for verb classification are the unaccusative alternation illustrated in (2.10-2.11) and the locative alternation (2.12-2.13)

(2.10)  
a Mary stopped the car.
b The car stopped.

(2.11)  
a Mary pushed the car.
b * The car pushed.

(2.12)  
a Mary loaded the books on the table.
b Mary loaded the table with the books.

(2.13)  
a Mary put the books on the table.
b * Mary put the table with the books.

The alternations are possible for the verbs in (2.10) and (2.12), while they are not possible for (2.11) and (2.13). The idea that underlies the Levin classification is that syntactic constraints such as these reflect certain semantic properties of verbs. Thus, observing syntactic behaviour of verbs could provide the background for their systematic and consistent classification that holds across languages.

The unit of classification in VerbNet is a verb sense. It covers 5 200 verb senses (of 3 600 distinct verbs). The classification is partially hierarchical, including 237 top-level classes with only three more levels of subdivision (Kipper Schuler 2005). Each class entry includes:

a) The list of member verbs.

b) semantic roles that the verbs assign to their arguments. All the verbs in the class assign the same roles. These roles are semantic roles that are more general than frame elements in FrameNet, but more specific than the numbered roles in PropBank. The label for a role in VerbNet does not depend
<table>
<thead>
<tr>
<th>Members</th>
<th>accept, discourage, encourage, understand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roles</td>
<td>AGENT [+animate</td>
</tr>
<tr>
<td>Frames</td>
<td>HOW-S:</td>
</tr>
<tr>
<td></td>
<td>Example: “I accept how you do it.”</td>
</tr>
<tr>
<td></td>
<td>Syntax: Agent V Proposition &lt;+how-extract&gt;</td>
</tr>
<tr>
<td></td>
<td>Semantics: approve(during(E), Agent, Proposition)</td>
</tr>
</tbody>
</table>

Table 2.5: The VerbNet entry for the class Approve-77.

on context, as in FrameNet and PropBank. There is a fixed set of roles that have the same interpretation with all verbs:

Roles in VerbNet (23): ACTOR, AGENT, ASSET, ATTRIBUTE, BENEFICIARY, CAUSE, LOCATION, DESTINATION, SOURCE, EXPERIENCER, EXTENT, INSTRUMENT, MATERIAL, PRODUCT, PATIENT, PREDICATE, RECIPIENT, STIMULUS, THEME, TIME, TOPIC.

c) Selectional restrictions on the verbs’ arguments, such as [+animate | +organization] for the role AGENT in Table 2.5. These restrictions are described in terms of the Euro WordNet ontology. They can be compared with the semantic types in FrameNet.

d) Frames, containing a description of syntactic realizations of the arguments and some additional semantic features of verbs. In the example class entry given in Table 2.5, only one (HOW-S) of the 5 frames that are defined in the original entry is included, since the other frames are defined in the same way. The semantics of the verb describes the temporal analysis of the predicate denote by the verb (see Section 3.3 below.)

The VerbNet database contains also information about the correspondence between the classes of verbs and lexical entries in other resources. 4397 links with the PropBank lexicon entries have been specified, as well as 3412 with the FrameNet entries.

\(^7\)Note that the VerbNet frames are different from the FrameNet frames.
No annotated example sentences are provided directly by the resource. However, naturally occurring sentences with annotated VerbNet semantic roles can be found in another resource, SemLink (Loper et al. 2007), which maps the PropBank annotation to the VerbNet descriptions. Each numbered semantic role annotated in the PropBank corpus is also annotated with the corresponding mnemonic role from the set of roles used in VerbNet. This resource enables comparison between the two annotations and exploration of their usefulness for the systems for automatic semantic role labelling.

### 2.2.4 Comparing the resources

The three resources that are described in the previous subsections all provide information on how predicating words combine with other constituents in a sentence: what kind of constituents they combine with and what interpretation they impose on these constituents. They are all intended to be used for training systems for automatic semantic parsing. However, there are considerable differences in the data provided by these resources.

The words that they cover are not the same. For example, 25.5% of the word instances in PropBank are not covered by VerbNet (Loper et al. 2007)), despite the fact that VerbNet contains more entries than PropBank (3 300 verbs in PropBank vs. 3 600 verbs in VerbNet). The criteria for distinguishing verb senses are differently defined, which means that different senses are described even for the same words. It can be noted, for example, in Table 2.4 that PropBank introduces a new verb sense for a phrasal verb even if its other properties are identical to those of the corresponding simplex verb, which is not the case in the other two databases.

The information that is included in the lexicon entries is also different. We can see, for example, that the morpho-syntactic properties of the constituents that combine with the predicating words are described in different way. While FrameNet provides detailed specifications (Table 2.2), VerbNet defines these properties only for some argument realizations (Table 2.5). PropBank does not contain this information in the lexicon at all, but all the instances of the
roles are attached to nodes in syntactic trees in the annotated corpus.

Finally, different set of roles are used in the descriptions. FrameNet uses many different role labels that depend on which frame they occur in. These roles can have a more specific meaning such as BUYER in the frame Commerce-buy, but they can also refer to a more general notions such as AGENT in the frame Accomplishment (see Section 2.2.1). VerbNet uses a set of 23 roles with general meaning that are interpreted in the same way with all verbs. PropBank uses only 6 role labels, but their interpretation varies depending on context (see Section 2.2.2).

A number of experiments have been conducted to investigate how the differences between the PropBank and the VerbNet annotation schemes influence the systems for automatic role labelling with machine learning. The task of learning the VerbNet labels can be expected to be more difficult, since there are more different items to learn. On the other hand, the fact that the labels are used in a consistent way with different verbs could make it easier because the labels should be better associated with the other features used by the systems.

Loper et al. (2007) show that the system trained on the VerbNet labels predicts better the label for new instances than the system trained on the PropBank labels, especially if the new instances occur in texts of a different genre. However, this finding only holds if the performance is compared for the ARG1 and ARG2 labels in PropBank vs. the sets of VerbNet labels that correspond to them respectively.8 If the overall performance is compared, the PropBank labels are better predicted, which is also confirmed by the findings of Zapirain et al. (2008).

Merlo and van der Plas (2009) compare different quantitative aspects of the two annotation schemes and propose the ways in which the resources can be combined. They first reconsider the evaluation of the performances of the systems for automatic semantic role labelling. They point out that

---

8The VerbNet labels were grouped in more general labels for this experiment though, 6 labels corresponding to ARG1 and 5 corresponding to ARG2.
an uninformed system that predicts only one role, the most frequent one, for every case would be correct in 51% cases if it learned the PropBank roles, and only in 33% cases if it learned the VerbNet roles, due to the different distributions of the instances of the roles in the corpus. They neutralize this bias by calculating and comparing the reduction in error rate for the two annotations.

This measure shows how much a system improves the baseline results. For example, if a system achieves an F-score of 75%, the error is 25%. If the baseline score is 50% (error 50% too), the system reduces the error from 50% to 25%. The reduction in error rate is 50% (25/50). According to this measure, the overall performance is better for the VerbNet labels, but it is more degraded in the cases where the verb is not known (not observed in the training data) compared to the cases where it is known, due to the stronger correlation between the verb and its role set. Thus, they argue that the VerbNet labels should be used if the verb is known, and the PropBank labels if it is new.

Looking at the joint distribution of the labels in the corpus, Merlo and van der Plas (2009) note different relations for roles with different frequencies. The frequent labels in PropBank can be seen as generalizations of the frequent labels in VerbNet. For example AGENT and EXPERINCR are most frequently labelled as ARG0, while THEME, TOPIC, and PATENT are most frequently labelled as ARG1, which means that the PropBank labels group together the similar VerbNet labels. The PropBank labels of low frequency are more specific and more variable, due to the fact that they depend on context, and the VerbNet labels are more stable. Thus for interpretation for a particular instance of a PropBank label a VerbNet label could be useful.

The comparisons of the sets of labels used in PropBank and VerbNet annotation schemes indicate that they can be seen as complementary sources of information about semantic roles. However, other aspects of combining the resources are still to be explored. The described comparisons are performed only for the lexical units which are included both in PropBank and VerbNet.
Since these two resources contain different lexical items, their combination might be used for increasing the coverage. Also, the potential advantages of using the other data provided by the resources (e.g. the hierarchies defined in FrameNet and VerbNet) are still to be examined.

2.3 Semantic role labelling using parallel corpora

Developing extensive sources of information about predicate-argument relations between words, such as those described in the previous section is a costly endeavour requiring engagement of many highly qualified professionals. This is why similar databases for other languages, although essential for automatic text analysis, are extremely rare. There is a big interest in exploring the ways in which the existing resources for English could facilitate creating new resources for other languages.

One way of using English annotation to create annotated texts in other languages is annotation projection via parallel corpora. A parallel corpus is a collection of translations between two (or more) languages, where each sentence in one language is aligned with the corresponding sentence in the other language. However, to use these ever growing resources for projecting annotation, the alignment has to be established also at the word level, which is still a challenging task.

In this section, we first describe a large, widely used parallel corpus as well as the program which is most often used for aligning words in parallel corpora. Then we review experiments in projecting semantic role annotation and discuss the problems related to it.

2.3.1 Parallel texts in Europarl

The Europarl corpus (Koehn 2005) is a collection of the proceedings of the European Parliament since 1996. It is created as a resource for research in
statistical machine translation.

