DISSERTATION

INTRLING.
A MACHINE TRANSLATION SYSTEM BASED ON THE INTERLINGUA METHOD, USING ESPERANTO AS THE INTERLINGUA, IN COMBINATION WITH SENTENCE PATTERNS

ausgeführt zum Zwecke der **Erlangung** des akademischen Grades eines Doktors der technischen Wissenschaften unter der Leitung von

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ÜBERSICHT

Int r l ing ist ein System für automatisches Übersetzen mit der Interlinguamethode. Es soll verschriftete naturwissenschaftliche und technische Texte von Deutsch nach Englisch und von Englisch nach Deutsch übersetzen. Die Restriktion bezüglich der Textsorte war notwendig, da naturwissenschaftliche und technische Gebrauchstexte mit eingeschränktem Wortschatz und Satzbau auskommen. Dadurch wird maschinelle Übersetzung überhaupt erst möglich.

Aus sprachlichen und technischen Gründen wurde Esperanto als Interlingua herangezogen. Damit wird die Übersetzung aus der Quellsprache nach Esperanto, und von Esperanto in die Zielsprache durchgeführt. Esperanto ist in seiner Grammatik sehr regelmäßig, es gibt keine Ausnahmen zu berücksichtigen, und es weist wenige Mehrdeutigkeiten in Satzbau und Semantik auf. Aus diesem Grund ist es für elektronische Verarbeitung bestens geeignet.

In der vorliegenden Arbeit wurden Deutsch und Englisch als Quell- und Zielsprache herangezogen, und die Übersetzung sollte in beiden Richtungen vorgenommen werden können. Da das System eine Zwischensprache benützt, läßt es sich relativ leicht erweitem. Zu diesem Zweck braucht man nur Funktionen und Prozeduren zum Übersetzen von der neuen Sprache nach Esperanto, und von Esperanto in die neue Sprache zu schreiben. Danach ist es möglich, Übersetzungen zwischen der neuen Sprache, Deutsch und Englisch in allen Richtungen durchzuführen.

Weiters funktioniert das System mit Satzbauplänen. Das bedeutet, daß die Satzbaupläne jeder Sprache aufgelistet werden müssen. Bei jedem eingegebenen Satz entscheidet die Valenz des Hauptverbs, nach welchem Satzbauplan der Satz gebildet wurde. Bei der Übersetzung wird das Hauptverb in der Zielsprache nachgeschlagen und dessen Valenz für den das Aufsuchen des entsprechenden Satzbauplans in der Zielsprache herangezogen. Auf diese Weise arbeitet die Zwischensprache hauptsächlich auf syntaktischer Basis, wodurch wiederum leicht zu programmierende und bewährte Algorithmen für das Parsen von Sätzen zur Anwendung gebracht werden können.

Esperanto wurde schon früher als Zwischensprache verwendet, allerdings nicht in Kombination mit Satzbauplänen. Tatsächlich ist der Gebrauch von Satzbauplänen im Zusammenhang mit automatischem Übersetzen völlig neu. Dieser Ansatz bringt aber den Vorteil, daß weitaus weniger Einschränkungen bezüglich der Satzstellung vorgenommen werden müssen, als das in früheren Systemen der Fall war. Wie sich an diversen Beispielen zeigt, lassen sich mit Hilfe von Satzbauplänen die unterschiedlichsten Sätze übersetzen.

Intrling est un Systeme de traduction automatique avec la methode interlingua, c'est-à-dire ä l'aide d'une langue intermediaire. Le Systeme a ete cree pour traduire des textes scientifiques et techniques écrits d'allemand en anglais et d'anglais en allemand. La restriction concernant la sorte de texte était necessaire, car les textes scientifiques et techniques utilisent un vocabulaire et une syntaxe limites, ce qui permet des traductions automatiques

Pour des raisons linguistiques et techniques, 1'esperanto a ete pris comme langue intermediaire. Les traductions sont effectuées de la langue source en esperanto, et d'esperanto en la langue cible.

La grammaire de 1'esperanto est très reguliere. Il n'y a pratiquement pas d'exceptions, et il n'y a que peu d'ambiguïtés en syntaxe et en sémantique. Pour cette raison, 1'esperanto est parfaitement adéquat pour etre traité par l'ordinateur.

Dans cette these, l'anglais et l'allemand ont ete pris comme langues source et cible, et les traductions doivent etre effectuées dans les deux directions. Comme le Systeme emploie une langue intermediaire, n'importe quelle langue peut y etre ajoutée facilement, en créant des fonctions et des procedures pour traduire de la nouvelle langue en esperanto, et d'esperanto dans la nouvelle langue. Après avoir fait cela, il sera également possible de traduire entre la nouvelle langue, l'anglais et 1'allemand dans les deux directions.

En plus, le Systeme fonctionne avec des modeles de phrase, qui se trouvent dans des dictionnaires spéciaux pour chaque langue. Pour chaque phrase entree par le clavier, on consulte le dictionnaire pour trouver la valence du verbe principal. Celle-ci établit le(s) modèle(s) au(x)quel(s) la phrase appartient. En traduisant la phrase, on cherche le verbe principal et sa valence dans le dictionnaire bilingue pour la langue cible. De nouveau, ce verbe determine le modèle de phrase pour la phrase donnée dans la langue cible.

L'espéranto a ete utilise comme langue intermediaire de traduction automatique, mais il a ete necessaire de limiter le nombre de phrases possibles ä traduire. Cela n'a pas ete fait avec Intrling. L'utilisation d'esperanto comme langue intermediaire avec Pemploi de modeles de phrases pour la traduction automatique a ete fait pour la premiere fois. Comme les exemples montrent, on peut traduire un bon nombre de phrases différentes avec cette methode.

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1 Introduction

1.1 The Task

This paper deals with Intrling, a machine translation system working by the interlingua method. Its task is to translate sentences from English into German and from German into Esperanto.

Essentially, the system has to translate written sentences taken of technical or scientific texts, such as manuals for mathematics, technology, or science, users' instructions, datasheets, and the like. With this system, only written sentences are translated. The user has to type in the source language sentences that are then translated into Esperanto. From Esperanto, they are translated into the target language. Furthermore, sentence patterns are used together with the interlingua. In contrast to literary texts, for example, technical texts use more conventional sentence patterns and certain well-defined technical terms. Thus vocabulary and syntax have been limited from the start.

1.2 The Method

With Intrling, translation is performed by the Interlingua method. Since the system works by means of an interlingua, it is relatively easy to expand it in a way that other languages can be processed as well. If there are n languages and translation shall be from and into each of them, a machine translation system without interlingua requires n(n-l) translation programmes. If translation is done by means of an interlingua, a machine translation system needs just 2n translation modules. As soon as the number of languages exceeds three, therefore, the interlingua approach is more economic.

With Intrling, Esperanto is used as an interlingua. This means that the German sentences are translated into Esperanto in a first step. In a second step, these sentences are translated from Esperanto into German. Likewise, English sentences can be translated into Esperanto in a first step, and then the resulting sentences in Esperanto are translated in a second step. The important feature of this system is that all source language sentences have to be translated into Esperanto first, and then the Esperanto sentences must be translated from Esperanto into the target language sentences. Even if other languages were added, translation would have to be performed in this way.

have been established for German, for English, and for Esperanto respectively. In a next step, the English and German sentence patterns have had to be mapped to Esperanto sentence patterns, and Esperanto sentence patterns have been assigned to English and French sentence patterns respectively. If the system were to be expanded, for example, by including French, the sentence patterns of French would have to be determined and then mapped to Esperanto sentence patterns, and Esperanto sentence patterns would have to be assigned to the French sentence patterns first.

The method of sentence patterns has not been used anywhere else either. In fact, Esperanto sentence patterns have not even been defined at all, neither in Esperanto grammars nor in other linguistic papers nor in other papers on machine translation, and therefore they had to be devised from the beginning in this paper. Thus, also the Esperanto sentence patterns themselves were defined completely from scratch.

Sentence patterns give the structures of possible sentences in a language. Every language has its own set of sentence patterns, and, of course, these sets are different for each language. Even if a given sentence pattern exists in two or more languages, it is not at all understood that they correspond to each other. Therefore the sentence pattern has to be looked up and examined for every single sentence. This has not been done anywhere else either.

For establishing the sentence patterns of a given language, it is necessary to find out the valences of the main verbs, as they are defined by Tesnière. A verb may or may not take certain complements, as for example a subject or a noun phrase in the nominative, one or more objects in the accusative or in the dative, adverbs of time, adverbs of space, and the like. There are optional and obligatory complements, and they can be stated for every single verb in a given language. If optional components of a given verb are missing in a sentence, the sentence is still correct. If an obligatory component has been dropped, this omission results in an incorrect sentence.

The obligatory components of a given verb determine the sentence patterns a certain verb may take.

In cases where the main verb is a linking verb, it may also be necessary to look up the valences of adjectives. This has to be done by means of a dictionary, and in that dictionary, the valences of the verbs and the adjectives must also be noted. For simplicity, only main clauses are treated in this paper, but it is possible to treat compound clauses by exactly the same method.

done for translating from German into Esperanto and Esperanto into German. German was chosen because German has the greatest number of sentence patterns, but the process is the same for any language pair of Esperanto and another language. In a following section, the process of translation is shown for these selected patterns, especially the way in which the sentence components are assigned to each other. Again, this is done for Esperanto to German and German to Esperanto.

This algorithm is easy to understand and can be programmed relatively easily. In this paper, main clauses were treated, but it is possible to expand the algorithm without problems by defining the sentence components either to be word groups or subordinate sentences that may be treated in the same way as the main clauses. Likewise, the additional information of the words can be entered into dictionaries. (Hrandek 2000b).

As has been shown above, the translation system would not work without dictionaries. Essentially, for each language, including the interlingua, the system requires a monolingual dictionary containing additional information to each word. In the case of translating between English and German, three dictionaries are needed, one for English, one for German, and one for Esperanto. Furthermore, four bilingual dictionaries are necessary: one from English to Esperanto, a second from German to Esperanto, a third from Esperanto to German, and a fourth from Esperanto to English. These contain words and sentence patterns of each language assigned to their Esperanto counterparts.

