Unifying Semantic Relations Across Syntactic Levels

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This is a report on ongoing research.

1 Overview

Expressions used in communication are only surface forms to express something deeper. We use this as a reason for the fact that we find the same semantic relations on different syntactic levels.

Semantic relations on different syntactic levels connect different types of entities. Clause level relations (CLRs) connect two occurrences. At the intra-clause level, cases connect a verb and its arguments. Noun modifier relations connect a noun and its modifiers. It possible to have the same semantic relation on different levels, if we consider the fact that an expression may surface in the form of an occurrence, a noun, adjective, and so on. We look at a collection of examples to analyse possible transformations and phenomena, that allow for semantically close variants of the same expression on different semantic levels.

Here is an example: *flu virus*. *flu* is a state, *virus* is a pathogen agent, the relation between these two entities is CAUSE. We recognize that causal relations stand between two occurrences. In our case there is no occurrence, but each of the two entities stand in for an occurrence - *flu* stands in for a state-type occurrence of an organism being sick, and presenting specific symptoms particular to this disease, *virus* stands in for the occurrence of the pathogen agent infecting an organism, whose AGENT it actually is.

The phenomenon of an entity standing in for an occurrence is similar to synecdoche, and it explains many of our various instances of semantic relations.

Other trasnformations and phenomena are used to justify the equivalence of semantic relations across syntactic levels, as it will be presented in this technical report.

This report is still under construction, some examples and structures may change in time, according to the results of the research.

2 Introduction

Two expressions can convey the same meaning and yet be different. This difference can be on the syntactic level, on the semantic level, or both. Some differences are more subtle, some are more obvious. Between an utterance and its paraphrase there might be no definite grammatical relation (Katz and J.A.Fodor, 1963), as in the example:

Two chairs are in the room.
There are at least two things in the room, and each of them is a chair.

or there might be a very obvious one:

The jeweller inscribed the name on the ring.
The jeweller inscribed the ring with the name.

Differences on the syntactic level can also have two levels - one that involves alternations (e.g. change of voice, change of position in the sentence of different constituents), and one that involves morphological changes (e.g. nominalizations). Studies of these phenomena was based on the fact that they preserve the meaning of the utterance.

Differences on the semantic level involve the use of synonyms, hypernyms or more complex paraphrases.

There are several syntactic levels in discourse, but in this work we focus on three of them: inter-clause, clause and noun phrase level. For each of these levels has been designed a set of semantic relations that can be expressed by the specific components of the corresponding syntactic structures (Barker, 1998), (Delisle, 1994). We argue that certain semantic relations can be expressed on more than one level. We explore this problem and analyse examples to see if there are systematic transformations that allow a certain expression on one level to be transformed into an expression on another level, while preserving the relations between the original enitities.

We consider semantic relations that characterize the interaction between two occurrences[1], entities or attributes denoted by clauses and phrases. The three syntactic levels we consider supply lexical and syntactic indicators we use to analyze semi-automatically and eventually automate the assignment of semantic relations. Semantic clues are derived from connectives and prepositions, and from lexical knowledge bases, including *WordNet* and *Roget's Thesaurus* . The level above multi-clause sentences is the paragraph, where syntactic clues are fewer and interaction between just two elements rare. Below the noun-phrase level we get into morphology.

We would like to find for each semantic relation a representation format which is independent of the syntactic realization of the relation. Each representation should contain only the elements in an expression that are needed to determine the semantic relation. Nothing gets discarded though, these representations should be seen as sets of pointers which pinpoint the entities that interact in a certain manner.

This problem then gives raise to several tasks.

1. **the lists of relations** – They have been designed and tested on technical tests, the result of these tests being that all the relations proposed are necessary (some of these did not appear in the analysed texts, but examples were given in support of their necessity), and sufficient (all the examples analysed were explained in terms of these relations, no addition necessary) (Barker, 1998), (Delisle, 1994).

2. **some semantic relations can be expressed on more than one syntactic level** – In support of this are the tables of relations, which contain examples that display the semantic relations on different levels. The blank spaces in these tables will be justified.

3. **transformations that are involved in this phenomena** – We explore how semantic relations transform when syntactic expressions change.

4. **ontologies** – We test the use of ontologies, like *WordNet* or *Roget's Thesaurus* that would allow us to generalize from specific concepts to categories, while preserving the semantic relation. This exploration

[1]The term occurrence encompasses events, processes, actions, activities and accomplishments (Allen, 1984)

would be on the semantic dimension on which expressions may vary, and yet still display the same semantic relation. The main purpose of this step is to effectively use this uniformity in a semi-automatic system. We would like to have some basis for learning where such semantic relations could occur, so if we manage to give the system some hints, it would make the learning process much simpler.

We will not look at syntactic trees and relations, because, as studies in alternations for verb patterns have shown, they depend on the semantics of the lexemes. We want to look though at how semantic relations change between levels of syntax. It is obvious that the inter clause level is the richest one, then the clause level (cases) and then noun phrases, but it will be interesting to see what gets discarded on the path to conciseness.

In what follows we consider the following ordering:

inter-clause relations $\succ$ *case relations* $\succ$ *noun modifier relations*

where noun modifier relations are the lowest syntactic level.

3 Theoretical Background

There are several levels (/dimensions) on which an expression can vary, while still conveying the same meaning:

- the syntactic level
  - *inter level* (or vertical) variation - it arrises from paraphrasing an utterance which changes the syntactic level it appears on. As mentioned previously, we consider three synstactic levels: inter-clause (IC), clause (CL), and noun phrase (NP).
    Example:
    virus causes flu $\leftrightarrow$ *flu virus*
  - *intra level* or horizontal variation - or alternations - the expressions varries while remaining on the same syntactic level.
    Example:
    The jeweller inscribed the name on the ring $\leftrightarrow$ *The jeweller inscribed the ring with the name*
- the semantic level - using synonyms

3.1 Intra-level variations

Alternations have been researched quite thorougly until now, especially in the context of verb classification with respect to the alternations that they allow (Levin, 1993). Although the focus was not on the transfromations that preserve the meaning, but rather taking for granted the fact that these alternations preserve the meaning of the utterance, this is proof that language is rich in expression variants closely related semantically.

Levin's book (Levin, 1993) is a manual work in organizing the verbs in English into categories according to the alternations that they allow. A practical implementation of some aspects of this work is (Lapata, 1998) that uses the dative and benefactive alternations to extract patterns from a part-of-speech tagged corpus and computationally prove Levin's idea. Another work that starts from Levin's categorisation of verbs is (Hai, 1998), that observes the fact that a verb can belong to several classes, and that might be an indication of different senses of the lexeme.

3.2 Inter-level variations

Part of this syntactic flexibility of language are morphosyntactic changes and grammaticalization. In the course of the evolution of language, there have been patterns of change. It is possible that the time constraint on society takes its toll on language as well. Time constrains us to compact our expressions such that more can be conveied faster, passing from full blown phrases to smaller noun phrases. Another reason could be that some experiences have found their way into a deeper level of our thought processes, and we find that more and more of what we want to communicate is implied and we don't mention these things anymore.

3.2.1 Nominalizations

One of the mechanisms that concur to the various forms displayed by utterances is nominalization - the transformation of a verb into a nominal form (in this case). Quirk, (Quirk et al., 1985) says the following about noun phrases:

> *The claim is however that we can match elements of the noun phrase (head, modifiers, determiners) with elements of clause structure, considered semantically in terms of the verb and its associated participant roles of agentive, affected, etc. We can also distinguish in the case of deverbal noun heads, between active and passive nominalization patterns.*

Some research in this area, although used for different purposes than mine, was done in the computer science department at NewYork University.