The texts are collected from the website of the European Parliament. They are automatically segmented into sentences and aligned at the level of sentence. The corpus contains about 30 million words (1 million sentences) of each of the 11 formerly official languages of the European Union: Danish (da), German (de), Greek (el), English (en), Spanish (es), Finnish (fin), French (fr), Italian (it), Dutch (nl), Portuguese (pt), and Swedish (sv). It should be noted that most of the possible language pairs are not direct translations of each other, since for each text, there is one source language and the others are translations. Some translations are also mediated by a third language. This means that considerable variations in the structure and lexical choice can be expected.

2.3.2 Word alignment

Links between corresponding words in two languages, necessary for projecting annotation, can be obtained from a parallel corpus such as Europarl using a program for automatic word alignment.

![Figure 2.2: Word alignment in a parallel corpus](image)

Word alignment establishes links between individual words in each sentence and their actual translations in the parallel sentence. Figure 2.2 illustrates such an alignment, where the German pronoun *ich* is aligned with the English pronoun *I*, German verb form *möchte*, with the English forms *would like* and so on. As the example in Figure 2.2 shows, correspondences
between the words in sentences are often rather complex. There are words that cannot be linked with any word in the parallel sentence (English *There, is, to*; German *daß* in 2.2). Some words need to be linked to multiple words in the parallel sentence (German *möchte, daraus*). Finally, in the case of idioms, the correspondence often cannot be established for individual words at all, but rather for sequences of words.

For the purpose of automatic extraction from parallel corpora, word alignment is usually represented as a single-valued function, mapping each word in the source sentence to one word in the target sentence. It is seen as a set of ordered pairs, which is a subset of the Cartesian product of the set of words of the source sentence and the set of words of the target sentence. With words being represented by their position in the sentence, the first member in each ordered pair is the position of the source word (\(j\) in 2.14) and the second member is the position of the target word that the source word is aligned with (\(i\) in 2.14).

\[
A \subseteq \{(j, i) : j = 1, \ldots, J; i = 1, \ldots, I\} 
\]  

(2.14)

For example, taking English as the source and German as the target language in 2.2, alignment between *I* and *ich* can be represented as the ordered pair (6, 1). Alignment of *would like* with *möchte*, is represented with two ordered pairs (7, 2) and (8, 2). To account for the fact that some source language words cannot be aligned with any target language word, a special empty word (“NULL”) is introduced in the target sentence. In this way, all the words that have no translation (such as English *There, is, to* in 2.2) can be aligned with this word.

It should be noted, though, that this definition only approximates the notion of word alignment, since it does not account for the cases where one source word is aligned with multiple target words, nor for the many-to-many alignment of idioms. Nevertheless, it is widely used, since it expresses the main properties of word alignment in a way that is suitable for implementing algorithms for its automatic extraction from parallel corpora.
Word alignments are usually automatically extracted from parallel corpora in the context of training programs for statistical machine translation. They are calculated as a part of building a translation model for two languages. Translation model defines what are possible translations of a sentence assigning certain probability to each option. The probability of translation is assessed by observing actual translations in a big parallel corpus. It can be expressed as a conditional probability of the sentence in a source language knowing the target language sentence ($p(f|e)$). The translations that occur most frequently can be assigned the highest probability.

Since whole sentences are not likely to reoccur even in a large parallel corpus, their possible translations are computed from the possible translations of the words that they consist of. The product of the probabilities of translations of each word is considered to be the probability of the sentence translation. Possible translations of words, on the other hand, cannot be directly extracted from a parallel corpus, since words are not aligned. The correct word alignment too has to be computed for each pair of sentences. This means that statistical modelling of the relation that holds between sentences in the source language and their corresponding sentences in the target language necessarily includes word alignment.

Word alignment is usually computed from sentence alignment by means of Expectation Maximisation Algorithm. This algorithm considers all possible alignments of the words in a pair of sentences ($\text{length}(f)\text{length}(e)$). The probabilities assigned to different alignments are iteratively updated using Expectation Maximisation Algorithm. This algorithm considers all possible alignments of the words in a pair of sentences ($\text{length}(f)\text{length}(e)$). The probabilities assigned to different alignments are iteratively updated using

9Following the notation common in statistical machine translation, the symbol for the source language in the formula is $f$, and for the target language is $e$. Contrary to the common conception of translation, where it is the source language that is known, the word of the target language is known in the formula. This is due to the noisy channel formulation (Manning and Schütze 1999) of translation, which is assumed in the statistical approaches to machine translation. In this formulation, the translated sentence is seen as a message corrupted by a noisy channel. The target language sentence is the corrupted message that is known, and the source language sentence is the original sentence that needs to be reconstructed.
evidence from corpus (recurring pairs of words in different pairs of sentences) to determine the most probable ones.

A commonly used program that provides alignments for words in a parallel corpus, GIZA (version GIZA++ (Och and Ney 2003)) uses several translation models with gradually increasing complexity. The basic model, known as the IBM Model 1, includes only information about word translations and word alignments. The more complex models include information about the fact that not all possible alignments are equally probable (Model 2), also that some words have no translation equivalents and that some are translated with more than one word (Models 3-5). Other refinements are added to the program too.

The experiments performed to evaluate this alignment method (Och and Ney 2003) showed that, apart from setting required parameters, the quality of alignment depends on the language pair, as well as on the direction of alignment (e.g. the performance is better for the direction English → German than the other way around). They also showed that combining the alignments made in both directions has a very good effect on the overall success rate.

2.3.3 Projecting semantic role labels

Padó (2007) proposes a framework for transferring the annotation of semantic roles from a source language for which a resource exists to a new (target) language using parallel corpora. More specifically, the framework concerns transferring the FrameNet resources (see Section 2.2.1) from English to German and French. The assumption that underlies the transfer is that if two predicating words are aligned in a parallel text as translations of each other, they are both targets (in the FrameNet sense) or frame evoking elements — FEEs of the same semantic frame. Assuming the same set of frames, Padó (2007) presents methods for transferring the other two data sources. The FrameNet lexicon describing the predicate-argument relations for English words is used to generate a parallel lexicon for the target languages. Also, a sample of sentences with annotated semantic role labels in English
are used to assign semantic roles to the sentence constituents in the target language.

Generation of the frame lexicon consists of two parts too. A list of candidate FEEs in the target language is formed first. Each predicating word in the target language which has been aligned with a frame-evoking element for a particular frame at least once is considered as a FEE candidate for this frame. Due to the fact that the frames are specified for word senses and not for words and that many words are ambiguous between different senses, this list will include many words that are not FEEs for the frame in question. For example, the English verb *say* is a FEE for the frame *Statement*. Since it can be (correctly) aligned with the German words *sagen* (*say*), *meinen* (*say*), and *beispielsweise* (*for example*), all these words are included in the list of FEE candidates for the frame *Statement* in German, although the last one does not belong to this frame. In the second step, a number of filters are applied to sort out the list and keep the good candidates. For example, a filter can be applied to keep only the candidates which are aligned in both direction of alignment. Also, a word-sense disambiguation filter can be applied to keep only the instances that correspond to a particular sense.

In projecting semantic role labels from the annotated sentences in the source language to the sentence constituents in the target language, Padó (2007) relies on the concept of *semantic similarity*. Semantically similar units in two languages are aligned as translations of each other in a parallel text. If two units are aligned, the semantic role in the source language is mapped on the unit in the target language. The optimal alignment \( A \) is the one that maximizes the similarity between a unit in the source language \( u_s \) and a unit in the target language \( u_t \):

\[
A = \arg \max_{A \in \mathcal{A}} \prod_{(u_s, u_t) \in A} \text{sim}(u_s, u_t)
\]

The simplest approach to projecting semantic roles across parallel corpora would be to regard each word as a linguistic unit and to assign to each word in the target language the same semantic role which is assigned to the aligned
word in the source language. The main problem with this approach is that
the unaligned words cannot be assigned a semantic role. The roles, thus,
have to be assigned to linguistic units that span over a group of words, so
that the entire span is assigned a role indicated by the label in the source
language.

In the constituent-based projecting of semantic roles, Padó (2007) uses
syntactic annotation in both languages to define constituents of the sentences
first. The roles are then projected from the constituent in the source lan-
guage to the constituent in the target language that is aligned with it. The
semantic similarity between the constituents in two languages is represented
with the number of overlapping words — the number of words which belong
to the constituents and which are aligned in a parallel text. Three types of
constituent matching are examined: total matching, where each constituent
in the source language has to be aligned with at least one constituent in the
target language, edge covers, where each constituent in both languages has
to be aligned with at least one constituent, and perfect match, where each
constituent in both languages has to be aligned with exactly one constituent.

In the experimental evaluation of the approach, automatically projected
annotation is compared with a gold standard. The comparison shows that
using syntactic information is necessary, since it improves the results signifi-
cantly. Also, the most strict type of constituent alignment, the perfect match,
proves to be most suitable for this task.