1.3 A Survey of the Paper

In the first chapter, different techniques of machine translation and examples of machine translation systems working by the interlingua method are discussed briefly along with their corresponding interlinguas . The second chapter deals with Esperanto and gives its advantages and disadvantages for machine translation. Likewise, arguments are given why it is used for Intrling. In contrast to other artificial languages, Esperanto resembles a natural language, i. e. a Romance language, and can be learnt and remembered easily In most bigger cities there are groups teaching it to beginners, e.g. to the engineers who will have to maintain the system. Second, in contrast to most natural languages, Esperanto is a highly regular language with very few ambiguities that can also be eliminated relatively easily.

A disadvantage is that speakers of other than Indo-European languages may have problems to learn Esperanto. Furthermore, its logic does not necessarily agree with predicate logic, i. e. the

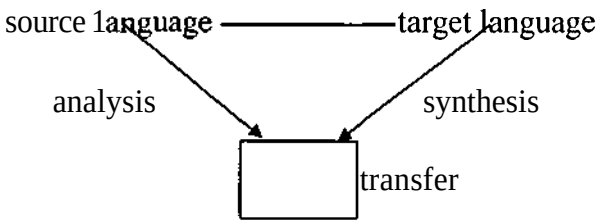
section, the process of translation is shown for these selected patterns, especially the way in which the sentence components are assigned to each other. Again, this is done for Esperanto to German and German to Esperanto. In the following section, an overall algorithm is given.

A later chapter deals with various possibilities of expanding the algorithm as well as advantages and disadvantages of machine translation. Finally, some open questions in machine translation are discussed.

In an appendix, translation tables, and translation matrices for all sentence patterns of German, English, and Esperanto are listed.

may also be analysed semantically. With transfer, these analysed source language sentences and words are 'translated' into the target language, an intermediary language, or some other kind of representation, depending on the technique that is used. With synthesis, correct target language sentences are generated.

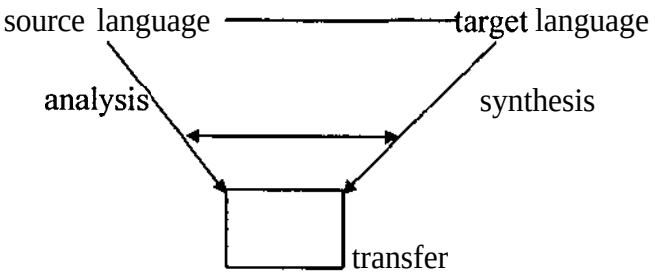
With **direct translation,** pairs of languages are taken and translated. Analysis is performed completely. After transfer, synthesis takes place. For each language pair, separate procedures and programmes have to be written.



(Hrandek [1997b])

With the **transfer approach** analysis is not performed completely. Sentences or parts of sentences may be represented by some formalism that makes transfer from one language into the other easier. There are transfer rules at earlier stages than would be with direct translation, and ad-hoc transformations may occur that may or may not be backtracked later. Transfer rules may be true for one or more languages, so the system need not necessarily be bilingual. Very often, Artificial Intelligence techniques and formalisms are employed together with transfer approach.

In the **interlingua approach** translation is performed with the help of an intermediary language. This means that analysis is not performed fully, but at the level of the interlingua.



(Hrandek [1997b]

With the **interlingua approach** analysis is not performed completely either. In contrast to the direct and transfer approaches, however, the interlingual approach is a two-stage process that maps the source-language sentence into a language independent representation from which the target language sentence is generated. There are no transfer rules or ad hoc transformation rules. Instead, the syntactical and lexical-semantic translation routines map the interlingua systematically to the surface structure and vice versa. Traditionally, the interlingual approach

2.2 *Classifying the Interlingua*

There are several possible ways of classifying intermediary languages for machine translation One possible way of classification of interlinguas according to their relation to the languages to be translated was performed by Andreev. Another way of classification taken up in this paper is to find categories according to the origin of the interlingua and the possible structure, categories that are partly derived from Weaver's memorandum.

2.2.1 Andreev's approach

Andreev belonged to the university of Leningrad (ELMP) and did much theoretical work about machine translation and interlinguas. For these, he found three categories:

- A-priori languages
- A-posteriori languages
- Mixed relations

2.2.1.1 A-priori Languages

A-priori languages are interlinguas that are fully independent from the languages to be translated. That means that their properties are in no way predetermined by the other languages in the system.

Their advantage is that semantic analysis of the text is thus guaranteed.

They can be subdivided into two categories:

- Natural languages
- Logical languages

2.2.1.1.1 Natural Languages

Natural languages like Russian can theoretically be used as interlinguas. There would be no need to construct any artificial language, as natural languages are 'ready-made'. Their disadvantage is that the problems inherent in machine translation as stated by Weaver are in no way solved by using them.

forms. In any case, Basic English must be modified for machine translation purposes. If it is too much simplified, however, it may become an **a-posteriori** language.

2.2.1.3.2 Grouping Interlinguas

Grouping **interlinguas,** make use of the relationships and similarities of the languages to be translated. In this way it can be regarded as a minimalist approach. **(Andreev** [1967], pp. **4ff)**

2.2.2 Classification According to the Origin of the Language

For classifying languages according to their origin, the first distinction can be made between natural and artificial languages. Artificial languages have been constructed by man in order to facilitate communication between members of different language communities or in order to support language processing for computers.

Natural languages can be classified in those that have not been modified, as **Andreev's** proposed Russian as an **interlingua,** and the ones that have been modified. Modified languages can be subdivided into those that have appeared as a result of close contact between two or more languages, as for example Pidgin English or Creole. This means that they have been modified in a natural way. On the other hand, natural languages may have been constructed explicitly for certain purposes, as for example machine translation, and used as controlled languages. These can be regarded as artificially modified languages.

Artificial languages can be subdivided into artificial auxiliary languages that were used for communication even before computers existed, as for example Esperanto, **Interlingua**[1], or **Volapük**. Since they have been developed from natural languages explicitly for communication, and, as in the case of Esperanto, have also been used for discourse in the same way as any other natural language, they will be designed as naturally modified artificial languages.

Completely new languages, however, definitely constructed for **a** specific purpose, will be considered as artificially modified artificial languages. In many cases, it is not even possible to use them for communication. They can in turn be subdivided into those laying emphasis on syntactic structures and those stressing semantical representations. In this latter group fall

[1] In this context, Interlingua is referred to an artificial language in its own right invented in the 20th century **(1922)**. This auxiliary language has nothing to do with the interlingua approach in machine translation.

forms and words by decree. These languages were used mainly for speech and exclusively for communication between people. Again, there is no project that makes use of pidgin languages as interlinguas, because they have still many features of natural languages like ambiguity in vocabulary, even if the syntax is very simple.

2.2.2.1.2.2 Controlled Natural Languages as Interlinguas

The idea to simplify an existing natural language in order to make it accessible to and usable for the largest possible number of people worldwide arose in the 1930s. A number of influential linguists and scholars devoted considerable effort to establishing a 'minimal variety' of English. *Basic English,* as it was called, differed from previous attempts to construct universal languages in that it was a perfectly well-formed part of English, rather than some entirely artificial or hybrid construction, like Esperanto. One of the central ideas of the Basic English movement was that the number of general purpose words needed for writing anything from a simple letter of receipt to a major speech on the world economic situation could be a few hundred rather than the 75000 upward words available to the skilled native speaker. This lexical economy was to be achieved in part by using 'operator verbs' with the set of nouns and adjectives to stand for the vast number of derived verbs, which are frequently used.

The authors of Basic English explicitly recognised that the dictionary would need to be extended with special terminology for scientific and technical writing. However, even if a text contained terminology specific to a certain subject field, the general language component of the text could be perfectly well accommodated with Basic English. The important point remains that, for writing in a particular subject field, nothing else is needed but the Basic English dictionary and a relatively small technical vocabulary of the subject field. (Arnold, node 70, p. 1)

2.2.2.1.2.2.1 Mechanical Pidgin

The group of the Cambridge Language Research Unit (CLRU) developed one of the first versions of such a 'pidgin' interlingua for machine translation purposes. They called it Mechanical Pidgin, and it was supposed to solve the problem of polysemy, i. e. multiple meanings of one word. The idea was to develop a crude prototype of an interlingual system producing 'pidgin' (essentially word-for-word) translation, and the development of a complex sophisticated tool for improving and refining the lexical expressions of unsatisfactory machine

texts, even for native English readers. Second, controlled languages produce better results with machine translation than uncontrolled languages.

The reasons for controlled languages' superiority in machine translation performance are easy to understand. First, the restricted vocabulary means that fewer words need to be added to the machine translation system dictionaries and more effort can be put into getting the entries which are required right. Second, the grammar component of the system can be tailored to handle all by having to deal only with those constructions which are licensed by the controlled language specification, a specification which excludes the most difficult and ambiguous constructions anyway.

Using a restricted pool of words and terms also means that the system dictionaries can be tailored (by machine translation suppliers or the responsible translator) to cover exactly that set of words and their translations. Being consistent about the use of terms will also help to improve the overall consistency and the quality of texts being translated. After all, one of the simplest and most direct benefits of machine translation for technical texts is that terms are always translated consistently because they are simply looked up in an electronic bilingual term dictionary. (Arnold, node 70, pp. 1f)

The best known example is the controlled English of Xerox company, Multinational Customised English (MCE), which has a restricted vocabulary of 3000 words and rules for writing unambiguous English. It was found that such steps not only improved the performance of machine translation systems, like for example SYSTRAN, but also the English of the authors of technical manuals. Fears that MCE would be a kind of pidgin English proved to be unfounded. Restricted languages are used for several machine translation systems, for example METEO, SMART, and TITUS. (Hutchins [1986], p.293)

2.2.2.1.2.2.3 Simplified English (SE)

Recently, the results of a study examining the effects of a restricted language called Simplified English (SE) have been published (Spyridakis [1997]). Simplified English is one of several restricted language standards that have been developed to reduce ambiguity and provide greater consistency and readability in technical documents. Thus, these documents are easier to read and understand, and easier to translate accurately into other natural languages. Simplified English was designed to be applied to both procedural and descriptive writing, but in practice it has primarily been applied to procedural technical documents.

that SE especially supports translation between Indo-European languages. (Spyridakis [1997], pp. 4f) Although it does not seem to have been tested with machine translation, there is evidence that it may be used also for this purpose, since synonymy and ambiguities are avoided and the writing rules are relatively strict. In any case, this example proves that controlled languages are currently constructed and used.