The work described in (Macleod et al., 1998) is concerned with the correspondence between the arguments of a nominal form a verb, and its arguments in the verb form. Their concern is purely grammatical, with no considerations of semantic relaions between the words. Only the arguments that a verb subcategorizes for are considered. They are concerned with transformations that relate the subject, object and indirect object to the arguments of the nominal form of the verb, and their relative positions in the new NP structure. The lexicon that is produced will contain the nominalization, the original verb, the verb's argument structure and the NP's argument structure.

In (Myers et al., 1998) is described the use of the nominalization lexicon in information extraction. An interesting part of this work is not just the use of patterns stored in the lexicon, but also a semantic generalization. The example described is the following: reformulating according to the nominalization patterns of the sentence "IBM appointed Alice Smith". Besides generating the paraphrases, the program (PET) also generalizes IBM to *company* and Alice to *person*, generating the following nominalization pattern:

np(C-comapny)'s appointment of np(C-person)

(IBM's appointment of Alice Smith)

They also consider the optional temporal arguments, but since they do not interfere with the nominalization pattern, they say, they are not described in the paper.

In (Hull and Gomez, 1996), the focus is on differentiating between verbal and non-verbal senses of a nominalization (e.g. promotion, decoration, etc), disambiguating the sense of the verbal sense of the nominalization (e.g. promotion of Peter, promotion of liberalism, etc), and then assigning proper thematic roles to the modifiers of the nominal, according to the underlying verb. For each sense of a verb that appears in WordNet, there is a structure that identifies what (ontological) classes its arguments belong to. There are specific arguments that verbs require, and based on this fact, and on additional information that resovles the mapping between the nominalization's modifiers and verb arguments, one can decide whether the current sense is verbal or not. The same structure, together with the mapping between modifiers and arguments are used for the nominalization, to fill its thematic roles. WordNet is the ontology used to classify a verb's arguments, and also to determine in a first step whether the noun is a potential nominalization by checking if any of its senses are hypernyms of actions or events.
This work relies on WordNet to identify the senses of a verb and to decide upon the class each of its arguments belongs to. In (Gomez, 1998) is described an approach to verb semantics. A hierarchy of predicates is built, starting with generic ones (verbs in which an animate agent changes location, verbs in which the agent causes the change of location of something else, cause-a-change of state, move-body-part, etc), and then specializing these, and so on. Synsets in WordNet are linked to predicates or subpredicates in this hierarchy (thematic roles and inferences are inherited by the subpredicates). Thematic roles pertaining to each of these predicates are WordNet ontological categories. For each of the thematic roles are specified selectional restrictions and syntactic relations that can realize the role.

In mapping WordNet synsets onto this hierarchy of predicates, several synsets can be mapped onto one predicate, or one synset can be mapped onto several predicates. A subpredicate is a "specialized" predicate. They can differ in the selectional restrictions for the thematic roles, in the syntactic realizations of the thematic roles and in the sets of inferences associated with the subpredicates.
In dinstinguishing predicates by the syntactic realizations of the thematic roles, they rely on Levin's work on verb classes and alternations.

Another view on the problem of nominalization is (Rappaport and Levin, 1992) that looks at a group of nominals in -er (writer, baker, teacher), often called "agentive" nominals, and at the claim that they inherit the argument structure of the verb from which they are derived.

The operation inverse to nominalization would be recovering the verb from its nominal form. There is no obvious algorithm to find the verb in such a situation. We work with a list of (nominal form, verb) pairs, semi-automatically extracted from texts. It would be very helpful to have a resource like *WordNet* or *Roget's Thesaurus* which has links between noun and verb senses. Hull and Gomez (1996) have an interesting approach to this problem, by considering as deverbal nouns the nouns whose hypernym in *WordNet* is *action*.

3.2.2 Adjectivalization

If in passing on a lower syntactic level the verb gets nominalized, then some of its arguments may get adjectivalized. In the example:

the country has a big debt

we can adjectivalize *country* to otain *national debt*.

Also, the verb can be used in it's past participle form as a modifier (deverbal adjective):

vanished treasure

The inverse operation would be restoring the verb form of the word. For example:

vanished treasure → *the treasure vanished*

3.2.3 Deletion

In passing from a more detailed syntactic level to a more concise one, some elements of the utterance will be dropped. Levi, (Levi, 1978), proposes a list of nine *recoverable deletable predicates* (RDPs), five of which are verbs – *cause, have, make, use, be*. By deleting one of these verb predicates, the expression becomes a noun phrase, for example:

virus causes flu → *flu virus*

Levi has designed a set of transformations that systematically transform an expression into a semantically equivalent complex nominal by deleting one of the RDPs. The transformations proposed are reversible.

The inverse transformation would have to recover the deleted information. This is much less obvious, but analyzing the context it is somtimes possible to recover the missing information. The representations we propose should help analyze the type of missing information given the context. We will design an experiment to find possible regularities in such missing information.

3.2.4 Compaction

I have called compaction the transformation of an entire verb phrase (the actual verb and one of its complements) into one word, could be the nominal head or a modifier.
Example: ORIENTATION

The tower was leaning$_1$ towards one side$_2$.
tilted$_2$ tower$_1$

3.2.5 Denominal verbs

Denominal verbs have an embedded case, one of the entities in this case relation is the noun at the origin of the denominal verb, and the other is an unspecified action.

Examples: *hammer* - embedded case - INSTRUMENT
I hammered the nail
it is implied that the hammer was used in the usual manner to push a nail through something. Then *hammer* is actually the instrument of some unspecified action.

tape - embedded case - OBJECT
I have taped the whole meeting
it means that I have used the tape in the usual way it is used when it is involved in an event, that is to record onto it. So the original noun, *tape* would be the object of *record*, which is implied.

3.2.6 Synecdoche

Human communication is often based on the assumption that the listener can understand the speaker even if the utterance does not contain all the details. We all have certain experiences that help us fill in some blanks, or we are just comfortable with a certain manner of speaking, and do not require detailed explanations. This is the phenomenon that is the basis of the existence of different syntactic manifestations of semantic relations. I will give an example. We define the EFFECT relation as a relation between two occurrences, the *Cause* and the *Effect*. The proposition expressing the *Cause* is true, and this makes the *Effect* proposition, true.

The student was anxious because he was writing an exam.

This is an example of the EFFECT relation at the clause level (the EFFECT CLR). The *Cause* proposition is "*he was writing an exam*", the *Effect* is "*he was anxious*". The *Cause* proposition is true, and as a consequence, the *Effect* proposition becomes true. Syntactically speaking, both *Cause* and *Effect* are expressed by occurrences (action for *Cause*, state for *Effect*, in this case).

It is possible that the speaker doesn't know exactly what about the exam makes the student anxious – writing it, answering it orally, thinking about it, etc. Then the speaker might choose the following expression:

The student was anxious because of the exam.

In this situation we still have an EFFECT relation, more specifically the EFFECT case. The *Effect* proposition is still expressed by a state occurrence, but the *Cause* is now just a noun – *exam*. The view that I will defend here is that the *Cause* part of the EFFECT relation is still expressed by an occurrence, but which in this situation is not fully verbalized. We consider the *Agent*, *Object*, head verb, and other components of an utterance as parts of the occurrence that is expressed. Then the phenomenon present in the example above is synecdoche: a part (in this case *exam*) stands in for the whole occurrence.