2.3.4 Cross-lingual parallelism and parallel corpora

The approach of Padó (2007) relies on the assumption that sentences which
are translation equivalents can be represented with the same predicate-argument
structure, despite the different lexical and syntactic realizations in differ-
ent languages. Although this assumption may be linguistically justified (see
Section 3.2), the translated sentences in parallel corpora are often different
in such a way that they cannot be represented with the same predicate-
argument structure.
(2.15) a I hope that the President of the Commission [...] tells us what he intends to do.

b J’espère que le président de la Commission [...] I hope that the president of the commission nous fera part de ses intentions. us will make part of his intentions

Even if the English sentence in (2.15a) can be translated into French keeping the parallel structure, it is not. As a result, the phrases tells us what he intends to do and nous fera part de ses intentions (will make us part of his intentions) cannot be represented with the same semantic frame. This example illustrates the difference between the concept-level parallelism and instance-level parallelism discussed by Padó (2007). If two languages are parallel at the concept-level, it means that they use the same set of categories and rules to form sentences or phrases. English and French do exhibit this kind of parallelism in the given example. There is a verb in French (communiquer) that corresponds to the English verb tell, taking the same types of the complements as the English verb. However, at the instance level, these two sentence are not parallel. The factors that influence the translations at the instance level are numerous, including discourse factors, broader cultural context, translators attitudes, and other factors. An interesting question to ask, then, is to what degree the existing translations can be useful for projecting linguistic annotation from one language to another.

In an experimental study on a sample of 1 000 sentences containing potentially parallel frames, extracted from the Europarl corpus (see Section 2.3.1) and manually annotated, Padó finds that 72% of English frames that could have a parallel frame in German were realized as parallel instances. The ratio is 65% for the pair English-French. However, once the frames are parallel, the parallelism between the roles (frame elements in FrameNet) within the frames is assessed as “almost perfect”.

The issue of parallelism in the predicate-argument structure of English and Chinese sentences is addressed by Fung et al. (2007). They find that in
a sample of the Parallel English-Chinese PropBank corpus containing over 1 000 manually annotated and manually aligned semantic roles, in 17.24% cases, the roles do not match. English arg0 role, for instance, is mapped to Chinese arg1 77 times. Although the sources of the mismatches are not discussed, they are interpreted as evidence against the assumption on parallel structures. Thus, Fung et al. (2007) abandon this assumption and propose a method for cross-lingual mapping of semantic roles based on syntactic and semantic annotation obtained by processing each language separately.

The plausibility of a strong version of the assumption of structural parallelism for projecting syntactic annotation from English to Chinese is explored by Hwa et al. (2002). It is formulated as the Direct Correspondence Assumption:

Given a pair of sentences $E$ and $F$ that are (literal) translations of each other with syntactic structures $Tree_E$ and $Tree_F$, if nodes $x_E$ and $y_E$ of $Tree_E$ are aligned with nodes $x_F$ and $y_F$ of $Tree_F$, respectively, and if syntactic relationship $R(x_E, y_E)$ holds in $Tree_E$, then $R(x_F, y_F)$ holds in $Tree_F$.

The evaluation of the projected annotation in Chinese against a gold standard shows that syntactic relations are not directly transferable in many cases. However, a limited set of regular transformations can be applied to the result of direct projection to improve significantly the overall results. For example, while English verb tense forms express verbal aspect at the same time (whether the activity denoted by the verb is completed or not), Chinese forms are composed of two words, one expressing the tense and the other the aspect. Projecting the annotation from English, the relation between the aspect marker and the verb in Chinese cannot be determined, since the aspect marker is either aligned with the same word as the verb (the English verb form), or it is not aligned at all. In this case, a rule can be stated adding the relation between the aspect marker and the verb to the Chinese annotation in a regular way.
The reviewed experiments in annotation mapping in parallel texts show that parallel texts can be used in transferring annotation from one language to another, but not in a straightforward way. Although they do not necessarily lead to abandoning the assumption of the parallel structures, the instance-level divergences which are frequently found in parallel texts have to be taken into account. This can be done by post-processing of the projected annotation (Hwa et al. 2002; Yarowsky et al. 2001) or by filtering out the sentence pairs that are found to be too different (Yarowsky et al. 2001).

Both monolingual and bilingual automatic labelling of semantic roles assume a set of distinct roles that can be assigned to constituents in a sentence. The set that is actually applied in a particular program depends on the linguistic resource that has been chosen. At the moment, a choice can be made between three different resources (Section 2.2), each proposing a different set. Although these resources have been conceived on the basis of linguistic theoretical frameworks, they do not necessarily represent coherent systems and adequate solutions. This is partially a consequence of the fact that annotating a big number of different sentences often brings up particular cases where it is hard to apply general principles and where an ad-hock solution is needed. On the other hand, semantic roles are still not fully investigated in linguistic theory itself. Different theories still propose different notions of semantic roles as well as different principles that underly these notions. In the following chapter, we first discuss the main theoretical proposals on how semantic roles are assigned and organised, and then we discuss two constructions, namely causative constructions and light verb constructions, that pose a problem both for monolingual and bilingual semantic role assignment and that are not treated in the existing resources.
Chapter 3

Semantic roles and the structure of a phrase

Linguistic resources that describe predicate-argument relations in sentences are necessary for automatic assignment of semantic roles. These resources are practical implementations of concepts and analyzes developed in linguistic theory. However, no standard linguistic account of predicate-argument structure can be taken as reference. This field is still subject of research and competing theories. In this chapter, we review linguistic accounts of semantic roles that provide theoretical background for different notions and systems used in automatic labelling of semantic roles.

It is generally assumed in linguistic theory that certain components of verbs’ meaning determine the number and the type of constituents in a sentence and that the meaning of a verb is interpreted as a relation that can hold for one or between two or more arguments. The pieces of information contained in a verb’s meaning that specify how many arguments it takes and what kind of interpretation they can receive (e.g. an agent, a patient or a recipient of an activity) are called semantic roles. It is assumed that the semantic roles of a verb determine the number and the interpretation of the constituents in a sentence, providing a link between the syntactic structure of a sentence and its semantic interpretation. Clearly, verbs can be divided
into a number of classes according to the number and the type of semantic roles that they specify. Transitive verbs assign two semantic roles (typically \textit{agent} and \textit{patient}). Intransitive verbs assign a single semantic role, which is \textit{agent} with \textit{unergative verbs}, and \textit{patient} with \textit{unaccusative verbs}.

(3.1) \textit{[agent Mary] called [patient a friend].}

(3.2) \textit{[agent Mary] laughed.}

(3.3) (a) \textit{[agent Mary] stopped [patient the car].}

(b) \textit{[patient The car] stopped.}

(3.4) \textit{[agent Mary] told [recipient her friend] [patient a story].}

On the other hand, verbs can also be divided into a number of semantic classes such as verbs of motion (e.g. \textit{come, go, fall, rise, enter, exit, pass}), state verbs (e.g. \textit{want, need, belong, know}), verbs of perception (e.g. \textit{see, watch, notice, hear, listen, feel}) etc. The members of these semantic classes tend to be associated with the same types of syntactic structures. For example, verbs of motion are usually intransitive, verbs of perception are usually transitive, while the verbs that denote states can be associated with a variety of different structures.

Finally, there is a relation that holds between the grammatical function and the semantic interpretation of the constituents of a sentence. For example, agents are usually subjects, while patients are objects. Furthermore, patients can also be realized as subjects (as it is the case b. in (3.3)), while, in many languages, agents cannot be realized as objects.

A theory of semantic roles is expected to formulate certain generalizations concerning the observed relations between verbs’ meaning, their semantic roles and the syntactic form of the derived sentences. It should address the following questions: What semantic roles are there? What combinations of semantic roles are possible? What are the rules of mapping between semantic classes of verbs and sets of semantic roles? What rules govern mapping from semantic roles to syntactic constituents?
3.1 Traditional semantic roles

Semantic roles are traditionally regarded as a set of labels for different arguments of verbs. Apart from the roles illustrated in (3.1-3.4), this set commonly includes: EXPERIENCER (3.5), INSTRUMENT (3.6), SOURCE (3.7), GOAL (3.8), and LOCATION (3.9).\(^1\) These labels capture the reoccurring semantic interpretations of syntactic constituent. The notion of semantic roles has been introduced in syntactic theory as a means to distinguish between different realizations of the same constituents (e.g. the subjects in (3.3) and (3.5)). This representation was also needed to account for the fact that the same content is expressed by the object of an active sentence and by the subject of a passive one. The labels that are most commonly used can be related to the “deep cases” in Case grammar (Fillmore 1968).

(3.5) \([\text{EXPERIENCER Mary}]\) enjoyed the film.

(3.6) Mary opened the door \([\text{INSTRUMENT with a card}]\).

(3.7) Mary borrowed a DVD \([\text{SOURCE from the library}]\).

(3.8) Mary arrived \([\text{GOAL at the party}]\).

(3.9) Mary stayed \([\text{LOCATION at home}]\).

However, as a list of atomic notions, as they are conceived in the traditional description, semantic roles have proved to be empirically and theoretically inadequate. First of all, the set of roles is not finite. New roles are often added to account for different language facts. For example, the sentence in (3.6) can be transformed so that INSTRUMENT is the subject as in (3.10), but if we replace the card with the wind as in (3.11), the meaning of this subject cannot be described with any of the listed roles. It calls for a new role — CAUSE or IMMEDIATE CAUSE (Levin and Rappaport Hovav

\(^1\)The labels patient and theme are often used as synonyms (as, for example, in (Levin and Rappaport Hovav 2005)). If a difference is made, patient is the participant undergoing a change of state, and theme is the one that undergoes a change of location.
Similarly, many other sentences cannot be described with the given set of roles. This is why different analyzes keep adding new roles (such as BENEFICIARY, DESTINATION, PATH, TIME, MEASURE, EXTENT etc.) to the set.