2.2.2.2 Artificially Modified Natural Languages as Interlinguas

The idea of interlingual machine translation was put forward by Weaver's memorandum in 1949. Researchers were fascinated by the centuries-old notion of a 'universal language' and by the practical advantages of translation via 'intermediary language' in multilingual environments. At the Cambridge Language Research Unit (CRLU) the idea of a basic universal set of primitives were tested along with the Thesaurus approach. The Milan group investigated in depth an interlingua which was intended to be a direct representation of 'conceptual relations', completely independent of any language, and was explicitly not based on universal or common linguistic features. Different conceptions of an interlingua were presented by the Soviet researchers Andreev and Mel'chuk. Mel'chuk suggested that an interlingua should be the sum of all features common to two or more languages. Andreev proposed an interlingua which would be a completely artificial language with special lexicon and syntax, based on the most frequent common features of the languages under consideration. Others suggested the use of one of the artificial auxiliary languages, such as Esperanto or Interlingua. (Hutchins [1986], p. 171)

2.2.2.2.1 Auxiliary Languages as Interlinguas

Although the idea of using an artificial auxiliary language has been put forward on several occasions during the history of machine translation research, a system with such an auxiliary language as an interlingua was implemented only relatively late. The use of auxiliary languages was proposed by Weaver first, and later by Bar-Hillel, among others. The most common choice has been Esperanto, since it is most widely accepted. Esperanto's supporters claim that it combines the regularity, consistency, and 'universality' required for a machine translation interlingua with the flexibility towards new technical and scientific vocabulary which is the attribute of a 'living' language.

Despite these obvious attractions, Esperanto has rarely been studied in machine translation projects. A. P. M. (Toon) Witkam, a senior consultant at the Buro voor systeemontwikkeling

Analysis of semantic relation as such was introduced by the analysis of logical relations (predicates, arguments, attributes), but this cannot be separated from syntactical analysis really. The thesaurus approach of the Milan group was conceived as an alternative to syntax-based approaches. However, the analysis of lexical sense relations (synonymy, paraphrase, causation) and lexical decomposition has generally appeared only in systems with AI approaches. 'Case frame' analysis has become very popular in the 1970s and is now a standard proven technique.(Hutchins [1986], p. 187)

2.2.2.2.2.1 Interlinguas Based on Syntax

Since the 1960s most machine translation systems have been predominantly syntax-based. One of the main reasons is that such systems are easier to process. Syntactical analysis has thoroughly been supported by linguistic theories, especially those of Chomsky, and also compiler techniques and formalisms of theoretical computer science and linguistical mathematics can be employed. Moreover, syntactical analysis was developed earlier than semantic analysis and has therefore been tested more thoroughly.

2.2.2.2.2.1.1 The Centre d'Étude pour la Traduction Automatique (CETA), University of Grenoble

The Grenoble group has been one of the most influential research groups in machine translation. It was founded in 1960 by Bernard Vauquois.

The group began research on three machine translation systems for Russian-French, German-French, and Japanese-French. This resulted in a syntactic interlingua and rigorous formalism. An early decision of this group was that machine translation could only be successful if analysis was pursued to a much 'deeper' level than most contemporary systems. It was acknowledged that at the current stage of machine translation research semantic analysis was not a practical proposition and that consequently most attention had to be paid to 'deep syntactic' analysis, and to the methods of syntactic transformation. The aim was to produce representations which would serve as the source for target language synthesis. A particular long-term emphasis of the CETA group at Grenoble was the great attention paid to the establishment of powerful algorithmic programmes based on rigorous modelling of linguistic formalisations. This emphasis led to substantial investigations of algebraic and formal linguistics concerned primarily with problems of morphology and to the development of the notion of 'sub-grammars' to increase the algorithmic efficiency of analysis programs. The key feature of

At the same time the semantically anomalous analyses were **'filtered out'** by checking the compatibilities of the constituent source language lexical components on the basis of information in the source language dictionary. Such a tree was the source for target language synthesis. **(Hutchins** [1986], pp. **190ff)**

It began with the substitution of source language lexical units in the pivot language representation by their equivalent target language units. In syntactic synthesis, units were examined for their potential word classes and for dependency relations with other word classes. First, a predicative was located and the arguments checked as possible nominal phrase dependants. Morphological synthesis completed the process by producing the correct surface form.

Unfortunately, the parser proved to be very inefficient, and only part of the input sentences were translated correctly. These disappointing results were the reason why after 1971, a **'transfer approach'** was adopted. (Hutchins [1986], pp. **192ff)**

2.2.2.2.2.1.2 Linguistics Research Center (LRC), University of Texas

The machine translation project of the Linguistics Research Center (LRC) at the University of Texas constitutes a second example of a thoroughly implemented and tested **interlingua** on syntactical basis. In 1970/71 the LRC had a series of study conferences and individual consultations of expert linguists and machine translation researchers. The major problems of machine translation were no longer computational, but linguistic. Departing from the hypothesis of a universal base of language common to all languages in the world the researchers wanted to construct a kind of universal intermediary language. Since the universal base can be used for deriving the surface structure of any language, the universal base can serve as the intermediary language between any source language and any target language. The project's aim was to develop methods of analysis and formalisms of representations which could be applied to any pair of languages.

As in the contemporary **CETA** project, the basic stages of the LRC system were:

1. analysis of source language texts into an intermediary representation

2. synthesis of target language texts from the intermediary representation

But, also like **CETA's** pivot language, the LRC interlingua was not a genuine interlingua. It was restricted to syntactic structures (universal **'deep'** structures); there was no attempt to

The understanding of a sentence or text involved, therefore, the construction of a correlational net on the basis of information about the correlational possibilities of each word, and the possible linkages among correlations, and limitations on relations within the 'notional sphere'. Translation involved the transformation of a correlational net into an equivalent net appropriate to the correlational possibilities of words and correlations of the target language.

Ceccato's method was no advance in linguistical analysis from the practical viewpoint, but it contributed to AI and gave a cognitive orientation to machine translation. (Hutchins [1986], pp. 124ff)

2.2.2.2.2.2.2 Institute of Linguistics, Moscow. Mel'chuk's 'meaning-text' model (1965 - 1976)

Igor Mel'chuk developed a Russian-Hungarian machine translation system and devised rules for morphological analysis, dictionary-searching, homograph resolution, recognition of sentence structures, and Russian sentence synthesis. Although a selective glossary was compiled, the study was concentrated on the investigation of algorithmic problems. As a consequence of this research on Hungarian, Mel'chuk came to formulate his notion of an interlingua. The problem of Hungarian word order compelled the abandonment of a word-for-word approach (which might be feasible e.g. for French-Russian or English-French) and favoured investigation of common syntagmatic structures e. g. of possession, of adjectival modification, etc. Similar investigations of many language pairs would build up a series of syntactic configurations, some common to all languages, but most common only to some. From this set of interlingual structures would be selected those needed for particular source language texts. A similar analysis of lexical differences and equivalences would produce sets of interlingual semantic units, e.g. indicating comparison, negation, 'larger than normal' size. In this view, the interlingua is the sum of all correspondences of languages involved. The subsequent development of Mel'chuk's ideas resulted in his well-known 'meaning-text' model of language and in the elaboration of a highly sophisticated machine translation model. (Hutchins [1986], pp. 137f)

In Mel'chuk's 'meaning-text' model there are six levels or 'strata' of representations: phonetic, phonemic, morphemic, surface syntactic, deep-syntactic, and semantic. The first two are unimportant for machine translation. Surface syntactic representations include such grammatical relations as 'subject-of', 'complement-of', 'auxiliary', and 'determinant', and the structure of nominal groups. The elements are the 'actual lexemes' (words) of the language.

for an interlingual system with an artificial interlingua based on semantic analysis. (Beale [1997])

Beale uses a semantical approach in his Mikrokosmos machine translation system in combination with AI algorithms. He especially employs the Hunters and Gatherers algorithm, which makes use of dependency information, to partition problems into appropriate sub-problems. The results of these sub-problems are then combined (gathered) by means of new synthesis techniques and pruned (hunted) by means of branch-and-bound techniques. Furthermore, an independent model of the world, the *ontology* is set up. The results of the analysis of a given input is depicted by an interlingual representation, the *text meaning representation (TMR).* The lexicon provides the link between the ontology and the TMR. In this lexicon, the meanings of most open class lexical items are defined in terms of their mapping into ontological concepts and their resulting contributions to TMR structure. The meaning of the input is represented in the TMR as elements of an independently motivated model of the world or ontology. (Beale, node [26]).

2.2.2.2.2.2.4 Dorr's UNITRAN MachineTranslation System

Another example for machine translation systems is the contemporary UNITRAN Machine Translation System. UNITRAN stands for UNIversal TRANSlator, that is, the system serves as the basis for translation across a number of various languages, not just two languages or a family of languages. The system has been implemented for translating English, Spanish, and German at the basis of a lexical-semantic translation. (Dorr [1993], p. xv).

The primary features that make this approach interlingual are that it relies on a language-independent underlying form and, furthermore, it makes use of a single, parameterised mapping between this representation and the syntactic structure of all three languages, i. e. German, Spanish, and English. The underlying form that is used in UNITRAN is based on lexical conceptual structure(LCS). Parameterisation of the translation mapping is achieved at two processing levels, syntactical and lexical-semantic; the former concerns the surface form and the latter concerns the properties of the lexical items. (Dorr [1993], p.2)

By relying on abstraction and compositionality to drive the translating process, the system is able to produce a translation that is not a literal word-for-word replacement of the source-language sentence. (Dorr [1993], pp. 13f)

		Model		implemented
		TMR	Steve Beale	Mikrokosmos
		LCS	Bonnie Dorr	UNITRANS

Most of the implemented machine translation systems were designed for translation between Indo-European languages. There are exceptions, for example the French-Japanese translation module of the CET A group, but they are few and far between. There are attempts, however, to write machine translation programs working with the interlingua method with Asian languages, as Chinese, Japanese, Indonesian, Malayan, and Thai. (CICC [1994], pp.2f) There, the interlingua depends on the language, but is not really specified in the text. Pre-editing and post-editing are possible in this system. (CICC [1994], pp. 6f) However, these systems do not constitute the majority.

The ideal interlingua works completely independently of all languages that may have to be processed in the machine translation system. It is doubtful, however, if such an ideal interlingua really exists or can ever be constructed. Most probably, it is not possible to construct one interlingua for all languages in the world. (Hrandek [1997b])

important component of the feasibility study was therefore an examination of modifications which were necessary to enhance Esperanto's suitability as a machine translation interlingua.