3.2.7 Equivalences

Some types of entities can be expressed equivalently using a complex clause or just a verb, noun, adjective or adverb. For example, we can identify a point in time by some action that occurs then, or by some specific time expression. In the following example:

They practice while others have lunch.

we pinpoint the time when the *practice* occurrence takes place, by expressing another occurrence that unfolds during the same time interval. We can use instead a specific time interval:

They practice during lunch hour.

In this case, the time interval during which the *practice* occurrence is unfolding is a definite time interval: the *lunch hour.*

4 Relations

Before looking at each semantic relation, some considerations on the equivalence of semantic relations on different levels. The focus of this work is on expressions that talk about the same things that are related in the same way - semantic relations are the same on different syntactic levels. But in passing from one level to another one it is inneviatable that something will change, and some of the relations will also change. I have identified the following patterns of change for a group of semantic relations, in transforming between levels:

- transform a compound or modifier to their verb form (or the opposite) opposite, nominalization or adjectivalization) - the relation that held between their nominal or adjectival form and modifiers will be mapped onto the relations between their verb form and the arguments.

  student protest $\longrightarrow$*the students protested (AGT)*

  In this situation there is a one-to-one correspondence between an NMR and a case relation : NMR $\longleftrightarrow$Case

- recover an association between a noun and an implicit event (or the opposite, deletion) - the relation that held between the noun and its modifiers or conjuncts will hold between the verb expressing the event and the arguments.

  sweets before dinner $\longrightarrow$*eat sweets before eat dinner (CO-OCC)*

  In this situation there is a one-to-one correspondence between an NMR and a pair of cases: NMR $\longleftrightarrow$(CaseC, CaseM)

- recover a deletable predicate - inserting a predicate between two nouns, will cause us to jump to the CL level, but the relations that we consider on this level will no longer be between the two nouns, but between each of the nouns and the predicate.

  musical clock $\longrightarrow$*the clock makes music (PROD)*

  In this situation, one NMR may correspond to several pairs of cases, but they can be distinguished by the semantic class of the verb that was introduced

Following is a detailed presentation of each of the relations we consider, with examples on each of the syntactic levels that can support them. The entities involed in the relations are marked, and a brief paraphrase is given to explain our definition for each relation.

4.1 Causality

4.1.1 In the literature

(Givon, 1975) analyses the causal construction in English on different syntactic levels. He starts from the premise that *cause* is a predicate that takes two sentential arguments, one to denote the cause (P_c), and the other the effect(P_e). Of these two arguments, according to the language expressions, the AGENT subject of P_c is the one usually considered to be the subject of the causative expression, and the PATIENTsubject of P_e is considered the object of causation.
In order to explain the different paraphrases of such a causal relation, Givon describes the *Raising/Foregrounding* process, which condenses the two sentential arguments P_c and P_e into a single proposition. The end result could be a sentence with only one lexical verb. The AGENT initiator and the PATIENT(undergoer) will be the subject and object of the causative verb, respectively.
Examples given in the article:

- George shot the gun at the elephant, and as a result, the elephant died.
- George shot the gun at the elephant, and thus caused the elephant to die.
- George's shooting the gun at the elephant caused the elephant to die.
- George caused the elephant to die by shooting the gun at him.
- George caused the elephant's death by shooting the gun at him.
- George killed the elephant by shooting the gun at him.
- George killed the elephant with the gun.

But he notes the following:

> By positing a "weak relatedness" between these examples, I do not wish to suggest that they are derivationally/transformationally relatable, nor that they share a considerable portion of their semantic structure. Paraphrases of this type are at best suggestive. ... The examples are different from focus/topic point of view

We don't share this view for this particular example that was presented. Our opinion is that causality relations hold between two occurrences. But we agree with the idea that sometimes clause-level relations are better explained by considering certain components of the clauses rather than the head verb.
The transformation proposed for the example presented is the following:

P_c [cause] P_e
Nom_a [cause] P_e by P_c
Nom_a [cause - v_e] Nom_p by Nom_i
where Nom_a is the AGENT of P_c, Nom_p is the PATIENT-subject of P_e, and v_e is the verb of P_e.

For some relation we will see that not always the AGENT subject of P_c is the AGENT of the action that causes p_e, but it can also be the OBJECT , like in the example:

The file printed because the program issued a command

Because the sentence can be paraphrased into a sentence that has a subordinate clause:

The file printed because of the command issued by the program
the semantic relation is not an CLR (clause level relation) between *printed* and *issued*, but rather a CLR between the action of *printing* and an unspecified action brought about by *command*. In this case *command* is the AGENT of some unspecified action that is the cause of the file being printed.

We consider this phenomenon similar to synechdoche. The occurrence can be viewed as a whole which has as parts the action and the participants. It is usually the action that stands in for the whole occurrence, but occasionally it can be another part as well, like the AGENT or OBJECT .

4.1.2 Cause Relation

1 causes 2 . 1 is sufficient to cause 2 . 1 is true, and 2 becomes also true as a consequence of 1 . 1 is emphasized.

- IC - it is the result of 1 (the verb that expresses the event 1) that causes the event 2
- CL - 1 causes the event 2 . At this point 1 could be the result, the event that made it come true is not specified, or 1 is the nominalized verb that expressed the event, or 1 is an agent that causes 2 to come true
- NP - 1 causes 2 . 1 is an agent, the action that it employs to make 2 true is not specified. 2 is a state

We analyze each example, and annotate it with semantic relation. We will represent the semantic relation that is the same on all three syntactic levels using the same structure. The amount of detailed present in each example is different.

To represent the CAUSE relation, we need to remember this relation links two occurrences, a *Cause* and an *Effect*. The link is sometimes made more visible by using a connective (we consider it to be an INDICATOR).

When we analyze an example of the CAUSE relation at the clause level, there is just one obvious occurrence. The *Cause* part will be expressed by an argument of the verb. Just like in synecdoche, the part stand for the whole. We know that there is an occurrence involved, but it is not explicitly presented. Therefore we design our representation structure to accomodate this possibility.

We have noticed from the examples analyzed that the *Effect*part of the relation is not replaced by its part, but is expressed by the verb or deverbal noun head of an occurrence.

We propose the following pattern for the CAUSE relation:

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to cause occurrence} \\ OCCURRENCE\,PART & \begin{bmatrix} TYPE & \texttt{occurrence part type} \\ FILLER & \texttt{pointer to occurrence part} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to effect occurrence} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \texttt{indicator} \end{bmatrix}$$

Only one of the two parts of the *Cause* component have to be filled at a time. They stand in for the *Cause* occurrence.