(3.10) \([INSTRUMENT]\) The card] opened the door.

(3.11) \([CAUSE]\) The wind] opened the door.

Another problem posed by traditional semantic roles is that there are no transparent criteria or tests for identifying a particular role. Definitions of semantic roles do not provide sets of necessary and sufficient conditions that can be used in identifying the semantic role of a particular argument of a verb. For example, AGENT is usually defined as the participant in an activity that deliberately performs the action, GOAL is the participant toward which an action is directed, and SOURCE is the participant denoting the origin of an action. However, as noted by Dowty (1991) both Mary and John in (3.12) seem to act voluntarily in both sentences, which means that they both bear the role of AGENT. Furthermore, John is not just AGENT, but also SOURCE, while Mary is both AGENT and GOAL. This does not just lead to inconsistent analyzes, but also makes the traditional notions of semantic roles inapplicable.

(3.12) (a) [? John] sold the piano [? to Mary] for $1000.

(b) [? Mary] bought the piano [? from John] for $1000.

\(\text{(Dowty 1991: 556)}\)

One more fact that can be noted about semantic roles is that they form groups of related roles. The roles that bear subjects in (3.6), (3.10), and (3.11), AGENT, INSTRUMENT, CAUSE respectively, constitute a paradigm — they can be replaced by each other in the same context. Similarly, there is

\(^2\)Dowty analyzes to Mary in (3.12a) as GOAL, while the role of this constituent would be analyzed as RECIPIENT by other authors, which further illustrates the problem.
an apparent relation between SOURCE and GOAL. It can also be noted that some roles can never occur together in a verb’s list (AGENT and CAUSE, for example). The traditional view of semantic roles as a set of atomic notions does not provide a means to account for these facts.

Different theoretical frameworks have been developed in the linguistic literature to deal with the problem of the infinite set of roles and to provide a more adequate definitions of roles, so that they can be identified in a consistent way. In the following sections, we review the two directions for systematizing the inventory of the observed semantic roles. We start with the approaches to decomposition of semantic roles into features or properties, regarding verbal meaning as a single predication. Then we move to the approaches to decomposition of verbal meaning into multiple predicates which generate semantic roles.

### 3.2 Semantic roles as clusters of features

An obvious direction for overcoming the problems posed by the traditional view of semantic roles was to analyze the notions of particular roles into features or properties. Using a limited set of features for defining all the roles should provide more systematic and more precise definitions of roles. It should also enable defining a role hierarchy that can group the roles according to properties that they share. Two approaches to the features of semantic roles are described in this section.

#### 3.2.1 Proto-roles

Dowty (1991) concentrates on argument selection — the principles that languages use to determine which argument of a predicate can be expressed by which grammatical relation. He argues that discrete semantic role types do not exist at all, but that the arguments are rather divided into only two conceptual clusters — PROTO-AGENT and PROTO-PATIENT. These clusters are understood as categories in the sense of the theory of prototypes (Rosch
1973), which means that they have no clear boundaries, and that they are not
defined with sets of necessary and sufficient conditions. These categories are
represented with their prototypical members, with other members belonging
to the categories to a different degree. The more the members are similar to
the prototypes the more they belong to the category.

Looking into different realizations of subjects and objects and the se-
manic distinctions that they express in different languages, Dowty proposes
lists of features that define agent and patient prototypes. Each feature is
illustrated by the sentence whose number is indicated.

AGENT:
  a. volitional involvement in the event or state (3.13)
  b. sentence (and/or perception) (3.14)
  c. causing an even or change of state in another participant (3.15)
  d. movement (relative to the position of another participant) (3.16)
  e. exists independently of the event named by the verb) (3.17)

PATIENT
  a. undergoes change of state (3.18)
  b. incremental theme (3.19)
  c. causally affected by another participant (3.20)
  d. stationary relevant to movement of another participant (3.21)
  e. does not exist independently of the event, or not at all) (3.22)

(3.13) [Bill] is ignoring Mary.

(3.14) [John] sees Mary.

(3.15) [Teenage unemployment] causes delinquency.

(3.16) [Water] filled the boat.

Dowty uses the parentheses to express his own doubts about the relevance of the last
feature in both groups.
(3.17) [John] needs a new car.

(3.18) John made [a mistake].

(3.19) John filled [the glass] with water.

(3.20) Smoking causes [cancer].

(3.21) The bullet overtook [the arrow].

(3.22) John built [the house].

These examples illustrate the properties in isolation, the phrases used in contexts where syntactic constituents are characterized with only one of the properties. Prototypical realizations would include all AGENT properties for subjects and all PATIENT properties for objects. These properties are conceived as entailments that are contained in verbs meaning specifying the value for the cognitive categories that people are actually concerned with: whether an act was volitional, whether it was caused by something, whether there were emotional reactions to it and so on. (Dowty 1991: 575)

The relation between a verb’s meaning and its syntactic form can be formulated in the following way: If a verb has two arguments, the one that is closer to the AGENT prototype is realized as the subject, and the one that is closer to the PATIENT prototype is realized as the object. If there are three arguments of a verb, the one that is in between these two ends is realized as a prepositional object. This theory can be applied to explain certain phenomena concerning the interface between semantics and syntax. For example, the existence of “double lexicalizations” such as those in (3.12) that are attested in many different languages with the same types of verbs can be explained by the properties of their arguments. Both arguments that are realized in (3.12) are agent-like arguments (none of them being a prototypical AGENT), so the languages tend to provide lexical elements (verbs) for both of them to be realized as subjects.
Dowty’s theory provides an elaborate framework for distinguishing between verbs’ arguments, accounting for numerous different instances of arguments. However, it does not integrate the notions of proto-roles into a larger theory of grammar (Levin and Rappaport Hovav 2005). Its scope does not include issues related to syntax, such as different syntactic realizations of the same arguments. The approach reviewed in the following subsection is more concentrated on these issues.

3.2.2 The Theta System

Unlike Dowty, who assumes monostratal syntax, Reinhart (2002) sets the discussion on semantic roles in the context of derivational syntax. She assumes three independent cognitive modules — the systems of concepts, the computational system (syntax), and the semantic inference systems. Linguistic information is first processed in the systems of concepts, then passed on to the computational system, and then to the semantic inference systems. The theta system is a part of the systems of concepts that enables the interface between these three modules. It consists of three parts:

a. Lexical entries, where theta-relations\(^4\) of verbs are defined.

b. A set of arity operations on lexical entries, where argument alternations are produced.

c. Marking procedures, which finally shape a verb entry for syntactic derivations.

There are eight possible theta relations that can be defined for a verb and that can be encoded in its lexical entry. They represent different combinations of values for two binary features: \textsc{cause change} (feature \([c]\)) and \textsc{mental state} (feature \([m]\)). They can be related to the traditional semantic role labels in the following way:

\(^4\)In this framework, theta-relations refer to specifications of semantic roles that a lexical unit assigns
a) [+c+m] — AGENT
b) [+c−m] — INSTRUMENT (. . .)
c) [−c+m] — EXPERIENCER
d) [−c−m] — THEME / PATIENT
e) [+c] — CAUSE (unspecified for / m); consistent with either (a) or (b)
f) [+m] — ? (Candidates for this feature-cluster are the subjects of verbs like love, know, believe)
g) [−m] — (unspecified for / c): SUBJECT MATTER / LOCATIVE SOURCE
h) [−c] — (unspecified for / m): roles like GOAL, BENEFACTOR; typically dative (or PP).

The entries in the lexicon can be basic or derived. There are three operations that can be applied to the basic entries resulting in derived entries: saturation, reduction, and expansion.

Saturation is applied to the entries that are intended for deriving passive constructions. It defines that one of the arguments is just an existential quantification and that it is not realized in syntax. It is formalized as follows:

a) Basic entry: \(\text{wash}(\theta_1, \theta_2)\)
b) Saturation: \(\exists x(\text{wash}(x, \theta_2))\)
c) Max was washed: \(\exists x(x\ \text{washed}\ Max)\)

Reduction can apply in two ways. If it applies to the argument that is realized within the verb phrase in syntax (typically, the direct object) it reduces the verb’s argument array to only one argument, so that the meaning of the verb is still interpreted as a two-place relation, but as its reflexive instance ((3.23b) vs. (3.23a)). If it applies to the argument that is realized outside of the verb phrase, which means as the subject in a sentence, it eliminates this argument from the array of verb’s arguments completely, so that the verb is interpreted as a one-place relation ((3.23c) vs. (3.23a)).

(3.23) (a) Mary stopped the car.
(b) Mary stopped.

(c) The car stopped.

Expansion is the operation usually known as causativization. It adds one argument — agent — to the array of the verb (3.24b vs. 3.24a).

(3.24) (a) The dog walked slowly.

(b) Mary walked the dog slowly.

All these operations take place in the lexicon, producing different outputs. While the operations of saturation and reduction produce new variations of the same lexical concept, expansion creates a whole new concept.