Remedies for some of Esperanto's known deficiencies are already available. Ambiguities, also those of prepositional phrases can be avoided; with the prescription of word order (subject predicate object), the introduction of new function words and the inclusion of special markers to indicate the antecedents of pronouns and the scope of co-ordinators, and the constant use of punctuation.

A more serious defect of Esperanto, which cannot be so easily overcome, is the lack of technical vocabulary. Esperanto permits national speakers to coin their own specialised terms; there is no standardisation. The DLT project is taking a 'pragmatic' approach, adapting a form common to at least two of the languages, English, French, and German. In effect, the project is building an interlingual dictionary for international technical terms from scratch, with all dangers of pragmatic ad-hocness. (Hutchins [1986], pp. 287ff)

Since the DLT system is fully interlingual, in lexicon as well as in syntax, and the interlingua 'modified Esperanto' at the centre is not an abstract representation but a regularised language, source language analysis and target language synthesis represent in effect two 'translation systems': from source language to Esperanto and from Esperanto to the target language. Although described as an 'interlingual' machine translation system, DLT is, as Witkam readily acknowledges, in fact a network of bilingual machine translation systems with 'modified Esperanto' at the centre. Only the economies of a full multilingual system can justify the added complexity.

Each bilingual machine translation system comprises a separate set of analysis and synthesis programs. Witkam has intended the system for conversion of source language texts into Esperanto texts as versions of 'direct' translation systems, while the systems converting Esperanto texts into target language texts are basically designed on the 'transfer' principle. The source language Esperanto 'direct' systems are semi-automatic, operating via computer interactions. The 'direct' translation strategy is evident from the explicit orientation of source language analysis to the lexical and structural features of the Esperanto interlingua.

The Esperanto target language 'transfer' systems are fully automatic. Most attention is paid to the details of the more regular syntax and morphology of the 'modified Esperanto' interlingua and the ATN formalisation. Translation is performed in three stages:

Esperanto is widely accessible and used as a human language of communication throughout the world. (Witkam [1983], p. xii) This means that there are groups who teach and use Esperanto in most bigger cities, and even if somebody lives far away from such a city, there are correspondence courses at relatively low cost, so that practically everybody has access to this language. Most members of the Esperanto community will be happy if somebody is interested in the language and will provide any kind of help a beginner may need.

There are specialised journals and organisations, a developed network of national and international organisations, a wide range of literature, relatively wide instruction (sometimes state-supported), large periodically occurring international events, regular radio programmes, and clear social and political distinctions in the already formed language community and its linguistic reflection. Furthermore, there are an independent youth movement and a certain evolution of self-supporting cultural elements linked to the language community. In some cases bilingualism (involving a natural language and Esperanto) of children can be found, most often in international families. (Blanke D. [1989], pp. 69f)

The phonological orthography, the mainly agglutinative morphology with isolating properties, the modern Romance quality of its basic material (about 70%), the autonomous and very elastic system of derivational word formation and at the same time the possibility of assimilating international words, and the regular grammar have in practice proved sufficient for relatively easy learning and application compared to other foreign languages.

The main structural property of the language is the unchangeability of its phonemes and morphological elements, and their relatively easy combinability in syllables, words, and syntactic units. The practical application over a hundred years in an increasing number of areas and countries has led to a language capable of producing more and more nuances. This has taken place in a field of tension between diversifying forces (for example, ethnic influences and different communicative needs for the users) and unifying forces (increasingly international applications). A sufficiently codified norm has developed and become stable.

Esperanto is characterised by all properties which are observable in practice in human language - the development of polysemy, homonyms, synonyms, specialised vocabularies, styles, and levels of language. Nevertheless, the fact that the main communicative goal of the language and its practical application are to serve internationally as a means of communication among people with different parent languages, has led to a particular awareness of norms which are more closely controlled, controllable, and subject to conscious influence than in ethnic

Furthermore, since there are practically no exceptions to the relatively simple rules, no additional storage space on the computer is required, as it would be if the interlingua were a natural language If an algorithm works for one paradigm, it will also work for all the others of the same kind, thus reducing the costs of programme development.

Esperanto is Indo-European in structure, but by the fact that there are no such things as conjugations of verbs or declinations of nouns, with the only exceptions of the plural ending *-j* and the accusative ending ***-n***, its structure comes close to that of isolating languages and possibly also agglutinating languages. This means that also the grammars of those can be mapped onto the grammar of Esperanto relatively easily.

Besides, by the usage itself the language is formed. As has been mentioned already, the vocabulary of the language has been taken from Romance languages, and, even when the language develops, elements of the existing language are used. This means that by this permanent and frequent practice, Esperanto has developed certain statistical properties. For example, certain general words occur more frequently than others, and some particular letter combinations, as for example *as*, *is*, or *os*, appear more often than for example something like *ss* or any other double consonants which do not exist in Esperanto. In this way it behaves like any other natural language, which facilitates learning of the language.

Although Esperanto is a planned language, it can be treated as a natural language in many ways. It can be learned easily, there are enough speakers of Esperanto and Esperanto language courses for those who have to learn the language. Books of instruction, grammars, and dictionaries are available in most languages all over the world. Due to its regular grammar and structure, it can be used as an interlingua for machine translation systems.

3.2.2 Disadvantages of Esperanto

Unfortunately, there are not only advantages to Esperanto as an interlingua. Indeed, there are some serious disadvantages to that language that have to be treated in some way or other. Esperanto certainly has to be modified, before it can be used for computer processing.

One shortcoming of this language is that it has no proper logic. It is simply not defined, which means that it will have to be determined specifically for the translation system. In Zamenhof's days there was no need for mapping mathematical logic onto the language, but for the computer it is strictly necessary. For example, the exact ranges of the Esperanto ***kaj*** (and) or ***vel*** (or) are nowhere given in the Esperanto grammar. For this reason, it is not quite clear if

Another drawback appears when syntax is considered. Indeed, syntax is never referred to in the *fundamento*. Obviously, sentences are supposed to come quite naturally, without having to set up rules for them. This may be true for speakers of Indo-European languages, but certainly not for members of other communities. They have to learn some definitions at least. Furthermore, if Esperanto is to serve as an intermediate language for machine translation, then sentence patterns have to be defined. To date, sentence patterns have neither been defined in the *fundamento* nor treated in traditional Esperanto grammars. For machine translation, however, they will have to be created, and they have been invented nearly from scratch in this paper. Although great care was taken to maintain Esperanto's original structure and Esperanto's characteristic features, the sentence patterns were somewhat redefined. These sentence patterns together with the valences of the verbs make up the key for translation.

3.3 *A Short Grammar of Esperanto*

For formulating Esperanto sentence patterns, Esperanto's grammar has to be discussed first. Whenever it was possible, this grammar was taken into consideration. With the help of this grammar, similar sentence patterns of German and English as well as several already existing texts and grammar books, the sentence patterns were created. At this stage, only sentence patterns of simple main clauses were considered, although these sentence patterns can easily be expanded into more complex clauses, if this is necessary. In a first step, the *fundamento* as the traditional grammar is given.

3.3.1 The Fundamento

The sixteen rules *of the fundamento* set up by Zamenhof in 1887 constitute the basis of the grammar of Esperanto. They define the main part of the Esperanto grammar. For linguists these formulations may seem vague and not at all clear, showing that Zamenhof himself was no linguist. His intuitive formulation of the language, however, showed good results, so that Esperanto is an artificial language used all over the world by a great variety of speakers. Some people have even been taught Esperanto as their second native language. Although Esperanto is a language in use nowadays, and although by this use certain conventions have been agreed upon by the different speakers all over the world, these sixteen rules of the *fundamento* have never undergone major changes. Therefore, the sixteen rules will be cited as a basis:

1. *LA* is the definite article. It is invariable. There is no indefinite article.

13. For referring to direction the accusative is used.

14. The meaning of the prepositions is unambiguous. If they are to be used metaphorically, a substitute preposition *JE* is added.

15. Words coming from different languages are adopted after adapting them to the language orthographically.

16. The end vowel of nouns or articles may be omitted and replaced by an apostrophe. (Gledhill [1998], p. 9)

Although lexically Esperanto resembles other Latin-based languages, these rules demonstrate a wide variety of influences, including a relatively Slavic morphology and innovations such as the explicit signalling of word class. Some rules were very specific in scope, aimed at speakers who might be tempted to use double negation, as in French, or cases after prepositions, as in German, or to use some form of indefinite article, as in English. Others offer useful redundancies: rule 14 allows speakers to avoid specific prepositions and shifts the role of the accusative to that of 'marked' or object case. Rules 11 and 15 allow for different vocabulary to develop in parallel. And rule 16 was written specifically to allow writers and poets to vary stress patterns.

One of the most original aspects of the language is the relative freedom to write and speak without the constraints imposed by a 'native' language community. After several years of debate Zamenhof and his followers agreed a convention in 1905 essentially sanctioning the use of 'unofficial' forms as long as they did not contravene the Sixteen Rules and the 900 basic words of the first dictionary which were declared as 'untouchable'. Esperanto's pattern of usage emerged more fully in Zamenhof s writings and speeches as well as the many publications by prominent contemporary members of the Esperanto movement who began to experiment with the language. The emphasis on consensus has led to organic developments in the language, since no innovations can be imposed or prevented.

Esperantists are above-average linguists and this engenders considerable debate on language issues within the movement. National and bilingual dictionaries as well as the teaching materials which have been developed in the various national languages are perhaps the most influential disseminators of Esperanto, and the conformity of these materials accounts for the degree of homogeneity that exists within the language. (Gledhill [1998], pp. 9f)

In this case, we have a necessary and sufficient condition. For example, the theorem of Pythagoras $a^2 + b^2 = c^2$ constitutes such a sufficient and necessary condition, and it is valid in both directions.

This question is nowhere discussed in grammar books on natural languages. Likewise, no grammar of Esperanto treats this problem. Thus it is legitimate to say that the logic of conditional clauses is not exactly defined. Mathematically there are three kinds of conditional clauses, whereas in most languages these are mapped to one and the same structure. It seems that the kind of information that logical sentences convey in this context has to be found in the speakers' knowledge of the world. **(Hrandek [1999/2000])** It is true that this question is not very often treated with other natural languages either. However, they have been investigated for German **(Menne [1993])** and English (Marcus **[1967])**.