Here are some of the examples mapped onto the proposed representation:

IC - The file printed$_2$ because the program issued a command$_1$

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \\ OCCURRENCE\,PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{command} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{printed} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{because} \end{bmatrix}$$

CL - The file printed$_2$ because of the [print] command$_1$

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \_ \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{Cause} \\ FILLER & \text{command} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{printed} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{because} \end{bmatrix}$$

NP - print$_2$ command$_1$

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \_ \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \text{command} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{print} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \_ \end{bmatrix}$$

IC - They battled$_2$ very hard and they both died$_1$
(IC or : They died$_1$ because they battled very hard$_2$)

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{battle} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \_ \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{die} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{and} \end{bmatrix}$$

CL - They battled$_2$ to death$_1$

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{battle} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \text{Effect} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{death} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \_ \end{bmatrix}$$

NP - battle$_1$ to death$_2$

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{battle} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \_ \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{death} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \_ \end{bmatrix}$$

4.1.3 Effect/Result

Effect is very similar with Cause , the difference is the fact that it is the part that expresses the effect/result of some event that is in the focus. (2 is the focus)

The HPSG-like structure we propose to represent Effect is the same with the one for Cause :

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to cause occurrence} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \texttt{occurrence part type} \\ FILLER & \texttt{pointer to occurrence part} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to effect occurrence} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \texttt{indicator} \end{bmatrix}$$

Examples mapped onto this representation of the EFFECT relation:

IC - The student was anxious$_2$ because he was about to write an exam$_1$

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{write} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{exam} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{be anxious} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{because} \end{bmatrix}$$

CL - The student was anxious$_2$ because of the exam$_1$

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & - \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{CAUSE} \\ FILLER & \text{exam} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{be anxious} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{because} \end{bmatrix}$$

NP - exam$_1$ anxiety$_2$

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & - \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & \text{exam} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{anxiety} \end{bmatrix} \end{bmatrix} \\ INDICATOR & - \end{bmatrix}$$

4.1.4 Purpose

1 is for 2 , but 2 does not necessarily come true.

The difference between the PURPOSE relation and CAUSE is only the fact that the *Effect*part is not necessarily true. We label then the *Effect*part of the PURPOSE relation, DESIRED EFFECT. In other respects this relation is similar to CAUSE . We propose the following structure:

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to cause occurrence} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \texttt{occurrence part type} \\ FILLER & \texttt{pointer to occurrence pa} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ DESIRED\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to desired effect occurrence} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \texttt{indicator} \end{bmatrix}$$

Sample representations:

IC - They finally gave her the medicine$_1$ so the pain should be relieved$_2$

$$\begin{bmatrix} CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{give} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{medicine} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ DESIRED\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{relieve} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{should, so} \end{bmatrix}$$

CL - The medicine was given$_1$ for pain relief$_2$

$$\left[\begin{array}{ll} CAUSE & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{give} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \textsc{Object} \\ FILLER & \text{medicine} \end{array}\right] \end{array}\right] \end{array}\right] \\ DESIRED\ EFFECT & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{relief} \end{array}\right] \end{array}\right] \\ INDICATOR & \text{for} \end{array}\right]$$

NP - pain-relief (analgesic)$_2$ medicine$_1$

$$\left[\begin{array}{ll} CAUSE & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \_ \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \text{medicine} \end{array}\right] \end{array}\right] \end{array}\right] \\ DESIRED\ EFFECT & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{relief} \end{array}\right] \end{array}\right] \\ INDICATOR & \_ \end{array}\right]$$

4.1.5 Entailment

1 entails 2 . We don't know if 1 is true, but if it is, then necessarily 2 is also true.

The difference between the ENTAILMENT relation and the CAUSE relation is the fact that the *Cause* part is not known to be true. If it is, then the *Effect*part will be true. We label then the *Cause* part of ENTAILMENT , POSSIBLE CAUSE. The representation will be:

$$\left[\begin{array}{ll} POSSIBLE\ CAUSE & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \texttt{pointer to possible cause occurrence} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \texttt{occurrence part type} \\ FILLER & \texttt{pointer to occurrence pa} \end{array}\right] \end{array}\right] \end{array}\right] \\ EFFECT & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \texttt{pointer to effect occurrence} \end{array}\right] \end{array}\right] \\ INDICATOR & \texttt{indicator} \end{array}\right]$$

IC - If students work$_1$ very hard, they pass$_2$ their exams.

$$\left[\begin{array}{ll} POSSIBLE\ CAUSE & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{work} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \end{array}\right] \\ EFFECT & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{pass} \end{array}\right] \end{array}\right] \\ INDICATOR & \text{if} \end{array}\right]$$

CL - Hard working students$_1$ pass$_2$ their exams

$$\left[\begin{array}{ll} POSSIBLE\ CAUSE & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \_ \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \end{array}\right] \\ EFFECT & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{pass} \end{array}\right] \end{array}\right] \\ INDICATOR & \_ \end{array}\right]$$

(the cause here is the modifier of the noun *students*)

NP - action$_1$ in case of fire$_2$??

$$\begin{bmatrix} POSSIBLE\ CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \_ \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \text{fire} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{action} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{in case of} \end{bmatrix}$$

Something I find interesting for the example at clause level: although *hard working students* is a noun phrase, therefore a unit with respect to the relation (semantic or otherwise) with other parts of the sentence, the ENTAILMENT relation seems to hold between the modifier *hard working* and the verb *pass*, while *students* is the agent in this sentence.

4.1.6 Enablement

1 enables 2 . 1 is necessary but not sufficient to make 2 true.

The *Cause* part of this relation is one of several which are required to make the *Effect*part true. It is also not known whether the *Cause* is true. We therefore relabel it POSSIBLE CAUSE, and the *Effect*is noe DESIRED EFFECT. In other respects it behaves similar to CAUSE . The representation is :

$$\begin{bmatrix} POSSIBLE\ CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to possible cause occurrence} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \texttt{occurrence part type} \\ FILLER & \texttt{pointer to occurrence pa} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ DESIRED\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to desired effect occurrence} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \texttt{indicator} \end{bmatrix}$$

Sample representations:

IC - The printer can print$_2$ if the paper tray contains paper$_1$

$$\begin{bmatrix} POSSIBLE\ CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{contain} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{paper} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ DESIRED\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{print} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{can, if} \end{bmatrix}$$

CL - The printer can print$_2$ from a full paper tray$_1$

$$\begin{bmatrix} POSSIBLE\ CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \_ \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{tray} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ DESIRED\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{print} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{can} \end{bmatrix}$$

This particular relation seems not to have an equivalent at the NP level, possibly because of the fact that in English we use modal verbs to express degrees of certainty.

4.1.7 Detraction

1 detracts/opposes 2 , but 1 being true may not be sufficient to prevent 2 from being true.

This relation is the opposite of ENABLEMENT . We don't know if the *Cause* part is true, but if it is, it may not be sufficient to prevent the *Effect*part of becoming true. The components of this relation were relabelled: OPPOSING CAUSE and EFFECT. The representation we propose is as follows:

$$\begin{bmatrix} OPPOSING\ CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to opposing cause occurrenc} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \texttt{occurrence part type} \\ FILLER & \texttt{pointer to occurrence pa} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to effect part} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \texttt{indicator} \end{bmatrix}$$

Sample representations:

IC - Although I warned$_1$ them, they persisted$_2$.

$$\begin{bmatrix} OPPOSING\ CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{warn} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{persist} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{although} \end{bmatrix}$$

CL - Despite my warning$_1$ they persisted$_2$

$$\begin{bmatrix} OPPOSING\ CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{warn} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{persist} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{despite} \end{bmatrix}$$

NP - persistance$_2$ despite warnings$_1$

$$\begin{bmatrix} OPPOSING\ CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{warn} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{persist} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{despite} \end{bmatrix}$$

4.1.8 Prevention

1 prevents 2 . If 1 is true, then necessarily 2 is false.