Before entering syntactic derivations, the concepts undergo one more procedure, the marking procedure, which assigns indices to the arguments of verbs. These indices serve as a message to the computational system as to where to insert each argument in the syntactic tree. Taking into consideration the number and the type of the feature clusters that are found in a verb entry, they are assigned according to the following rules:

Given an n-place verb entry, $n > 1$,\(^5\)

a) Mark a $[-]$ cluster with index 2.

b) Mark a $[+]$ cluster with index 1.

c) If the entry includes both a $[+]$ cluster and a fully specified cluster $[/\alpha, /-c]$\(^6\), mark the verb with the ACC feature.\(^7\)

This marking is associated with the following instructions for the computational system:

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\(^5\)Insertion of a single argument as subject follows from a more general syntactic rule, namely the Extended Projection Principle, which states that each clause must have a subject.

\(^6\)A cluster that is specified for both features, where one of them has to be $[-c]$ and the other can be any of the following: $[+m]$, $[-m]$, $[+c]$, $[-c]$.

\(^7\)ACC stands for accusative. This feature determines whether a verb assign accusative case to its complement.
a) When nothing rules this out, merge externally.
b) An argument realizing a cluster marked 2 merges internally.
c) An argument with a cluster marked 1 merges externally.

With this system, some generalizations concerning the relation between theta roles and syntactic functions can be stated. Arguments that realize [+clusters ([+m−c] AGENT, [+c] CAUSE, [+m] ?) are subjects. Since there can be only one subject in a sentence, they exclude each other. Arguments that realize [−] clusters (−m−c] PATIENT, −m] SUBJECT MATTER, −c] GOAL) are objects. Only the fully specified one can be the direct object (introducing the ACC feature to the verb). The others (underspecified ones) have to be marked with a preposition or an inherent case (e.g. dative), thus realized as indirect objects.

Arguments that are specified for both features, but with opposite values ([+m−c] EXPERIENCER and [−m+c] INSTRUMENT) are neutral. They have no indices, so they can be inserted to any position in the tree that is available at the moment of their insertion. The same applies to the arguments that are encoded as the only argument of a verb.

These generalizations provide a syntactic account of different syntactic realizations of the same arguments (argument alternations). It can also be applied to account for the differences between certain classes of verbs that select the same kinds of subjects. For example, both unaccusatives (e.g. break, open, fall, freeze, melt, grow) and emission verbs (e.g. glow, shine, beam, sparkle) are intransitive verbs with THEMES realized as subjects. However, it has been noted (Levin and Rappaport Hovav 1995) that emission verbs pattern with agent unergatives (e.g. walk, run, march, gallop, hurry with respect to their syntactic behaviour. Reinhart explains this fact by different derivations of unaccusatives and emission verbs. Unaccusatives are derived lexical entries (derived from transitive verbs). Their argument is marked with the index 2, as the internal argument of the transitive verb. By the operation of reduction, the other argument is removed. The remaining argument is merged internally, even if it stays the only argument of the verb due to the
fact that is marked with the index 2. It then moves to the position of the subject to satisfy general syntactic conditions. As for emission verbs, their subject is originally the only argument. This is why it cannot be marked. And since it is not marked, it is merged to the first position available — and this is the external position of the subject.

The approaches reviewed in this section concentrate mainly on the relation between the properties of semantic roles and their syntactic realizations. The approaches reviewed in the following section address the meaning of the verb and the relation between its components and the semantic roles that are encoded in the verb’s lexical entry.

3.3 Predicate decomposition and semantic roles

In theories of predicate decomposition, it is assumed that verbs do not denote one single relation, but more than one. These relations are regarded as different components of an event denoted by the meaning of a verb. Some of these components can be rather general and shared by many verbs, while others are idiosyncratic and characteristic of a particular verb entry. In this framework, semantic roles are arguments of subevent predicates. The number and the type of roles assigned depend on the predicates that are included in a verb’s meaning.

Hale and Keyser (1993) argue for a separate level of lexical representation of verbs — lexical relational structure (LRS). The conceptual, idiosyncratic meaning of a verb, as well as its semantic roles are the arguments of these relations. This part of lexical representation, for example, is the same for the verbs get in (3.25) and bottle in (3.26) denoting that machine did something to the wine. The difference between these two verbs is explained by two different incorporations in the structure. In the first case, the head of the abstract structure incorporates the verb get with its own complex structure, while in the second case, it incorporates the noun bottle.

(3.25) A machine got the wine into bottles.
(3.26) A machine bottled the wine.

Different approaches offer different representations of this relation structure, depending on what organizational principle is taken as a basis for event decomposition.

### 3.3.1 Aspectual event analysis

Aspectual analysis of events takes into consideration temporal properties of verbs’ meaning. It aims at explaining why verbs’ arguments differ depending on whether a verb denotes a temporally delimited event (telic) as in (3.28) or temporally unlimited event (atelic) as in (3.27).

(3.27) Mary walked for two hours / * in two hours.

(3.28) Mary drank [a bottle of wine] for 2 hours / * in two hours.

(3.29) (a) Mary crammed [the pencils] into the jar.

(a) Mary crammed [the jar] with the pencils.

The role **Incremental theme** (3.28-3.29) is the central notion in this approach. This is the argument of transitive verbs that is typically realized as the direct object in a sentence. Its presence in the semantic structure of a verb is explained but the fact that it temporally delimits, or quantifies, the activity denoted by the verb. Verbs that do not have this argument in their structure are not temporally delimited. This temporal quantification is represented as a relation in the relation structure of the verb, and **Incremental theme** is an argument of this relation.

This view of the semantic structure relates the complexity of the event denoted by the verb with the complexity of its argument structure, and by

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8Temporal adverbials with prepositions in and for are standard tests for telicity, the former being compatible only with telic reading and the latter only with atelic. Many verbs and verb phrases are ambiguous between the two readings (e.g. (26)). Use of these adverbials specifies the readings in these cases.
this, with the complexity of the structure of the clause that is formed with the verb. If a verb is intransitive, it denotes a temporally unlimited event. If a verb is transitive, it denotes a temporally delimited event. If a verb has two objects, the one that delimits the event is its direct object, and the other is indirect. It also predicts some argument alternations, such as the one in (3.29) (Levin and Rappaport Hovav 2005) as shifts in temporal quantification of the same event.

3.3.2 Causal event analysis

In a causal analysis, events are analyzed into entities (participants) that interact according to a particular energy flow or force-dynamic schemata (Talmy 2000). The main concept in this framework is the direction that the force can take. Semantic properties of verbs such as aspect and argument structure are seen as a consequence of a particular energy flow involved in the event denoted by the verb. If a verb denotes an event were some energy is applied, it will be an action verb, otherwise it will denote a state. In the domain of argument structure, the participant that is the source of energy will have the role of AGENT and the one that is the sink of the energy will have the role of patient.

This approach has been applied to account for different senses of the same verb, as well as for its different syntactic realizations. Both different verb senses and their argument alternations are explained by the shifts in the energy flow with the root meaning that stays unchanged. The following examples illustrate different force-dynamic patterns for the verb take.

(3.30) Sandy took the book { from Ashley / off the table }.

(3.31)  (a) Sandy took the book to Ashley.

(b) Sandy took Ashley (to the movies).

The action in (3.30) is self-oriented, with Sandy being the energy source and sink at the same time. In (3.31), another participant (Ashley / to the
movies) is more important, since it denotes the direction of energy. These are two different senses of the verb *take*. The difference is reflected in the fact that this argument can be omitted in sentences like (3.30) whenever it is indefinite or indeterminate, while in sentences like (3.31), it can only be omitted if it can be interpreted from the context.

### 3.4 Semantic roles in complex predicates

Although many authors argue that the meaning of single verbs is composed of multiple predicates as well (see Section 3.3), the term *complex predicates* usually refers to phrasal predicates such as those illustrated with the bracketed words in the following examples:

(3.32) The story [made] Mary [laugh].

(3.33) Mary [looked up] a dictionary.

(3.34) (a) Mary [wiped] the table [clean].

    (b) Mary [wiped clean] the table.

(3.35) Mary [had] a [laugh].

These constructions include combinations of (typically) two words which are both argument taking or predicating words — the combination V + V illustrated in (3.32), V + P in (3.33), and V + A in (3.34). Although nouns are generally not predicating words, certain V + N combinations exhibit properties of complex predicates (Wierzbicka 1982). Those are the cases illustrated in (3.35), where nouns are derived from verbs preserving the argument structure of the verbs. All these combinations of words behave as single lexical units even if they can be separated by other constituents in a sentence, as the sentences in (3.34) show (Williams 1997).

In the case of the V + V combinations, the fact that they behave as single lexical units means that two verbs form a single clausal structure. For
example, there is only one direct object (Mary) and one subject (the story) in the sentence that contains two verbs (made and laugh) in (3.32). Since both verbs that are involved in the construction assign semantic roles to their arguments, this further means that there are more arguments of verbs with semantic roles than constituents in the clause that can realize them syntactically. The mismatch between the semantic and the syntactic structure of these constructions, together with the fact that they are attested in many different languages (Durie 1997), makes them especially interesting for theories of the interface between syntax and semantics. The main questions that are addressed by these theories are: What are the semantic roles of the constituents of the sentences with complex predicates? How are they represented? What are the rules that govern their syntactic realization?

In the following section, we review the two approaches to the analysis of complex predicates in general — the lexicon approach and the syntax approach, taking a closer look at the constructions that are the subject of this research, namely causative constructions and light verb constructions, in the two subsequent sections.