3.3.3 Esperanto Syntax

Although the basic morphology and lexicon were set out in explicit terms by Zamenhof, the syntax was essentially left open to interpretation. Syntax is not defined in **the *fundamento*,** and if grammarians want to make statements about it, they have to resort to large corpora. This was done by Christopher **Gledhill** who studied **156** texts of many kinds with about **312** 130 words. (Gledhill, **[1998])**. It is often assumed that Esperanto reflects the different native patterns of syntax of its speakers, not least because word order is said to be **'free'**. This means that due to the conjunction of the systems of the different donor languages Esperanto's syntax cannot be described as Germanic, Latinate, or Slavic, although these are the main influences for particular forms of expressions.

There are two reasons for this. Firstly, a tolerant stylistic consensus was consciously manufactured within the community itself. Secondly, the streamlining effect of certain universal principles (as proposed by the theory of universal grammar) may serve to generalise any conventions that were established. A similar process has taken place in the formation of Creoles.

Thus it is impossible to talk about fixed syntactic rules in Esperanto. Each attempt to set up sentence patterns must remain an attempt, a somewhat arbitrary working definition. This may be a reason why Esperanto is said to be so flexible. On the other hand, it is not possible to use Esperanto as an interlingua without such terminology, since sentence patterns are the basis of this method of machine translation.

languages as mother tongues. If Esperanto is to be used as an interlingua for machine translation, its syntax has to be defined in a far more precise way than by the *fundamento*.

Obviously, finding out what kinds of sentences in Esperanto are correct and which ones are wrong is also a question of language psychology, not only of grammar. This may do for every day language, where no hard and fast definitions are needed. Indeed, many speakers of Esperanto even seem to like this feature that nothing is defined clearly. They consider the language to be open and flexible and feel that strict definitions would restrict them in their ways of expression. Apparently, they like this freedom of use that the missing definitions imply.

This fact may appeal to human speakers, but it is not possible to avoid definitions when the language is used as an interlingua for machine translation. In this case, rules have to be defined, otherwise the language could not be processed by a computer. Therefore definitions had to be made to enable automatic processing, even if the language is otherwise very flexible for human speakers.

For designing the interlingua, the sentence patterns had to be established with respect to the most common usage. Thus the sentence patterns of Esperanto may have been formed somewhat arbitrarily, with the help of texts and the Vienna Esperanto group, especially of Mrs. Helga Farukuoye, who offered me invaluable help and advice. Starting point for these sentence patterns are the valences of the main verbs. On these the various obligatory and optional complements of a sentence depend. The valences of verbs will be treated in one of the following sections.

The sentence patterns had to be defined completely new, with the help of Esperanto grammars, especially the descriptive grammars of Gledhill and Mayer, Esperanto texts, and German and English sentence patterns. They are by no means complete, but an attempt to define Esperanto's sentences in a way that they can be processed automatically. In this paper only simple sentences are treated, but, as has been shown above, it is also possible to generate and process more complex patterns by the same method.

For this purpose, a function δ‘ from Q x Z* to Q. δ‘(q,w) is the state of the automaton after reading *w*. In other words, δ‘(q,w) is exactly state *p* for which there exists a path from *q* to *p* marked by *w*. This can be defined formally as follows:

Definition 3.2

1) 5<(q,e) = q

2) For each string *w* and each input symbol *a*

$$\delta'(q,wa) = \delta(\delta'(q,w),a)$$

(1) says that the finite automaton cannot change the state without reading an input symbol and (2) shows how to find the state after reading a non-empty string *a*, i. e. by determining state δ‘(q,w) after reading a non-empty string *w* and calculating state δ(p,a).

Definition 3.3

A string *s* is called **accepted** by the finite automaton M = (Q, Σ, 5, q_0, F), if b(*qo* ,x) = p for a state *p* from F. The language **accepted by M** called L(M) constitutes the set {x| 5(*qo* ,s) ∈ F}. A language is called **regular or regular set** if it is the set accepted by a finite automaton. (Hopcroft [1994], pp. 16ff).

If there is a state having no successor states this state is called a terminal state. An automaton has one starting state, but may have an unlimited number of terminal states. There may, for example, be one or more terminal states for success and one or more terminal states for failure of a certain process or course of events.

4.2 Augmented Transition Networks

With augmented transition networks it is possible to collect the features of sentences and syntagms as they are parsed. Thus, one particular noun phrase of a given sentence can be identified as the syntactic subject, whereas another one can be determined as the syntactic object of the verb. Within these noun phrases other structures may be found, as for example determiner structure, adjectives, the head noun, etc.

With *transition networks* a grammar can be visualised easily. They consist of *nodes* and *labelled arcs.* Each arc is labelled with a word category. Starting at a given node you can traverse an arc if the current word in the sentence is in the category on the arc. *Recursive transition networks* are like simple transition networks except that they allow arc labels that

even complement clauses. (Gledhill [1998], p. 60) Thus it is possible to speak of the valences of adjectives.

The usual structure of an Esperanto adjective phrase is:

AP → (SPECIFIER) ADJ (COMPLEMENT)

Adjectives precede nouns in German and English. In these languages it is not possible that the noun is followed by an adjective. Most of the time, the nouns are preceded by adjectives also in Esperanto. Although adjectives may also succeed the noun, this does not happen often. As this feature will not be used together with English or German sentences it can be neglected altogether.

Adjectives may be specified by adverbs. These always precede the adjectives. It is possible to join two or more nouns, adverbs or adjectives by conjunctions. These adjectives always depend on one or more nouns, and the adverbs in turn depend on one or more adjectives.

4.3.1.2 Determiners

Determiners may be definite or indefinite articles, numerals, demonstrative pronouns, indefinite pronouns, or possessive pronouns. In Esperanto, as in German and in English, it is possible to place a prepositional phrase between the determiner and a noun.

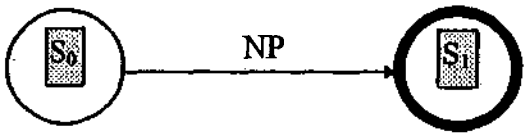
4.3.1.3 Articles

In Esperanto, the invariable definite article **la** is used when the head noun is modified by a prepositional phrase, but it is not often used when the prepositional phrase is a complement and not a modifier. With plural forms and nouns modified by a prepositional phrase the zero article is used. There are no indefinite articles in Esperanto. To indicate vagueness, indefinite pronouns like ***kelka / several***, ***certa / a certain***, ***iu / some***, may be used. These forms are considered determiners, because they exclusively specify the noun. No other determiners can be used alongside with them. The correlatives ***kia / what kind*** *of* and *ia* ***/some*** *kind of* are also used in this way. The most common determiners ***(tiu, kiu)*** act as specifiers, signalling selection of reference between the noun phrase and others in the immediate context. (Gledhill [1998], pp. 58f) Determiners depend on one or more nouns. In some cases they can also be joined together by conjunctions, but it is not possible to specify them by adverbs.

This means that a typical noun phrase may start with a personal pronoun, a noun, or a determiner and a noun. If there are adjectives, they must precede the noun they refer to, and, if there are determiners, the noun must succeed the determiners. A noun phrase may consist of a simple noun group, but it may also contain several nominal groups connected by conjunctions or commas.

If entire sentences are considered, they usually start with a noun phrase. Here, the grammatical categories serve as transitions between the different states. This means that these categories constitute the linguistic unit of these augmented transition networks and also serve as terminal symbols. In this way, also the sentence patterns will be represented.

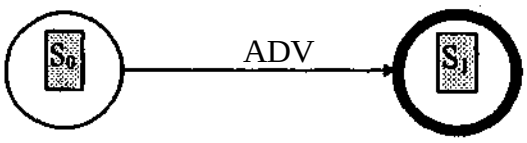
Subsequently, a simple noun phrase is depicted.



This means that from a given starting point So a noun phrase leads to an equally predefined successor state S_1. Of course, this cannot be the final state of a sentence, but of the noun phrase it is.

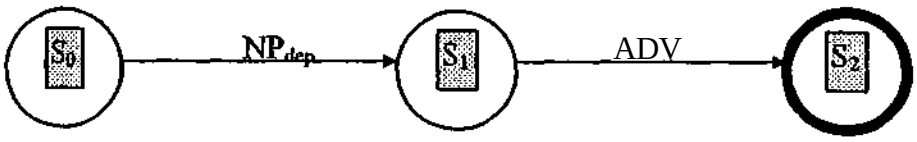
4.3.2 ADVERBIAL PHRASES

An adverbial phrase may be implemented either by a simple adverb or by an adverb with a dependent noun phrase. In the latter case the noun phrase fully depends on the adverb, which in turn may require its valence. In the following augmented transition network, an adverbial phrase with a simple adverb is depicted.



It is also possible that a noun phrase depends on a given adverb or adjective. This noun phrase provides extra information for the adverb, as for example in the sentence *He throws the ball two meters away*.

In the following augmented transition network, an adverbial phrase with an adverb with a dependent noun phrase is depicted.



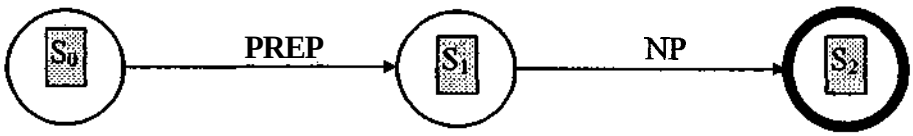
prepositions are involved in two basic sentence functions: adjuncts and indirect complements. (Gledhill [1998], p. 66)

4.3.4.1 Adjuncts

The preposition and its phrase have an adverbial function, modify the verb or the clause and can often take any position in the sentence. Rule 13 indicates that direction is expressed by the accusative-n, a similar function of the accusative in a number of Indo-European languages, and this usage only affects adjuncts. In some cases one and the same preposition has two different meanings and requires two cases, as with prepositions designating place or direction in Esperanto.

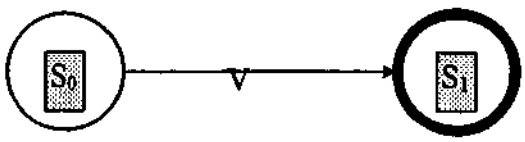
4.3.4.2 Indirect Complements

The preposition and its phrase are complements of the verb, i. e. are determined by the choice of the verb, and are somewhat more fixed in position. One property of an indirect complement preposition is that it can not be used as a prefix to a verb. (Gledhill [1998], p. 67) In Esperanto grammars for German speaking students of Esperanto, the preposition *de* may mark a genitive modifier or genitive object, whereas the preposition ***al*** is supposed to mark dative modifiers or objects.