PREVENTION is the opposite of CAUSE . The *Cause* part prevents the *Effect*part from becoming true. The *Cause* part of PREVENTION was relabeled OPPOSING CAUSE, and the *Effect*, OPPOSING EFFECT. The proposed representation is:

$$\begin{bmatrix} OPPOSING\ CAUSE & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to opposing cause occurrenc} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \texttt{occurrence part type} \\ FILLER & \texttt{pointer to occurrence pa} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ OPPOSED\ EFFECT & \begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointr to opposed effect occurrence} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \texttt{indicator} \end{bmatrix}$$

Examples:

IC - The files were not copied$_2$ since the hard disk crashed$_1$

$$\left[\begin{array}{ll} OPPOSING\ CAUSE & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{crash} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \textsc{Object} \\ FILLER & \text{hard disk} \end{array}\right] \end{array}\right] \end{array}\right] \\ OPPOSED\ EFFECT & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{copy} \end{array}\right] \end{array}\right] \\ INDICATOR & \text{since} \end{array}\right]$$

CL - The files were not copied$_2$ because of a a hard disk crash$_1$

$$\left[\begin{array}{ll} OPPOSING\ CAUSE & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{crash (nom)} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \end{array}\right] \\ OPPOSED\ EFFECT & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{copy} \end{array}\right] \end{array}\right] \\ INDICATOR & \text{not, because} \end{array}\right]$$

NP - service breakdown$_2$ on account of a crash$_1$

$$\left[\begin{array}{ll} OPPOSING\ CAUSE & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{crash} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \end{array}\right] \\ OPPOSED\ EFFECT & \left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{breakdown} \end{array}\right] \end{array}\right] \\ INDICATOR & \text{on account of} \end{array}\right]$$

4.2 Temporal

We have seen for the Causality relations, that the inter clause relation is not very clear cut. The inter clause relation should stand between two events, yet in the Causality case, the relations would much better be described as standing between the result (or consequence) of an event, and some other event. As opposed to this situation, the Temporal inter clause relations stand clearly between two events, that stand in some temporal order with respect with one another.

The different types of **Temporal** relations is given by the actual span of the time intervals involved, and their relative position on the time axis (Allen, 1984). An interval can be expressed not only by an explicit time interval, but also by an occurrence unfolding in time. We can thus find the same **Temporal** relation on different syntactic levels.

4.2.1 Co-occurrence

1 and 2 occur or exist at the same time. Neither delimits an interval of time.

The two intervals are expressed by ongoing actions, which unfold in parallel. We have also found examples in which, similar to Cause , a part of an occurrence stands for the whole. We will therefore use the format used to represent the *Cause* part of the **Causality** relations, to allow for phenomena similar to synecdche, in which a part of the occurrence stands for the whole.

This is the proposed representation:

$$\left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \texttt{pointer to first occurrence} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \texttt{occurrence part type} \\ FILLER & \texttt{pointer to occurrence part} \end{array}\right] \end{array}\right] \\ OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \texttt{pointer to second occurrence} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \texttt{occurrence part type} \\ FILLER & \texttt{pointer to occurrence part} \end{array}\right] \end{array}\right] \\ INDICATOR & \texttt{indicator} \end{array}\right]$$

Here are some examples represented using the structure proposed:

IC - He writes$_1$ novels while his wife plays$_2$ the piano

$$\left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{write} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{play} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ INDICATOR & \text{while} \end{array}\right]$$

Neither of the two occurrences linked by the CO-OCCURRENCE relation has precedence. We can change either of them into a noun phrase by transforming the head verb into a participle, and obtain a semantically related expressed that still displays the CO-OCCURRENCE relation. CL - * He writes$_1$ novels while listening to music$_2$.

$$\left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{write} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{listen (part)} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ INDICATOR & \text{while} \end{array}\right]$$

CL - * He listens$_1$ to music while writing novels$_2$.

$$\left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{listen} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{write (part)} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ INDICATOR & \text{while} \end{array}\right]$$

NP - writing$_1$ novels while listening$_2$ to music

$$\left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{write (part)} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{listen (part)} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ INDICATOR & \text{while} \end{array}\right]$$

Here is an example of synecdoche: NP - * fish$_1$ and wine$_2$ (make a good meal)

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \_ \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{fish} \end{bmatrix} \end{bmatrix} \\ OCCURRENCE & \begin{bmatrix} VERB/STATE & \_ \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{wine} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{and} \end{bmatrix}$$

4.2.2 Frequency

1 occurs every time 2 occurs

FREQUENCY expresses a tenporal link between two occurrences, such that on the time axis, whenever one of them is present (we labet it TIME), the other one (labelled OCCURRENCE) is present, too. TIME can be an occurrence, or an interval in time. We consider it punctual, as it is needed only to anchor OCCURRENCE somewhere on the time axis.

We propose the following representation:

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \texttt{pointer to the occurrence} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & \texttt{type of time indicator} \\ FILLER & \texttt{pointer to time indicator} \end{bmatrix} \\ INDICATOR & \texttt{indicator} \end{bmatrix}$$

Examples:

IC - * Every time he plays$_2$, we win$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{win} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & OCCURRENCE \\ FILLER & \begin{bmatrix} VERB/STATE & \text{play} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{every time} \end{bmatrix}$$

CL - We play$_1$ volleyball every week$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{play} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & DEFINITE\ TIME \\ FILLER & \text{week} \end{bmatrix} \\ INDICATOR & \text{every} \end{bmatrix}$$

NP - * weekly$_2$ game$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{game} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & DEFINITE\ TIME \\ FILLER & \text{week} \end{bmatrix} \\ INDICATOR & \text{-ly} \end{bmatrix}$$

4.2.3 Precedence

1 occurs or exists (or begins to occur or exist) before 2
IC - I watered$_1$ the flowers before I left$_2$ for the holidays

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{water} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \\ OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{leave} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{before} \end{bmatrix}$$

CL - * I watered$_1$ the flowers before leaving for the holidays$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{water} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \\ OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{leave (part)} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{before} \end{bmatrix}$$

NP - * sweets$_1$ before dinner$_2$ (spoil your appetite)
(or – before dinner$_2$ exercise$_1$ ...)

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & - \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{sweets} \end{bmatrix} \end{bmatrix} \\ OCCURRENCE & \begin{bmatrix} VERB/STATE & - \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{dinner} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{before} \end{bmatrix}$$

4.2.4 Time (At)

1 occurs when 2 occurs

IC - * He went$_1$ there when they called$_2$ him

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{go} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & OCCURRENCE \\ FILLER & \begin{bmatrix} VERB/STATE & \text{call} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{when} \end{bmatrix}$$

CL - He traveled$_1$ extensively last year$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{travel} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & DEFINITE\ TIME \\ FILLER & \text{last year} \end{bmatrix} \\ INDICATOR & - \end{bmatrix}$$

NP - winter$_2$ semester$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{semester} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & DEFINITE\ TIME \\ FILLER & \text{winter} \end{bmatrix} \\ INDICATOR & \text{\_} \end{bmatrix}$$

IC - He eats a snack$_1$ when the clock strikes$_2$ midnight

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{eat} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & OCCURRENCE \\ FILLER & \begin{bmatrix} VERB/STATE & \text{strike} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{when} \end{bmatrix}$$

CL - He eats a snack$_1$ at midnight$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{eat} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & DEFINITE\ TIME \\ FILLER & \text{midnight} \end{bmatrix} \\ INDICATOR & \text{at} \end{bmatrix}$$

NP - midnight$_2$ snack$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{eat (snack)} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & DEFINITE\ TIME \\ FILLER & \text{midnight} \end{bmatrix} \\ INDICATOR & \text{\_} \end{bmatrix}$$