3.4.1 Lexical and syntactic account of complex predicates

The key issue in analyzing complex predicates is whether their formation is governed by the rules of lexical derivation or by the rules of syntactic derivation. Lexical derivation means that they are composed in lexicon entering syntactic derivations as a single lexical unit and forming a single clause. In the case of syntactic analysis, two predicating words enter syntactic derivations separately, each with its own semantic roles. While the account of

\footnote{Auxiliary and modal verbs constitute a single lexical unit and a single clausal structure with the main verbs, but the problem of syntactic realization of verbal arguments does not arise with them because they are purely functional words with no idiosyncratic lexical content; they do not assign to their arguments any semantic roles that need to be interpreted.}
assignment of semantic roles is straightforward in the lexical approach, it complicates the overall theory by introducing a special (complex) kind of lexical entry. On the other hand, syntactic approach offers a more general account of the structures, but requires a special consideration of assignment of semantic roles. Two main lines of thought can be distinguished with respect to this question.

The *lexical account* of complex predicates is motivated by the following observations, indicating that their components do not behave as independent syntactic constituents:

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- The verbs in SVCs [serial verb constructions] “share” the same arguments.
- SVCs tend to force a “single event” reading.
- The verbs in SVCs are associated with a single tense specification.
- SVCs involve no coordinating conjunction.

(Aboh 2009: 1)

This approach assumes a set of rules that govern different lexical derivations (Baker 1988) regarding the composition of verb sequences as a case of lexical derivation. The result of this derivation is a complex lexical unit that forms a special verb phrase comprising two verbal heads.\(^\text{11}\) Both verbs in this phrase assign semantic roles to their arguments, but the assignment must obey the Argument Sharing Hypothesis:

In a serial verb construction, \(V_1\) and \(V_2\) must share an internal argument.

(Collins 1997: 463)

Argument sharing is realized in syntax by means of an empty category that occupies a position similar to the one illustrated in (3.36) and (3.37).

\(^{10}\)The quoted observations concern one type of complex predicates — those involving two verbs, but they apply to the other types as well.

\(^{11}\)The exact positions of the verbs in this complex structure can vary in different analyzes (Collins 1997).
(3.36) (a) Mary saw [Johnₐ [e, leave]].

(b) * Mary saw [Johnₐ [Annaₑ leave]].

(3.37) (a) Mary made [Johnₐ [e leave].

(b) * Mary made [Johnₐ [Annaₑ leave]].

Even if it is not pronounced, this category exists in the structure, ensuring by its syntactic position the right interpretation for the argument of leave, i.e. the interpretation that identifies it with John (which is an argument of saw). Thus, both verbs assign semantic roles to their arguments, but the argument of the second verb not verbalized, it is realized by a syntactic category that is not pronounced.

It can be noted, though, that the argument that is shared between the verbs in the given examples is not an internal argument for both verbs as it is required by the Argument Sharing Hypothesis, but that it is external for leave. This is because “core verb serialization” for which this hypothesis is formulated does not exist in English. However, it is attested in many other languages. The following examples illustrate the cases of core serialization in Gungbe (Aboh 2009) and Ewe (Collins 1997).

(3.38) Ôjé! Sèsinú kìn mòto cè só òdó.
    EXCL Seeinou drive car 1sg.poss hit wall
    Seeinou hit the wall with my car. (Gungbe)

(3.39) Àsìbá dà làsì ðù.
    Asiba cook/prep rice eat
    Asiba cooked the rice eat
    (i.e. she ate the rice). (Gungbe)

(3.40) Kofi tso ati-ε fo Yao (yi).
    Kofi take stick-DEF hit Yao P
    Kofi took the stick and hit Yao with it. (Ewe)

(3.41) Me kplo Ama yi Lome (yi).
    I lead Ama go Lome P
    I led Ama to Lome. (Ewe)
The sentences in (3.38) and (3.40) represent instrumental serial verb constructions, where the verbs share the instrument, móto in (3.38) and ati-ɛ in (3.40). In (3.39) the verbs share the theme (lési), and (3.41) is an example of comitative constructions, where Ama is a comitative shared by the verbs.

The verbs in the serial verb construction in the given examples share the external arguments as well (subjects in (3.38), (3.39), and (3.40)). This is syntactically realized through an invisible movement, that takes place after syntactic computations (i.e. in the domain of Logical Form of the sentence). By this movement, the second verb is incorporated into the first verb, which enables the shared interpretation of the external argument.

Taking a more syntactic approach, Aboh (2009) argues that complex predicates are formed in the syntactic derivation and that their formation can be explained by general rules of syntax, which means that there are no special complex verb entries for verb series in the lexicon. Derivation of complex predicates does not include small clauses.\textsuperscript{12} The two verbs are given different lexical status. Only the second verb in the sequence is a fully lexical verb that forms a clause and assigns semantic roles to its arguments, while the first verb is a functional word. It selects for a complement but it does not assign a semantic role to it.

According to this account, the semantic roles that bear the constituents of the clause involving a complex predicate are divided between the verbs. The first verb assigns the role to the subject, while the second verb assigns the roles to the other arguments. Sesinou is merged as the external argument of the first verb (kùm) in (3.38), while both móto and àdó are merged as the arguments of só, àdó as its theme and móto as the instrument.\textsuperscript{13}

The example in (3.39) illustrates the case when there is only one internal argument (lési) that looks like an argument of both ɗà and ɗù. However,

\textsuperscript{12}The structure that contains the empty category pro can be viewed as a small clause because it includes a predication relation between its constituents.
\textsuperscript{13}The constituent that expresses the instrument is introduced by the applicative functional projection vappd (Aboh 2009: 24).
Aboh (2009) argues that this is an argument and the object of dù only. It moves in the position that precedes dù by an object movement that also takes place in other similar constructions, such as the auxiliary verb construction.

**The complex predicate parameter**

While the syntactic account presented by Aboh (2009) attempts to apply more general rules of syntactic derivations to verb series, arguing that verb series do not require a special account, typological investigations show that languages can be divided according to whether they allow verb serializations (and other complex predicates) or not. To account for this fact, Collins (1997) proposes the *verb serialization parameter*, for which the value can be set to “on” for some languages (such as Gungbe and Ewe for instance) or to “off” for others (such as English). He defines the parameter as the ability of the tense functional category to license multiple verbal heads. A more general version of this parameter, stating that certain categories can licence multiple heads, applies to other multiple constituents (such as Wh-words in some languages) too.

Snyder (2001) provides evidence for a complex predicate parameter involving resultative complex predicates. In an analysis of cross linguistic and language acquisition data, a language’s ability to form complex predicates is related to its ability to form endocentric compounds with words of the same category, such as English N + N compounds *sauce pen*, *apple juice*, *peanut butter*. Languages that show productive N + N compounding, also allow complex predicates (American Sign Language, Austroasiatic (Khmer), Finno-Ugric (Hungarian), Germanic (English, German), Japanese-Korean (Japanese, Korean), Sino-Tibetan (Mandarin), Tai (Thai)). Languages that do not allow N + N compounding do not allow complex predicates either (Afroasiatic (Egyptian Arabic, Hebrew), Austronesian (Javanese), Bantu (Lingala), Romance (French, Spanish), Slavic (Russian, Serbo-Croatian)). Basque represent a third group of languages, those that do allow the compounds, but do not allow complex predicates. These languages suggest that
the ability to form compounds is a prerequisite for the ability to form complex predicates. The data from language acquisition show the same tendencies (complex predicates are acquired after compounds).

Another kind of parameter is proposed by Alsina (1997). On the basis of an analysis of causatives in Romance and Bantu languages (described in more detail in the following section), he argues for a parameter that defines two groups of languages: languages that form complex predicates in the lexicon (Bantu) and languages that form complex predicates in syntax (Romance). More precisely, Alsina (1997) argues that complex predicates are formed in the lexicon in both types of languages. The difference is in subsequent derivations that apply to them. In languages such as Bantu, this lexical structure requires a particular morphological derivation that results in causative forms of verbs, while in languages such as Romance, it requires a special syntactic derivation resulting in causative constructions.

Finally, it should be noted that English is classified as having the “off” value for the parameter proposed by Collins (1997), which would also be the case for the other two languages considered in our research, German and Serbian. The parameter proposed by Snyder (2001) classifies English and German as “on” and Serbian as “off”. The third parameter is the most interesting one for the differences between these three languages. Complex predicates are realized as single words in Serbian, while they can be realized either as constructions or as single words in English and German. We review these differences in more detail in section 3.5.

### 3.4.2 Causative constructions

Causation is a notion that plays an important role in verbal semantics cross linguistically. It is one of the most common elements of verbal meaning that is expressed by semantic roles (see section 3.2). It can also be observed that many genetically unrelated languages use special constructions — causative constructions — to encode this relation. Causative constructions often involve verb serialization. The following examples present cases of causative
constructions in English (3.42), French (3.43) and (3.44), and Gungbe (3.44)

(3.42) The story \( [VP \text{ made } [SC \text{ e laugh}]] \).