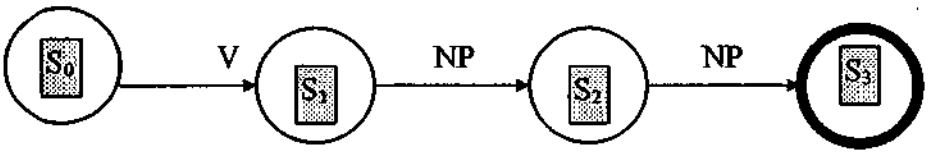


4.3.5 VERB PHRASES

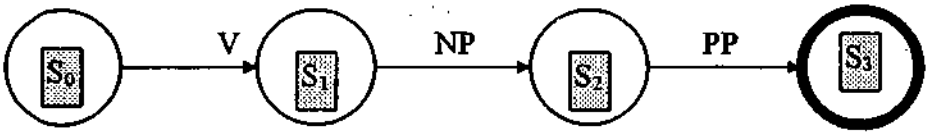
Verb phrases form the most important parts of sentences. They depend on the valence of the main verb and determine to what sentence pattern a given sentence belongs. Also, verb phrases are the most varied components of English, German, and Esperanto sentences. They can be formed by a simple verb. Such verb phrases have the valence 1, which means that they require a nominative noun phrase as a subject. This subject is omitted in these ATN's. In Esperanto there are also verbs with the valence 0, which means that they have no subject or nominative noun phrase. Mostly, these are verbs referring to the weather. When they are translated into German or English, they are translated into German or English verbs with the valence 1, i. e. verbs requiring a subject.



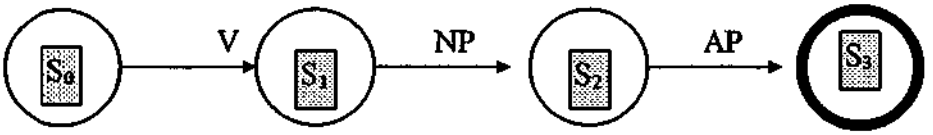
Many verbs take two noun phrases, very often one of them as a direct object, and the other one as an in direct object, i. e. a noun phrase in the accusative, or a direct object, and a noun phrase in the dative. These verbs are called double transitive verbs, since they refer to both objects equally. In most, if not all ,cases, the direct object is an impersonal object and the indirect object is a personal object. In German, also indirect objects in the genitive are possible, although these forms tend to disappear. Furthermore, in German a double transitive verb may require two direct objects. This sentence pattern is not used with many verbs and also tends to disappear. The personal direct object tends to be replaced by an indirect object in informal speech, and, when such sentences are translated, the personal object is also translated into an English or Esperanto indirect object. Verbs of this kind have the valence 3, because they also take a subject.



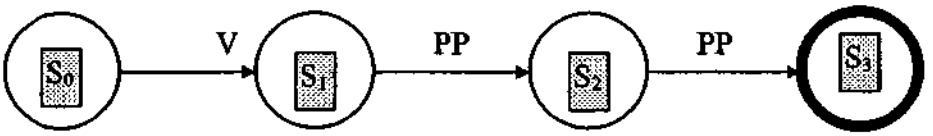
Other verbs take a noun phrase as a direct or indirect object and a prepositional phrase. Verbs of this kind are called complex transitive verbs, as they require a direct object and an object complement. They have the valence 3, because they also take a subject.



Some complex transitive verbs require a noun phrase as a direct object or indirect object and an adjective or an adjective phrase as an object complement. These verbs have the valence 3, because they also take a subject.



Certain intransitive verbs, i. e. verbs requiring no direct object, take two prepositional phrases as adjuncts. They have the valence 3, because they also take a subject.



With the verb phrases, the sentence patterns are determined. To find out the sentence pattern, a given sentence is parsed in order to find out the main verb. Then this verb has to be looked

5 Sentence Patterns and Linguistic Issues

5.1 Sentence Patterns and Translation

The most important part of the grammar treated in this paper are sentence patterns of each language. They are closely related to what is called *grammatical relations* elsewhere (Arnold [1994], node 24), but this method has not been employed explicitly yet. The grammatical relations were considered as kinds of phrases rather than complete sentence patterns, and analysis was performed at a syntagmatic level. In this way, the concept of utilising full sentence patterns for translation is new.

The translation algorithm is based on these sentence patterns. In contrast to **Witkam's interlingua** (Witkam [1983]), which is also based on Esperanto, there are no restrictions concerning the word order. With the sentence patterns and the possible permutations of the word order, there is no necessity of prescribing a fixed word order. On translation, the programme will look up the verb in the sentence, find out its valence, and thus determine the correct sentence pattern. All sentence patterns depend on the valences of the main verbs.

As has been showed above, the sentence patterns are formed by different syntagmatic components. Thus, every text consists of words that constitute the elements of syntagms, and the syntagms in turn form full sentences. They have to be grammatically correct, i. e. they have to obey certain grammatical rules. For example, the case a preposition requires and the case of the noun phrase that it takes must agree, if the sentence is to be well-formed. If these rules are not respected, the sentence in question is either rejected completely or interpreted in a way that it corresponds to an existing sentence pattern. In order to be able to evaluate the verbs and the sentence patterns fully, questions concerning the morphology of a language have to be treated. Without morphology, it would not even be possible to parse the sentences. The section on morphology was taken from an earlier paper again. **(Fütty [1997])**

5.2 *Morphology*

5.2.1 Double Articulation of Language

A linguistic system is based on units having no signification in themselves but distinctive features, namely the *phonemes.* The number of phonemes is limited in a language (25 - 50

components it requires and what optional elements it may take. According to the valence of the verb the sentence pattern can be determined.

5.3 *Syntax*

The next units formed by morphemes are *sentences,* which are investigated by syntax. In the structuralism sentences are defined as independent linguistic forms which do not depend on more complex linguistic forms syntactically. In this definition subordinate clauses are not regarded as sentences, but as parts of sentences. For example, a verb may take one obligatory direct object. This object may be a noun phrase, as for example in the sentence „I know many new words." or a subordinate clause fulfilling the function of a direct object, as for example „I know what I learned yesterday.", where this subordinate clause can also be regarded as a direct object. As this subordinate clause also has a main verb, it can be analysed in the same way as the main clause.

Thus it becomes possible to treat also more complex sentences by using the concept of sentence patterns. Again, rules must be given how to combine morphemes to sentences, there must be blueprints for them. These blueprints constitute the sentence patterns.

Sentences must be grammatically correct. This means that the form and sequence of morphemes must conform to the rules of the linguistic system. Sentences must also be acceptable, which means that they must be easy to decode. (Pelz [1996], pp. 147ff)

5.3.1 Structuralist Syntax. Constituent Structure Grammar

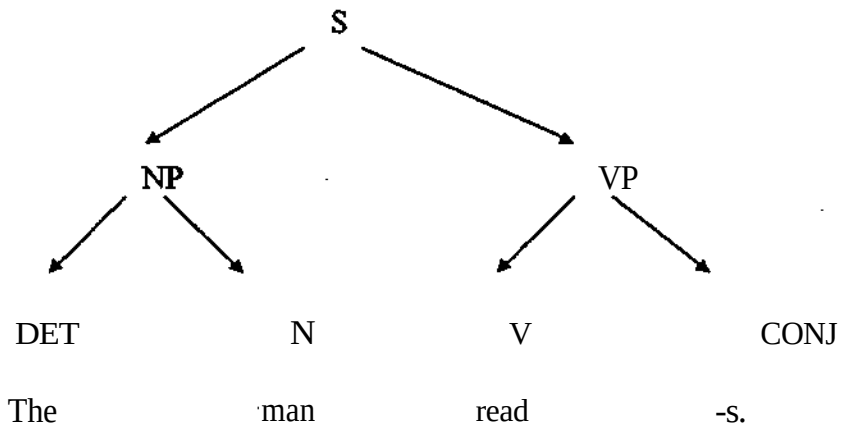
For deciding to which sentence pattern a sentence belongs, it must first be split into its constituting parts, i. e. it must be parsed. After this first step its single components are examined. Furthermore, the sentence patterns themselves must be defined for each language. For this reason, the possible structures of grammatically correct sentences must be determined and listed, i. e., the *structures* of well-formed sentences have to be considered. This can be done by structuralist syntax.

The object of structuralist syntax is to find out all the elements that constitute the sentences of the respective language system i. e. the *constituents* of the sentences, and their *structures* that they must conform to. The list of description of these sentences provides a constituent structure grammar.

examining single linguistic elements, but is the result of a larger context. Language can be looked upon as a wide network between the single members and their linguistic values. Also, the value of an English word in Basic English will be different from the value of the same word in for example British English, i. e. in the context of much larger vocabulary. (Nickel [1985], pp. 57ff)

5.3.2 Immediate Constituents Analysis

One of the most efficient ways of setting up sentence patterns in a language is immediate constituents analysis. Here again, language is treated on a purely syntactic level. A sentence must be subdivided into constituents in a way that shows both the relation of the morphemes of the sentence among each other and the relation between morphemes and sentence. Such a structure can be represented in a graph:



These are the meanings of the symbols:

S ... sentence

NP ... noun phrase

VP ... verb phrase

DET ... determiner

N ... noun

V ... verb

CONJ ... conjunction

At the terminal nodes of the graph the constituents can be attached. The nodes show the single constituents, whereas the arcs represent the relations between them. Without the arcs, for

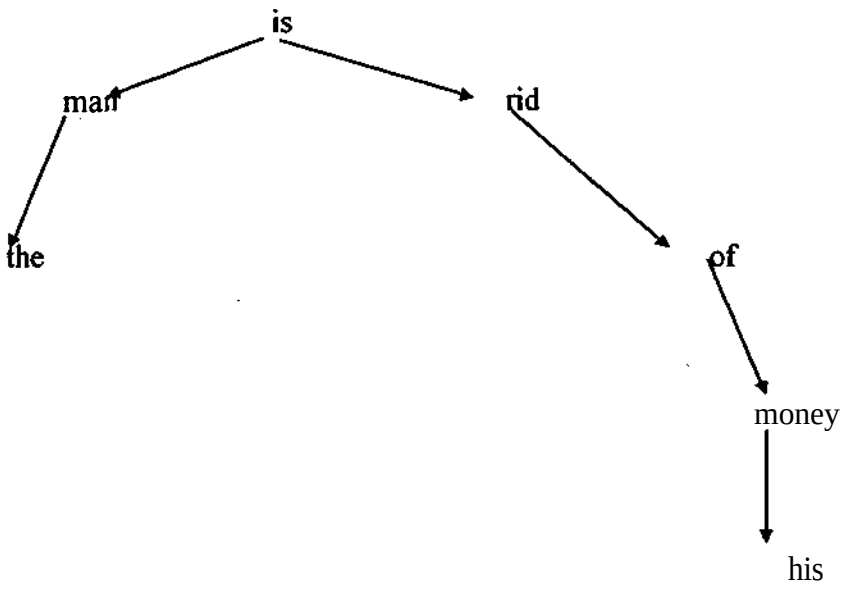
Here „man" and „book" are the actants and „the" the indices. Tesnière calls the subject the prime actant, the direct object the second actant, and the indirect object as the tertiary actant. Usually the actants are placed on the left side, and the circumstants on the right side at the same level of the hierarchy.