4.2.5 Time From

1 began to occur when 2 became true. 2 can be punctual

IC - * He plays$_1$ well since we coached$_2$ him

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{play} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & OCCURRENCE \\ FILLER & \begin{bmatrix} VERB/STATE & \text{coach} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{since} \end{bmatrix}$$

CL - I will stay$_1$ at your home from Tuesday$_2$ until Saturday

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{stay} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & DEFINITE\ TIME \\ FILLER & \text{Tuesday} \end{bmatrix} \\ INDICATOR & \text{from} \end{bmatrix}$$

NP - * working$_1$ non-stop since yesterday$_2$ (must be tiring)

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{working} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & DEFINITE\ TIME \\ FILLER & \text{yesterday} \end{bmatrix} \\ INDICATOR & \text{since} \end{bmatrix}$$

4.2.6 Time Through

1 existed while 2 existed. 2 delimits an interval of time

IC - * He stood$_1$ there while Jane played$_2$ the whole piece

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{stay} \end{bmatrix} \\ INTERVAL & \begin{bmatrix} TYPE & OCCURRENCE \\ FILLER & \begin{bmatrix} VERB/STATE & \text{play} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{while} \end{bmatrix}$$

CL - The meeting lasted$_1$ for six hours$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{last} \end{bmatrix} \\ INTERVAL & \begin{bmatrix} TYPE & DEFINITE\ INTERVAL \\ FILLER & \text{six hours} \end{bmatrix} \\ INDICATOR & \text{for} \end{bmatrix}$$

NP - * six-hour$_2$ meeting$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{last} \end{bmatrix} \\ INTERVAL & \begin{bmatrix} TYPE & DEFINITE\ INTERVAL \\ FILLER & \text{six-hour} \end{bmatrix} \\ INDICATOR & \_ \end{bmatrix}$$

IC - The band practices$_1$ during the hour when others have lunch$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{practice} \end{bmatrix} \\ INTERVAL & \begin{bmatrix} TYPE & OCCURRENCE \\ FILLER & \begin{bmatrix} VERB/STATE & \text{have lunch} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{while} \end{bmatrix}$$

CL - The band practices$_1$ during lunch hour$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{practice} \end{bmatrix} \\ INTERVAL & \begin{bmatrix} TYPE & DEFINITE\ INTERVAL \\ FILLER & \text{hour} \end{bmatrix} \\ INDICATOR & \text{during} \end{bmatrix}$$

NP - lunch hour$_2$ practise$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{practice} \end{bmatrix} \\ INTERVAL & \begin{bmatrix} TYPE & DEFINITE\ INTERVAL \\ FILLER & \text{hour} \end{bmatrix} \\ INDICATOR & \_ \end{bmatrix}$$

4.2.7 Time To

1 existed until 2 started to exist or occur. 2 can be punctual

IC - * They played$_1$ until their mother sent$_2$ them to bed

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{play} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & OCCURRENCE \\ FILLER & \begin{bmatrix} VERB/STATE & \text{send} \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{until} \end{bmatrix}$$

CL - They played$_1$ until 9 o'clock$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{play} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & DEFINITE\ TIME \\ FILLER & \text{9 o'clock} \end{bmatrix} \\ INDICATOR & \text{until} \end{bmatrix}$$

NP - * party$_1$ until dawn$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{party} \end{bmatrix} \\ TIME & \begin{bmatrix} TYPE & DEFINITE\ TIME \\ FILLER & \text{dawn} \end{bmatrix} \\ INDICATOR & \text{until} \end{bmatrix}$$

4.3 Space

4.3.1 Direction

1 is directed towards 2 . 2 is not the final point

CL - Look$_1$ inside yourself$_2$ for the answer

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{look} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \_ \end{bmatrix} \end{bmatrix} \\ DIRECTION & \text{inside} \\ INDICATOR & \_ \end{bmatrix}$$

NP - * outgoing$_2$ mail$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{go} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \textsc{Object} \\ FILLER & \text{mail} \end{bmatrix} \end{bmatrix} \\ DIRECTION & \text{out} \\ INDICATOR & \_ \end{bmatrix}$$

4.3.2 Location From/Source

1 originates at 2

CL - The capital comes$_1$ from abroad$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{comes} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \textsc{Object} \\ FILLER & \text{capital} \end{bmatrix} \end{bmatrix} \\ LOCATION\ FROM & \text{abroad} \\ INDICATOR & \text{from} \end{bmatrix}$$

NP - foreign$_2$ capital$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \_ \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \text{capital} \end{bmatrix} \end{bmatrix} \\ LOCATION\ FROM & \text{foreign} \\ INDICATOR & \_ \end{bmatrix}$$

4.3.3 Location To/Destination

The destination of 1 is 2 . 2 is the final point

CL - I went$_1$ home$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{go} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \textsc{Agent} \\ FILLER & \text{I} \end{bmatrix} \end{bmatrix} \\ LOCATION\ TO & \text{home} \\ INDICATOR & \_ \end{bmatrix}$$

NP - homeward$_2$ journey$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{journey} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \_ \end{bmatrix} \end{bmatrix} \\ LOCATION\ TO & \text{home} \\ INDICATOR & \text{-ward} \end{bmatrix}$$

NP - homebound$_2$ traveler$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \_ \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \textsc{Agent} \\ FILLER & \text{traveler} \end{bmatrix} \end{bmatrix} \\ LOCATION\ TO & \text{home} \\ INDICATOR & \text{-bound} \end{bmatrix}$$

4.3.4 Location Through

1 occurred through 2

CL - I drove$_1$ on highway 60$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{drive} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \textsc{Agent} \\ FILLER & \text{I} \end{bmatrix} \end{bmatrix} \\ LOCATIONTHROUGH & \text{highway 60} \\ INDICATOR & \text{on} \end{bmatrix}$$

NP - * driving$_1$ on highway 60$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{drive (part)} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \_ \end{bmatrix} \end{bmatrix} \\ LOCATIONTHROUGH & \text{highway 60} \\ INDICATOR & \text{on} \end{bmatrix}$$

4.3.5 Location

1 is the location of 2

CL - The storm started$_2$ in the desert$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{start} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{AGENT} \\ FILLER & \text{storm} \end{bmatrix} \end{bmatrix} \\ LOCATION & \text{desert} \\ INDICATOR & \text{in} \end{bmatrix}$$

NP - desert$_2$ storm$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \_ \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \text{storm} \end{bmatrix} \end{bmatrix} \\ LOCATION & \text{desert} \\ INDICATOR & \_ \end{bmatrix}$$

4.3.6 Located

1 is located at 2

CL - My home is$_1$ in a town called Cluj$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{be} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{town} \end{bmatrix} \end{bmatrix} \\ LOCATED & \text{home} \\ INDICATOR & \text{in} \end{bmatrix}$$

NP - home$_1$ town$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \_ \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \_ \\ FILLER & \text{town} \end{bmatrix} \end{bmatrix} \\ LOCATED & \text{home} \\ INDICATOR & \_ \end{bmatrix}$$

4.3.7 Orientation

1 is oriented like 2

CL - The tower lay$_1$ on its side$_2$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{lay} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & \text{OBJECT} \\ FILLER & \text{tower} \end{bmatrix} \end{bmatrix} \\ ORIENTATION & \text{side} \\ INDICATOR & \text{on} \end{bmatrix}$$

NP * tilted$_2$ tower$_1$

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{tilt} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \\ ORIENTATION & \text{tower} \\ INDICATOR & - \end{bmatrix}$$

4.4 Conjunctive

The fact that there are no examples that display this relation for the CL level, has the following explanation - this type of relations hold between entities on the same level of a phrase (two events, two nouns). In the clause level case, teh relations are between the verb and its arguments.