(3.43) \textit{Marie} a \( [VP[v \text{ fait } partit]} \text{ Pierre}] \).
\begin{align*}
\text{Mary} & \quad \text{aux} \quad \text{made} \quad \text{go} \quad \text{Peter.} \\
\text{Mary made Pierre leave.}
\end{align*}

(3.44) \textit{Marie} a \( [VP[v' [v \text{ fait]} [VP \text{ manger la pomme}]] \text{ à Pi}} 	ext{erre}].
\begin{align*}
\text{Mary} & \quad \text{aux} \quad \text{made} \quad \text{eat} \quad \text{the apple to Peter} \}.
\text{Mary made Peter eat the apple.}
\end{align*}

(3.45) \textit{Asiba} \text{ dà \text{ lèsì \text{ dù}}.}
\begin{align*}
\text{Asiba} & \quad \text{cook/prepare/make rice eat} \\
\text{Asiba cooked/prepared/made the rice eat} \\
\text{(i.e. she ate the rice).}
\end{align*}

All the examples above involve complex predicates, although with somewhat different syntactic structures.

The difference between the two French examples (in (3.43) and (3.44)) is explained by their different derivations. The structure in (3.43) is derived in the lexicon, while the structure in (3.44) is derived in syntax. Arguing for two different representations of the two forms of causatives in French, Williams (1997) shows that the complex predicate in (3.43) has the same properties as English phrasal resultatives (e.g. \textit{make clean}): it is formed in the lexicon and it behaves as a single word in syntactic derivations (including complementation as well as semantic role assignment). On the other hand, the structure in (3.44) is formed in syntactic derivation. The causative verb \textit{fait} and the verbal phrase of the lexical verb \textit{(manger la pomme)} are merged into an intermediate projection in the sense of X’ theory. This projection has to merge with one more constituent (à \textit{Pierre}) to form a full verb phrase. This constituent receives its semantic role from the intermediate projection in this case (Williams 1997: 24).
Comparing the causative structures in Bantu (Chichewa) and Romance (Catalan), Alsina (1997) argues that they are formed in the lexicon in Chichewa and in the syntax in Catalan. He regards both types of the constructions that are Catalan counterparts of (3.43) and (3.44) in the same way, i.e. as being syntactically derived. Keepin in mind Williams’ distinction between the two structures, the syntax/lexicon distinction discussed by Alsina should be limited to the cases such as (3.44).

The analysis of the causative constructions in Gungbe (3.45) has already been discussed in section 3.4.1. As argued by Aboh (2009), it resembles formation of complex verb tenses involving a movement of the object. semantic roles to the internal arguments are assigned by the lexical verb in these constructions. The subject receives its role from the functional verb.

Finally, the construction in English does not require any special representation. It can be seen as a case of verbal complementation involving a small clause. This means that both verbs assign semantic roles to their arguments in this construction, but that the argument that is repeated in the embedded phrase is not pronounced.

We could see in this subsection that the relation of causation is often expressed as a complex predicate and grammaticalized as a construction involving a series of verbs. The way the constructions are derived can vary across languages due to different factors. Some languages have a verb specialized for expressing causation (such as made in (3.42) or fait in (3.43-3.44)), others can use more lexically specified verbs (such as dà in (3.45)). In some languages this relation is not grammaticalized as a construction, but is marked through lexical derivations. This can also be done in two ways. Languages like Chichewa (Alsina 1997) use a specialized derivational affix that is added to verbs to express this relation, while languages like Serbian, as we will see in section 3.5, use more general (polysemous) affixes. However,

\[14\] It should be noted, though, that this limitation is not entirely relevant for the discussion in (Alsina 1997) because its aim is to show that the argument structure is the same in both languages despite the structural differences.
it still remains subject to debate whether causatives need to be associated with special syntactic derivations or more general rules of syntax can apply to them (see also section 3.4.1).

### 3.4.3 Light verb constructions

Light verb constructions are verb phrases that consist of a verbal head and a complement headed by a deverbal noun. The verbs that head these constructions are called “light” verbs because they are not used as ordinary lexical verbs, but rather as function words, in conjunction with the deverbal complement. In English, light verb constructions are often found as paraphrases of single verbs, as shown by the following examples.

(3.46) (a) Mary \([VP \text{ had } NP \text{ a laugh}]]\).

(b) Mary \([VP \text{ laughed}]]\).

(3.47) (a) Mary took a shower.

(b) Mary showered.

(3.48) (a) Mary took a walk.

(b) Mary walked.

(3.49) (a) Mary had a jog this morning.

(b) Mary jogged this morning.

(3.50) (a) Mary gave the show a miss.

(b) Mary missed the show.

These constructions have received much less attention than causative constructions in the literature on complex predicates, due to the fact that, syntactically, they are formed as regular verb phrases. However, they need to be analyzed as complex predicates since both the heading verb and its nominal complement are predicating words.
Deverbal complement of light verbs

The nouns that head complements of light verbs are derived from verbs, keeping the verbal argument structure. In some languages such as Urdu (Butt and Geuder 2001), light verbs can take both verbs and nouns as complements. In English, they only take deverbal nouns. The verbal argument structure of these nouns is reflected in the structure of the phrases that they form. This can be seen by comparing the verb and the noun look in the following examples.

(3.51) (a) Mary took a look [at her daughter].
        (b) Mary looked [at her daughter].

The noun that heads a light verb complement in English can be more or less similar to the corresponding verb. Its form can be identical to the verb form, as it is the case in (3.51), or it can be derived from a verb with a suffix (e.g. inspect\text{V} vs. inspection\text{N}). Although certain parallelism in their meaning is reflected in the fact that they take the same argument (at her daughter in (3.51)), the syntactic realization of this relation can be different. In some cases, the same argument is realized as the same complement at the syntactic level (3.51). In other cases, the argument can be differently realized in syntax (his brother vs. to his brother in (3.52)) or it can be left unspecified (the project site vs. no complement in (3.53)).

(3.52) (a) Mary visited [her brother].
        (b) Mary paid a visit [to her brother].

(3.53) (a) They inspected [the project site] last week.
        (b) They made an inspection last week.

The meaning of a deverbal noun can be more or less similar to the meaning of the corresponding verb. Grimshaw (1990) distinguishes between event nominals and result nominals, arguing that only event nominals actually
denote an action and can take arguments (e.g. the examination of the papers vs. *the exam of the papers).

Since one of the characteristics of the event nominals is that they cannot be modified by the indefinite article, most light verb complements would be classified as result nominals according to this analysis.

On the contrary, Wierzbicka (1982), underlines the difference in meaning of the complements of the verb have in (3.54) and in (3.55-3.57). The nouns like swim in (3.54) are claimed to be verbs “despite the fact that they combine with an indefinite article” and should be distinguished from deverbal nouns. All the derived forms are considered to be nouns, together with some nouns that have the same form as verbs, but whose meaning is clearly that of a noun, such as smile in (3.55), cough in (3.56), or quarrel in (3.57).

(3.54) He had a swim.

(3.55) She has a nice smile.

(3.56) He has a nasty cough.

(3.57) They had a quarrel.

Kearns (2002) notices that the complements of light verbs are not “real nouns”, but that they are coined for light verb constructions and do not occur freely in other nominal environments. Based on an analysis of Japanese light verb constructions, Grimshaw and Mester (1988) provide evidence for a similar distinction between the transparent noun phrases that are complements of the verb suru and opaque noun phrases that are complements of the verb soseru. The former are special noun phrases which occur only as complements of light verbs, and the letter are more similar to the regular noun phrases.

**Light verb constructions and semantic roles**

Two approaches can be distinguished with respect to the lexical status of light verbs and their ability to assign semantic roles to their arguments.
Kearns (2002) assumes the notion of complex lexical entry introduced by Hale and Keyser (1993) (see section 3.3) in distinguishing between two parts of the lexical entry of verbs: the lexical conceptual structure (LCS) and syntactic argument structure (SAS). The former represents the semantic content of verbs, including the specification of the participants of the event denoted by the verb. The latter specifies the open syntactic positions to be filled by the constituents of a sentence (such as subject or object). For example, the LCS of the verb cut defines that this verb denotes “linear separation in the material integrity”, as well as that there are two participants in this event: the one that cuts and the one that is cut. Its SAS defines that the sentence formed with this verb will contain a subject and an object.

Light verb constructions are generated in the cases where the two components of the verb’s lexical entry are separated, so that only the SAS is active in syntactic derivation. In a conjunction with a predicing nominal, the light verb gives up its LCS, turning into a functional word with no semantic content. It takes the content of its complement and distributes it to its syntactic positions. As a result, semantic roles that bear the constituents of these phrases are assigned by the nominal complement. (See section 3.4.1 for a similar approach to verb serialization.) Thus, common syntactic transformations, passive (3.58), Wh-movement (3.59), and pronominalization (3.60), cannot be applied to light verb constructions because the constituents do not express semantic arguments of the heading verbs.

(3.58) * A groan was given by the man on the right.

(3.59) * Which groan did John give?

(3.60) * I gave the soup a heat and then Bill gave it one too.

Kearns (2002) makes a distinction between true light verbs which exhibit these characteristics and vague action verbs that also take deverbal complements, but are not characterized with the described restrictions (as in (3.53)). Other authors do not make this distinction.
Butt and Geuder (2001) compare different constructions with English verb *give* and its Urdu counterpart *de*. Both light *give* and light *de* are seen as instances of lexical polysemy. They show that there is a continuum of gradual alternation of meaning between the prototypical meaning of *give* (e.g. *give him the ball*) and its light use *give the car a wash*. The presence of an agent, completion of the action, and its “directedness” are the components of meaning present in all the realizations. These are also the components that the English *give* and the Urdu *de* have in common. This means that the light verb can assign the agent role to the subject of the phrase. The other two components can also be related to the interpretations that semantic roles can have (see section 3.2).