The number of actants depends on the verb. The maximum number of possible actants that a verb may take is called valence, in analogy to the valence of chemical elements. Therefore the structure of a sentence depends on the verb as initial node. Only the verb determines the possible number of actants. In some cases not all possible actants need to appear in a sentence. Valences can also be left empty. (Pelz [1996], pp. 158ff) The valence of a verb is a semantic feature on which the syntax of a sentence depends. Thus the dependency grammar shows that syntax and semantics cannot be separated from each other. (Pelz [1996], p. 167)

The image of valence is taken from chemistry, where each element requires a definite number of other elements for combination. It is also possible to consider this concept mathematically. In terms of mathematics and mathematical logic, the verb can be seen as a function which needs certain strictly defined arguments. The number and quality of the verb's obligatory arguments are called valence of the verb. Thus, if a transitive verb requires a direct object and a subject, it can be written down as $V_t(NP_1, NP_4)$. This verb has the valence 2. Such a verb is „like", and a correct sentence „I like mathematical linguistics." If the direct object were omitted, the sentence would be incomplete. In an other case, a double transitive verb requires a direct object and an indirect object, both of which are strictly necessary. We write $V_{dt}(NP_1, NP_4, NP_3)$, and this verb has the valence 3. An example of such a verb is „give", and the sentence „I give her the book." Again, the sentence would be incomplete without both objects. An intransitive verb has the valence 1, and we write $V_i(NP_1)$. An example of such a verb is „sleep", and the sentence „He is sleeping." requires only a subject. In Esperanto, as in Romance languages like Italian or Spanish, there are also verbs with the valence 0. We write V_i. An example of such a verb is „pluvi", and the sentence „Pluvas." *(It is raining.)* has neither subject nor subject. In German and English this pattern is used by taking an intransitive verb of valence 1.

For each verb, this information must be stored in a dictionary. On parsing the sentence of the source language for translation into Esperanto, the valence of the main verb has to be looked up first. Then the rest of the sentence is parsed and all elements are assigned to their obligatory and optional constituents, or, mathematically speaking, the arguments of the function are filled

which have in turn valences. With verbs other than verbs designing states or changes of states, these valences



The man **is** rid of his money.

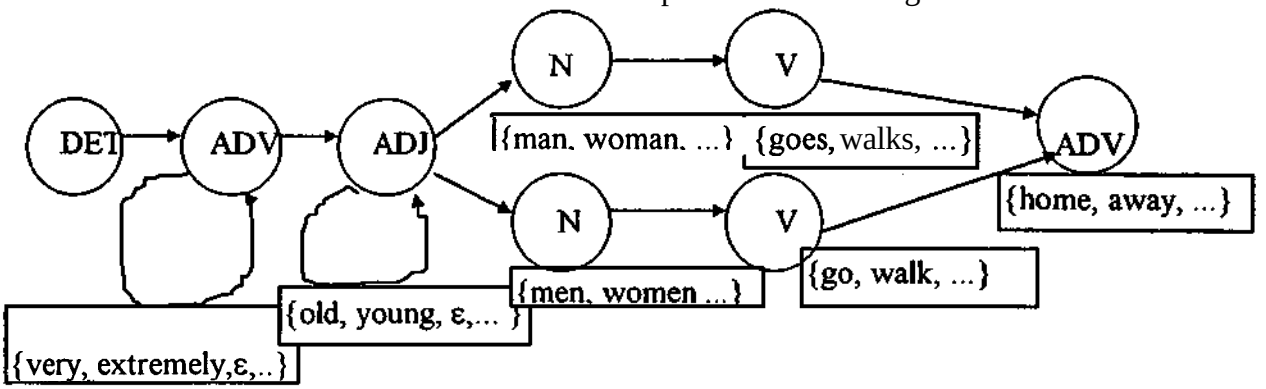
In this example, the adjective requires a prepositional phrase as a complement. The sentence ***The** man **is** rid.* would not make sense. Clearly, the prepositional phrase has become requisite by the use of the adjective, not by the use of the verb. A verb like *to be, to become, to look, to sound, ...,* takes one subject complement. This subject complement may be a noun phrase or an adjective. The noun phrase may or may not have depending optional complements. Adjectives, however, have certain valences that have to be taken into account in the same way as with verbs. Therefore, any time a verb like *to be, to become, to look, to sound, ...,* occurs in a sentence, the subject complement must be examined. If the subject complement is a noun phrase, the sentence pattern has been found, if it is an adjective, the valence of the adjective must be determined. In this case the sentence pattern will be determined with the help of both the valence of the adjective and the linking verb.

5.3.4 Phrase Structure Grammars

Graphs that are made in the first step of immediate constituents analysis are also used in another model. This model is called phrase structure grammar and was created by Noam Chomsky. He works with terminal and non-terminal symbols.

5.3.5 Finite State Grammars

Another way of looking upon language where Chomsky applied methods of mathematics, mathematical logic, and computer science to the analysis of natural language is his *finite state grammar.* There sentences are generated in analogy to finite automata. Each element leads to a certain state that offers a limited set of further possibilities leading to the successor state.



This grammar, however, is very limited and can only generate a finite number of sentences. It can become very complicated at times. Sentences can be expanded recursively where loops are found. The more complicated sentences become, the more exactly must be examined where these loops can be placed.

The idea of recursivity symbolised by the loops comes from mathematics. It corresponds to Chomsky's idea that the possibility of linguistical expression by means of a limited inventory of rules is unlimited. The human brain being a finite instrument, no infinite number of rules can be stored. Even according to Chomsky himself, this model violates the principle of simplicity. It shows formal simplicity for single elements in a high degree, but complexity for describing complex sentences in a very high degree. This formalisation involves an extremely high number of repetitions, thus increasing complexity to a very high extent.

Furthermore only linear dependencies can be shown, but not those that comprise whole sentences or syntagms or even texts. An example for such a case would be a relative clause whose predicate has to conform to the subject of the main clause that has been separated from the rest of the sentence by the subordinate clause, as in the sentences *He who steals is a criminal.* versus *Those who steal are criminals.* Another of the shortcomings of the model is that it does not show the speakers' intuition and creativity. Language is certainly not generated in such a limited and automated way. (Nickel [1985], p. 97f)

They saw the tree. i. e. They got a visual impression of the tree.

This result is particularly interesting for machine translation. If a sentence has one surface structure and two or more different deep structures, then a means must be found first to detect that there may be different deep structures, second, if this is the case, to determine which of them is required in this particular case. A possible solution to that problem is to present all possible deep structures to the user and let him or her decide which of them has to be taken.

This distinction between surface structure and deep structure has been particularly useful since it provides an efficient means of showing a difference that could not be represented by structuralist sentence graphs. Structuralism does not consider these two different levels of generating sentences. Chomsky is not only interested in language as a system, but also as a means of investigating the structure and functions of the human mind. For him, linguistics may be part of cognitive psychology. (Pelz [1996], pp. 169ff)

With his transformations Chomsky could simplify his model even more. He managed to reduce the number of rules, while the numerous remaining rules became more complex and more abstract in order to assume the functions of the cancelled rules.

Chomsky wanted to model the intuition of the speaker or listener. In a phrase structure grammar very similar sentences may be described by completely different diagrams, thus ignoring the human intuition that would classify them as similar. This is true for active and passive sentences or propositional sentences and questions. According to Chomsky, these can be derived by so-called *facultative transformation rules.*

Obligatory transformation rules, for example, would be applied to rewrite a sentence into all tenses. In this way, a rule like

V → AUX, V

AUX → TENSE | MODE| have, EN| be, ING

TENSE → PRESENT | PAST

MODE → can| may| must| shall| will

EN → V,ed| caught| ...

ING → V,ing

could be applied.

The boy hit the ball. The boy caught the ball. ⇒ *The boy hit and caught the ball.*

With the passive sentence, the subject is often cancelled, e.g.

Customers are required to observe the regulations.

The transformation operations described above ensure that the following sentences are based on the same string:

(1) *The boy caught the ball.*

(2) *The boy did not catch the ball.*

(3) *Did the boy catch the ball?*

(4) *Didn't the boy catch the ball?*

(5) *The ball was caught by the boy.*

(6) *The ball was not caught by the boy.*

(7) *Was the ball caught by the boy?*

(8) *Wasn't the ball caught by the boy?*

According to Chomsky's criteria the first of these sentences would be called the core sentence. It is not identical with the chain DET, N, AUX, V, DET, N, but contains one obligatory auxiliary transformation in tense, namely (catch → caught).

By means of transformations it is also possible to explain some ambiguities more fully than it is possible with simple phrase structure grammars without transformation rules. Such a structural ambiguity can be encountered in the sentence *Flying planes can be dangerous.* In this case *planes* may be the object of the gerund *flying,* in the other case it is part of the complex subject *flying planes.* Simple immediate constituents analysis does not show such differences. A phrase structure grammar can show the two different structures, without showing the structural simplicity of these sentences. By permutation transformation it is possible to show that these two sentences have the same *surface structure,* but two different *deep structures.* (Nickel [1985], pp. 101ff) Another example would be the sentence with the surface structure *This poet reads well.* meaning that the poet is able to read well, which one possible meaning or deep structure, or that it is pleasant to read the works of this poet, which corresponds to the second deep structure being a kind of passive meaning of the sentence. (Nickel, G. [1985], p. 104)

word we will recall other related words along with it immediately. This approach presents problems, however, because there is no way of controlling these associations which can be continued infinitely, then they depend on the individual speaker/listener, and they are not necessarily based on language itself, but may be derived from the outside world experienced by the speaker.