4.4.1 Conjunction

Both 1 and 2 occur or exist
In the case of NP, the two nouns (or NPs) appear in conjunction because they share some event (*running and swimming* appear in conjunction because they have in common the fact that they *are good for you*). For this particular example the conjunction can be split, because each of the activities are good for you independent of one another (*swimming is good for you and running is good for you*), but are there cases where this is not possible, because it is the conjunction itself that is important? I thought about the example: *Fish and wine make a good meal* that is acctually a CO-OCCURRENCE relation. Because *fish and wine* is more than a conjunction. It is not meant by the sentence that fish by itself and wine by itself make a good meal, but that the combination - or rather co-occurrence - of the two does.

IC - The computer runs$_1$ applications and the printer prints$_2$ documents

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{run} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \\ OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{print} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{and} \end{bmatrix}$$

NP - * running$_1$ and swimming$_2$ (are good for you)

$$\begin{bmatrix} OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{run (part)} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \\ OCCURRENCE & \begin{bmatrix} VERB/STATE & \text{swim (part)} \\ OCCURRENCE\ PART & \begin{bmatrix} TYPE & - \\ FILLER & - \end{bmatrix} \end{bmatrix} \\ INDICATOR & \text{and} \end{bmatrix}$$

4.4.2 Disjunction

Either one or both 1 and 2 occur or exist

IC - The program may terminate$_1$ or it may hang$_2$ indefinitely

$$\left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{terminate} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{hang} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ INDICATOR & \text{or} \end{array}\right]$$

NP - * painting$_1$ or drawing$_2$

$$\left[\begin{array}{ll} OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{paint (part)} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ OCCURRENCE & \left[\begin{array}{ll} VERB/STATE & \text{draw (part)} \\ OCCURRENCE\ PART & \left[\begin{array}{ll} TYPE & \_ \\ FILLER & \_ \end{array}\right] \end{array}\right] \\ INDICATOR & \text{or} \end{array}\right]$$

4.5 Participant

4.5.1 Accompaniment

1 is accompanied by 2 . 2 is a co-agent.

CL - I eat supper$_1$ with my family$_2$

$$\left[\begin{array}{ll} VERB & \text{eat} \\ AGENT & \text{I} \\ CO-AGENT & \text{family} \\ INDICATOR & \text{with} \end{array}\right]$$

NP - * supper$_1$ with my family$_2$

$$\left[\begin{array}{ll} VERB & \text{eat (supper)} \\ AGENT & \text{I} \\ CO-AGENT & \text{family} \\ INDICATOR & \text{with} \end{array}\right]$$

4.5.2 Agent

1 performes 2

CL - The students$_1$ protested$_2$ against tution fee raising.

$$\left[\begin{array}{ll} VERB & \text{protest} \\ AGENT & \text{student} \\ INDICATOR & \_ \end{array}\right]$$

NP - student$_1$ protest$_2$

$$\begin{bmatrix} VERB & \text{protest} \\ AGENT & \text{student} \\ INDICATOR & \text{\_} \end{bmatrix}$$

4.5.3 Beneficiary

2 benefits from 1

CL - This year's rain produced$_1$ a bumper crop for the farmer$_2$

NP - student$_2$ discount$_1$

$$\begin{bmatrix} VERB & \text{discount} \\ BENEFICIARY & \text{student} \\ INDICATOR & \text{\_} \end{bmatrix}$$

4.5.4 Exclusion

2 is excluded from 1 or 1 replaces 2

CL - Jeff played$_1$ instead of Howard$_2$

$$\begin{bmatrix} VERB & \text{play} \\ AGENT & \text{Jeff} \\ EXCLUDED & \text{Howard} \\ INDICATOR & \text{instead} \end{bmatrix}$$

NP - * flowers$_1$ instead of cannons$_2$

$$\begin{bmatrix} VERB & \text{\_} \\ AGENT & \text{flowers} \\ EXCLUDED & \text{cannons} \\ INDICATOR & \text{instead} \end{bmatrix}$$

4.5.5 Experiencer/Stative

1 is in a state of 2

CL - * The dog$_1$ is sleeping$_2$

$$\begin{bmatrix} STATE & \text{sleep} \\ EXPERIENCER & \text{dog} \\ INDICATOR & \text{be} \end{bmatrix}$$

NP - sleeping$_2$ dog$_1$

$$\begin{bmatrix} STATE & \text{sleep} \\ EXPERIENCER & \text{dog} \\ INDICATOR & \text{\_} \end{bmatrix}$$

4.5.6 Experiencer/Property

1 is 2

CL - * The dog$_1$ is brown$_2$

$$\begin{bmatrix} PROPERTY & \text{brown} \\ EXPERIENCER & \text{dog} \\ INDICATOR & \text{be} \end{bmatrix}$$

NP - brown$_2$ dog$_1$

$$\begin{bmatrix} PROPERTY & \text{brown} \\ EXPERIENCER & \text{dog} \\ INDICATOR & \text{\_} \end{bmatrix}$$

4.5.7 Experiencer/Possessor

2 has 1

CL - * The country has$_2$ a big debt$_1$

$$\begin{bmatrix} POSSESSION & \text{debt} \\ POSSESSOR & \text{country} \\ INDICATOR & \text{has} \end{bmatrix}$$

NP - national$_2$ debt$_1$

$$\begin{bmatrix} POSSESSION & \text{debt} \\ POSSESSOR & \text{national} \\ INDICATOR & \text{\_} \end{bmatrix}$$

4.5.8 Experiencer/Possession

1 has 2

CL - * The man has$_1$ a long beard$_2$

$$\begin{bmatrix} POSSESSOR & \text{man} \\ POSESSION & \text{beard} \\ INDICATOR & \text{has} \end{bmatrix}$$

NP - * bearded$_2$ man$_1$

$$\begin{bmatrix} POSSESSOR & \text{man} \\ POSESSION & \text{beard} \\ INDICATOR & \text{-ed} \end{bmatrix}$$

4.5.9 Instrument

1 used 2

CL - The system administrator notified$_1$ the users via e-mail$_2$

$$\begin{bmatrix} VERB & \text{notify} \\ INSTRUMENT & \text{e-mail} \\ INDICATOR & \text{via} \end{bmatrix}$$

NP - laser$_2$ printer$_1$

$$\begin{bmatrix} VERB & \text{printer} \\ INSTRUMENT & \text{laser} \\ INDICATOR & \_ \end{bmatrix}$$

4.5.10 Object

2 is acted upon by 1

CL - The window$_2$ broke$_1$

$$\begin{bmatrix} VERB & \text{brake} \\ OBJECT & \text{window} \\ INDICATOR & \_ \end{bmatrix}$$

NP - engine$_2$ repair$_1$

$$\begin{bmatrix} VERB & \text{repair} \\ OBJECT & \text{engine} \\ INDICATOR & \_ \end{bmatrix}$$

4.5.11 Object-Property

1 was the object of 2

CL - The ship$_1$ sunk$_2$.

$$\begin{bmatrix} PROPERTY & \text{sink} \\ EXPERIENCER & \text{ship} \end{bmatrix}$$