Brugman (2001) focuses on the English verbs *give*, *take*, and *have*, arguing that light verbs are cases of polysemy. In an analysis that assumes the force-dynamic schemata (See section 3.3), she argues that light verbs retain the pattern of force dynamics (or a part of it) of their heavy (i.e. semantically specified) counterparts.

The differences in meaning between light verbs such as *take* in (3.61) and *give* in (3.62) are explained in terms of different force-dynamics patterns.

(3.61) Take a {sniff / taste} of the sauce, will you?

(3.62) Give the sauce a {sniff / taste}, will you?

In (3.61) it is the opinion of the addressee that is asked for. So, the energy is directed towards the agent, which corresponds to the force-dynamic pattern of the verb *take* (a self-oriented activity). The question in (3.62) is about the *sauce*. One wants to know whether it had spoiled. This direction corresponds to the pattern of the verb *give* (directed activity).

We have seen in these two subsections that light verb constructions can be analyzed as a case of verb serialization due to the fact that the nominal complements of light verbs are also predating words with verbal argument structure, assigning semantic roles to the constituents of a clause. Linguistic
analyzes differ regarding the ability of light verbs to assign semantic roles too. Some authors (Kearns 2002) argue that light verbs have no lexical content and, thus, do not assign semantic roles. All the semantic roles in a clause are assigned by their nominal complements. Other authors (Brugman 2001; Butt and Geuder 2001) argue that light verbs retain the components of their lexical meaning that are sufficient to assign semantic roles (such as *agentivity, completion, directedness*). This means that both light verbs and their complements assign semantic roles to the constituents of a phrase, i.e. that they share their arguments (see section 3.4.1 for the notion of argument sharing).

### 3.5 Causative constructions and light verb constructions in English, German, and Serbian

The subject languages of this research are English, German, and Serbian. Although genetically close, all belonging to the Indo-European language family (English and German to the same branch too), these languages show interesting differences in the syntax of complex predicates. English is the most analytical of the three languages, using both causative constructions and light verb constructions. On the other hand, Serbian is characteristically flectional language. It expresses the same complex content using lexical derivations (or sentential complementation when lexical derivations are not available). German can be placed between the two, using causative constructions, but not light verb constructions.\(^{16}\) These differences bring to divergences in the number and type of syntactic constituents that express semantic roles of the predicates, making it difficult to map semantic roles in translated sentences in

\(^{16}\)The restrictions on the use of light verb constructions in German and Serbian apply only for the true light verb constructions in the sense of Kearns (2002). Both languages use vague action verbs in the same way as English.
these languages. In this section, we analyze German and Serbian translation equivalents of English causative constructions and light verb constructions.

Causative constructions in English and German are formed in the same way (similar to French causatives (Section 3.4.1)). They are headed by a specialized causative verb that takes as a complement a phrase headed by a lexical verb. The verbs that can “specialize” for expressing causation are highly frequent and extremely polysemous verbs such as make, let and have.\(^{17}\) In Serbian, on the other hand, causative meaning of verbs is generally not grammaticalized. Serbian equivalents of English constructions are prefixed single verbs. Unlike in Bantu languages (Section 3.4), however, causative affixes do not exist in Serbian. Causative meaning of a verb is only implied, while the prefix changes the aspect of the verb encoding other semantic components such as resultative meaning (Arsenijević 2007).

The examples that follow illustrate causative constructions in English formed with the verbs make (3.63-3.65), let (3.66-3.68), and have (3.69-3.71) in comparison with their translations to German and Serbian.

(3.63) Mary [made John leave].

(3.64) Maria [liess John weggehen].

(3.65) (a) Marija je [o-terala Jovana].
      Mary AUX PREF-made-go John-ACC

(b) Marija je [uˇcinila da Jovan ode].
      Mary AUX caused that John leaves.

(3.66) Mary [let John stay].

(3.67) Maria [liess John bleiben].

(3.68) (a) Marija je [do-pustila Jovanu da ostane].
      Mary AUX PREF-let John-DAT to stay.

\(^{17}\)Note that the same verbs, with the exception of let, are involved in light verb constructions too.
(b) Marija je [dopustila da Jovan ostane].
Mary AUX let that John stays.

(3.69) Mary [had her room painted].

(3.70) Maria [liess ihr Zimmer malen].

(3.71) (a) Marija je [o-krečila sobu].
Mary AUX PREF-painted room-ACC

(b) Marija je [dala da joj se okreči sobaj].
Mary AUX let that her-DAT SE paint room.

All the three types of the constructions can be translated literally to
German, although only one verb (lassen) is used.18

Serbian translations are different for each English verb reflecting subtle
differences in causal meaning of the English verbs. English made-causative
is translated with a single prefixed verb. The prefix o- has a prepositional
locative meaning (similar to from) and it changes the verb’s aspect from im-
perfective to perfective at the same time. This is only one of many different
prefixes that are used for translating different English causatives. For exam-
ple, make...cry corresponds to ras-plakati..., make...laugh to na-smejati..., make...believe to u-veriti... and so on. English let (3.66) has a lexical equiv-
alent in Serbian (pustiti), but with a sentential complement required (3.68).
Finally, the single verb translation of English have-causative is ambiguous
between two readings: that Mary painted her room herself and that Mary
had her room painted by someone else, which means that Serbian does not
mark naturally this kind of causation. However, it can be marked using the
paraphrase in (3.71b) if needed.

18There is a distinction between machen for make and lassen for let, but it is rarely
realized. Moreover, the verb lassen is used for other constructions such as middle con-
structions too (e.g. Dieses Buch laesst sich gut lesen. — This book reads well.) (Frense
and Bennett 1996).
Since lexical derivations are more limited (or less productive) than syntactic derivations, not all instances of the constructions can be translated with single verbs to Serbian. The strategy used in the cases where lexical derivations are not available is to employ a lexical verb with primarily causative meaning that takes a sentential complement. Sentences in (3.65b), (3.68b), and (3.71b) represent the clausal complement translations. However, this is only a back-up strategy, the sentences formed in this way do not sound natural.

Light verb constructions are formed with a highly frequent and extremely polysemous verb (with no particular lexical meaning) — light verb — and a nominal complement headed by a deverbal noun. Unlike causative constructions, light verb constructions are not obligatory expressions of the given predicate content. They are paraphrases of single verbs (see section 3.4.3). The following examples illustrate some typical light verb constructions in English and their translations to German and Serbian.

(3.72) Mary [had a laugh].
(3.73) Maria [lachte].
(3.74) Marija se [na-smejala].
       Mary  SE  pref-laugh.
(3.75) Mary [gave the table a wipe].
(3.76) Maria [wischte den Tisch].
(3.77) Marija je [o-brisala sto].
       Mary  AUX  pref-wiped  table-ACC
(3.78) Mary [took a look at the door].
(3.79) Maria [blickte zur Tür].
Two types of light verb constructions can be distinguished in English: constructions with *true light verbs* and constructions with *vague action verbs* (Kearns 2002). True light verb constructions (3.78-3.77) typically translate with single verbs both to German and to Serbian. However, Serbian verbs are prefixed and perfective, which indicates that their meaning involves a complex predicate. Constructions with vague action verbs are mostly translated with constructions of the same type, but with the heading verbs that are not direct translations of English light verbs, as illustrated in the following examples.

(3.80) *Marija je [po-gledala prema vratima].*
Mary AUX PREF-look at door-DAT

(3.81) Mary [gave a talk].

(3.82) Maria [hielt einen Vortrag].

(3.83) *Marija je o-držala predavanje.*
Mary AUX PREF-held lecture-ACC

(3.84) Mary [made a decision].

(3.85) Maria [hat eine Entscheidung getroffen].

(3.86) *Marija je do-nela odluku.*
Mary AUX PREF-brought decision-ACC

Translations of English light verb constructions can also be different depending on the kind of the heading verb. For example, English constructions headed by the verbs *have* and *take* are translated with single verbs to Serbian in most cases, while those headed by the verb *make* tend to be translated with the equivalent constructions (Samardžić 2009).

With the illustrated differences in syntax of the three languages, mapping semantic roles in sentences that include causative and light verb constructions
is a challenging task. Syntactic information is very important both for automatic assignment of semantic roles in one language (see Section 2.1) and for transferring the labels to other languages via parallel corpora (Section 2.3.3). Constructions with complex predicates introduce two kinds of problems. On one hand, they include two predicating (argument-taking) words that can assign more semantic roles than there are syntactic constituents to which the roles can be assigned, as it is already discussed in Section 3.4.1. On the other hand their lexical and syntactic realizations are different even in close languages such as English, German and Serbian. It is not clear, for instance, whether an element (a morpheme or an abstract category) can be identified in Serbian clauses to which English and German causative verbs could be mapped in order to map the semantic roles that they assign. Without identification of corresponding predicates, the existing approaches to cross-lingual transfer of semantic role labels cannot be applied. A multilingual analysis of translation equivalents of complex predicates can help establishing a more abstract representation of predicate-argument relations in these constructions, addressing both of these problems and yielding structures that are portable across languages.
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