NP - sunken$_2$ ship$_1$

$$\begin{bmatrix} PROPERTY & \text{sink} \\ EXPERIENCER & \text{ship} \end{bmatrix}$$

4.5.12 Recipient

2 receives the object of 1

CL - I wrote$_1$ Smilla a reference letter to prospective employees$_2$

4.5.13 Part

1 is part of 2

NP - the funnel$_1$ of the ship$_2$; $_2$ board $_1$ member

4.5.14 Whole

2 is part of 1

4.5.15 Product

1 produces 2

CL - * The factory builds$_1$ cars$_2$

$$\begin{bmatrix} VERB & \text{builds} \\ AGENT & \text{factory} \\ PRODUCT & \text{cars} \\ INDICATOR & \_ \end{bmatrix}$$

NP - automobile$_2$ factory$_1$

$$\begin{bmatrix} VERB & \_ \\ AGENT & \text{factory} \\ PRODUCT & \text{automobile} \\ INDICATOR & \_ \end{bmatrix}$$

Looking at some other languages, (Dixon, 1977) looks at word categories across languages, mainly at adjectives. It turns out that there are languages (Samoan, Yurok, Japanese, etc) that have very few "pure" adjectives. The adjectives are replaced by verbs or nouns in different constructions. For example, to say something is wet, the past participle of the verb "to wet" is used. Or, to say for example: *I am proud* one would actually say *I have pride.* In this example, it looks like in one case there is a **Property** relation, and in the other case there is a **Possession** relation, and yet the phrases convey the same meaning.

In German, they use a lot of "composed" verbs, so a certain relation that appears in English could be hidden inside the verb itself.
(Example:
English: The dog ran around the house.
German : Der Hund is um das Haus herumgelaufen.)

4.6 Quality

4.6.1 Content(phys)

1 contains 2

CL - He filled$_1$ the container with milk$_2$

$$\begin{bmatrix} VERB & \text{filled} \\ CONTAINER & \text{container} \\ CONTENT & \text{milk} \\ INDICATOR & \text{with} \end{bmatrix}$$

NP - milk$_2$ bottle$_1$

$$\begin{bmatrix} VERB & \_ \\ CONTAINER & \text{bottle} \\ CONTENT & \text{milk} \\ INDICATOR & \_ \end{bmatrix}$$

4.6.2 Topic (abstract content)

1 is concerned with 2

CL - * John wrote$_1$ about volcanoes$_2$

$$\begin{bmatrix} VERB & \text{wrote} \\ CONTAINER & \_ \\ TOPIC & \text{volcanoes} \\ INDICATOR & \text{about} \end{bmatrix}$$

NP - volcano$_2$ documentary$_1$

$$\begin{bmatrix} VERB & \_ \\ CONTAINER & \text{documentary} \\ TOPIC & \text{volcano} \\ INDICATOR & \_ \end{bmatrix}$$

4.6.3 Container

1 is contained in 2

CL - * Milk filled$_1$ the mug$_2$

$$\begin{bmatrix} VERB & \text{filled} \\ CONTAINER & \text{milk} \\ CONTENT & \text{mug} \\ INDICATOR & \_ \end{bmatrix}$$

NP - film$_2$ music$_1$

$$\begin{bmatrix} VERB & \_ \\ CONTAINER & \text{music} \\ CONTENT & \text{film} \\ INDICATOR & \_ \end{bmatrix}$$

4.6.4 Manner

1 occurs in the way indicated by 2
This relation is the equivalent of the EXPERIENCER - PROPERTY relation for verbs or deverbal nouns. In the case of the EXPERIENCER - PROPERTY relation, the relation stands between an entity and one of its attributes. The verb in this case is just a link between them. In the case of the MANNER relation, the relation stands between some event and its manner of evolution. The verb, or a deverbal noun expresses the event.

CL - Emily writes$_1$ with style$_2$

$$\begin{bmatrix} ACTIVITY & \text{writes} \\ MANNER & \text{style} \\ INDICATOR & \text{with} \end{bmatrix}$$

NP - * stylish$_2$ writing$_1$

$$\begin{bmatrix} ACTIVITY & \text{writing (nom)} \\ MANNER & \text{stylish (adj)} \\ INDICATOR & \_ \end{bmatrix}$$

4.6.5 Material

1 is made of 2

CL - We build$_1$ houses with brick$_2$

$$\begin{bmatrix} VERB & \text{build} \\ OBJECT & \text{house} \\ MATERIAL & \text{brick} \\ INDICATOR & \text{with} \end{bmatrix}$$

NP -brick$_2$ houses$_1$

$$\begin{bmatrix} VERB & - \\ OBJECT & \text{house} \\ MATERIAL & \text{brick} \\ INDICATOR & - \end{bmatrix}$$

4.6.6 Measure

2 is a measure of 1

CL - I bought$_1$ the car for five hundred dollars$_2$

$$\begin{bmatrix} VERB & \text{bought} \\ OBJECT & \text{car} \\ MEASURE & \text{five hundred dollars} \\ INDICATOR & \text{for} \end{bmatrix}$$

NP - * a five hundred dollar$_2$ car$_1$

$$\begin{bmatrix} VERB & - \\ OBJECT & \text{car} \\ MEASURE & \text{five hundred dollars} \\ INDICATOR & - \end{bmatrix}$$

4.6.7 Order

1 is before 2 in physical space

CL - He filed the Baker file$_1$ before the Abel file$_2$

$$\begin{bmatrix} VERB & \text{filed} \\ OBJECT\ IN\ FRONT & \text{(Baker) file} \\ OBJECT\ IN\ THE\ BACK & \text{(Abel) file} \\ INDICATOR & \text{before} \end{bmatrix}$$

NP - * flowers$_1$ in front of the window$_2$

$$\begin{bmatrix} VERB & - \\ OBJECT\ IN\ FRONT & \text{flower} \\ OBJECT\ IN\ THE\ BACK & \text{window} \\ INDICATOR & \text{in front of} \end{bmatrix}$$

4.6.8 Equative

1 is also 2
NP - composer$_1$ arranger$_2$

4.6.9 Type

1 is a type of 2
NP - $\underline{\text{oak}}_1$ $\underline{\text{tree}}_2$

About other works in knowledge acquisition, the paper (Gomez et al., 1994) presents the problem of knowledge acquisition from encyclopedic texts. As input data they use a hierarchy of verb concepts, and rules grouped into the following categories: *subj-rules, verb-rules, obj-rules, io-rules, pred-rules, prep-rules, end-of-clause-rules*, in order to determine the meaning of the verb (VM rules). The parser's aim is to identify the meaning of the verb, and it proceeds in a syntactic manner, until the meaning of the verb is identified. What I find interesting is the fact that although they use thematic roles to express the semantic relation between the verb and its arguments, when it comes to noun phrases, the relation between a noun and its modifier is based on information that can be extracted from the a priori ontology, there is no set of noun modifier relations used. For a noun pharse of the form mod_1 mod_2 ... mod_n *head* all the combinations mod_i mod_j and mod_i *head* are tried, all the possible interpretations will be output. The meaning of one such combination, mod_i mod_j or mod_i *head* is actually the relation that connects the two concepts in the a priori hierarchy. If such a relation is not found, then the combination is considered a subconcept of the head. (Example: *rain forest* is a subconcept of *forest*).
This process of knowledge acquisition was done on texts about animals and their habits, and was tested by asking questions.

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