Another approach is made by semantic fields. That means that a subset of the words of a language is taken. These words must fall into the same category, i. e. they must e. g. be all nouns or all verbs and they must have similar contents. This approach has been made by J. Trier, L. Weisgerber, G. Matoré and P. Guiraud. In this approach meaning only exists within semantic fields in relation to other similar words or their antonyms. Language is regarded as a web of meaning that gives structure to reality and helps to recognise it.(Pelz [1996], pp. 188ff)

There are also syntactical rules that must be observed. It is not possible to substitute one member of a semantic field arbitrarily. First these words must match morphologically and syntactically. For example the following sentences are grammatically correct:

He is leaving tomorrow.

He is leaving next week.

He is leaving this afternoon.

He is leaving the day after tomorrow.

All the adverbs given have the same function. But it is not correct to say * *He is leaving yesterday.* because the adverb and the tense do not agree. On the other hand there are sentences that may be grammatically correct, but they do not correspond to the general standard, as for example */ *make my homework.* instead of / *do my homework.* Standard is a concept by Coseriu situated somewhere between Saussure's *langue* and *parole* and can be regarded as the totality of everything that has become usual in a language, as far as sentences are concerned. Such common syntagms are called *collocations.* For learning a foreign language the knowledge and command of such collocations is a very important factor, and that is why new words should not be learned isolated from each other, but within fields of such collocations. Of course, they must also be considered on translation.

Another approach for semantics comes from the Copenhagen school of structuralism whose object was to formalise Saussure's structuralism. Here, in the same way as lexical signs can be

in the interaction of the speakers. He investigates the relations between grammar and semantics and is interested in the context in which a given sign can be used. (Pelz [1996], pp. 194ff)

In natural languages the relation between the lexical symbols and their contents is not symmetrical. There are three types of asymmetries:

- **Homonymies:** Two or more signs have the same expression, but different contexts.

1) Homophonies: The same sequence of sounds but different orthography and contents, for example the English words *meet* and *meat.*

2) Homographs: The same way of writing but different pronunciation and meaning, for example the principal parts of the verb *read, read - read - read.*

3) Homophony with additional homographs, as for example the principal parts of the verb *cut, cut - cut - cut,* or the words *pupil* as part of the eye or *pupil* as a student. Homophony is not restricted to single words, but can also be encountered at a syntactical level, for example in the sentence: *Flying planes can be dangerous.* In one interpretation the speaker may be afraid of planes that have taken off, in another interpretation the speaker does not particularly want to sit in the cockpit of a plane, but would not mind being one of the passengers. (Pelz [1996], pp. 210ff)

- Synonymies: One or more signs may have different expressions, but the same content, as for example *underground* or *subway* or *mirror* and *looking-glass.* This would mean that a sign could be replaced by a synonym in all possible contexts without making a difference to the meaning, i. e. these signs would have to have the same distribution. These words are usually quasi-synonyms, because their connotations are different, as for example in *The way to the station? Don't ask me.* * *Don't question me.* or in *The examiner questioned me for half an hour.* * *The examiner asked me for half an hour.*

- Polysemies: A sign has several related contents, e. g. the verb *ride* for riding a horse or riding a bike, a car, or a bus. There is one sign with a variety of meanings. (Pelz [1996], pp. 212ff)

This asymmetric relation between linguistic signs and their contents can be seen as a characteristic of natural languages. Usually polysemies can be encountered which are a good example of the principle of linguistic economy. Many jokes or literary texts are based on the use of such intended ambiguities.

In communication the partners do not only want to tell something to each other, but they also want to obtain certain results. In this way speech is not only a way of communicating things, but a way of acting, for example of asking questions, ordering, denying, proposing things. Pragmatics studies linguistic acts and the context when they are performed. (Pelz [1996], pp. 240ff)

For example, with operating manuals, the author wants to explain to another person how the device in question works, and his intended result is that the other person will be able to operate this device himself later on. In order to achieve his aim, he will not give a poetic description of the appliance, nor will he use language that shows emotions about the apparatus, nor will he write a pamphlet about the advantages or disadvantages of technology in general. He will just give instructions about what to do to operate the device. If the reader of this text is capable of operating the device after reading, he has been successful, otherwise he has not. With a spoken text, if the speaker's partner happens to be his superior he may use the first conditional for explaining him how to operate the appliance, if his partner is his peer or subordinate he may rather use the imperative. Therefore, in written instructions the imperative can be found very often, since this is considered as a communication between an expert - who is superior to the reader in his special field - to any other reader. For describing the possible states of the device propositional or conditional clauses may be used. Since the text should be understood fast and clearly the writer will most probably use relatively short sentences that are not ambiguous, and he will avoid complex phrases that cannot be kept very long in short term memory - otherwise the reader may go and look for a users' manual which is easier to read. At the same time the writer should take care to use simple language and to explain each technical term.

Pragmatics becomes important with translation, since the use of language involves certain knowledge of the world that computers do not possess. For example, if I want to translate a sentence like *He took a dictionary, looked up the word, and put it back on the table.* then I know by my knowledge of the world that the neuter personal pronoun in the object case refers to *the dictionary* and not to *the word*, because I know that I can't put a word anywhere. If I did not know this, I might make use of another rule, namely the one that personal pronouns refer to the corresponding noun mentioned last, and this would be *the word.* Of course, this does not make sense in this context.

6.1 The Classification of the Sentence Patterns

6.1.1 Preliminary Remarks Concerning the Structure of the Sentence Patterns

The sentence patterns were classified according to the main verbs. Indeed, sentence patterns depend on the valences of the main verbs, i. e., whether or not these verbs have to take certain obligatory complements. If they do, the sentence becomes ill-formed or even unintelligible, if these complements are incomplete or missing. Every verb has at least one valence, and each valence corresponds to a certain sentence pattern. Sometimes, one verb may have several valences and thus form different sentences with different sentence patterns.

For technical reasons, these patterns were classified in the same way with all the languages. This may not correspond to the actual use of these sentences and idioms, but it facilitates looking up corresponding patterns. After all, strings have to be marked and parsed, and the sentences were classified according to their formal structures only. Therefore, pattern 1 of English has exactly the same formal structure as pattern 1 of Esperanto or pattern 1 of German, even if this pattern is used most often in Esperanto.

6.1.2 The Patterns

Pattern 0 can only be found in Esperanto, mostly with verbs referring to the weather. Although in some cases of spoken language, the subject may be left out with verbs of feeling and belief, if it is a subject in the first person singular, and if the verbs are followed by a subordinate clause, they cannot be regarded as verbs with valence 0, because the subordinate clause takes the function of a direct object. They are verbs with valence 2, where the subject has been omitted as an ellipsis. Verbs of the valence 0, however, invariably take neither a subject nor an object. Sentences of this kind are translated by English as well as German sentences of pattern 1.

Pattern 1 describes sentences with intransitive verbs taking subjects, but no objects, complements, or closely linked adjuncts. This pattern is used very often in Esperanto, even for sentences that would take other patterns in German or English. In some cases optional adverbs of time, manner, result, etc. can be used, i. e. they can change to verbs of pattern 7, pattern 8, pattern 9, or pattern 10 a. Some of these verbs can be used as intransitive pattern 1 verbs and as transitive pattern 3 a or pattern 4 a verbs, where they take a direct or an indirect object. Very often, sentence patterns with reflexive verbs, as for example the German and English patterns 3m, 3n, and 3o, are translated into pattern 1 sentences in Esperanto, where strictly reflexive verbs do not exist.

e. verbs followed by a direct object and an indirect object. In German and English there are some reflexive verbs that can be used only as reflexive verbs, i. e. not with other direct objects. They are described by patterns 3m, 3n, and 3o, where pattern 3m takes one adverb of manner, pattern 3n one adverb of manner and one prepositional phrase, and pattern 3o no other complement. Since in Esperanto all reflexive verbs can be used as transitive verbs and vice versa, these verbs were treated as transitive verbs. Therefore, in Esperanto, patterns 3m, 3n, and 3o do not exist. Sentences of this kind are usually translated by pattern 1 (German or English 3o and some 3m), pattern 3a (German or English 3o), pattern 6a (German and English pattern 3o and 3n), pattern 10a (German and English 3m) and pattern 10b (German and English 3n). All pattern three verbs must be followed by at least one direct object.

Pattern 3a is formed by transitive verbs and can be found in all three languages quite often. In Esperanto, it is together with pattern 1 the most frequently used pattern. This is due to the fact that in Esperanto it is possible to add prefixes and sometimes also suffixes to the verbs that take the function of adverbs of time, space, or manner. Thus the German or English object complement taking this function becomes unnecessary, and only the direct object is left over.

Patterns 3b, 3c, 3d, and 3h are formed by complex transitive verbs. They are followed by an object complement giving extra information about the direct object. With pattern 3b, the object complement is a prepositional object, with 3c, the object complement is a spatial object, with 3d, the object complement is a temporal object, and with 3h, the object complement is an adverb.

In German and English, sentences with adjective phrases as object complements can be found. These object complements describe a feature or quality of the direct object. They form pattern 3i. Very few of them can be translated into Esperanto with the same pattern, but in Esperanto, this sentence pattern is considered as primitive and as the way very young children speak. The corresponding „elaborate" sentence pattern is pattern 3a, where the verb and the object complement of 3i form the verb of pattern 3a, where only the direct object has to be added. This direct object is kept in its original position.

Pattern 3e is formed by a complex transitive verb with a direct object and an object complement indicating the role, status, etc. of the direct object. Patterns 3k and 31 resemble pattern 3e, but in the case of pattern 3k, a preposition is added to the direct object, in pattern 31, a preposition is added to the adjective that takes the place of the object complement. Patterns 3k and 31 can be interchanged in translations. They can be found in all languages. In

The sentence patterns 4c, 4d, 4e, 4f, 4g, and 4h are typically German. A dative of pertinence is a personal dative providing additional information to other noun phrases. On translation in other languages, this dative is translated as a kind of attribute to the noun phrase. Pattern 4c is formed by an intransitive verb with a dependent adjective phrase. With other languages this verb is mostly translated into a linking verb, i. e. pattern 2h, or, as in Esperanto, into one verb or a verb with an indirect object, i. e. pattern 1 or pattern 4a.

Pattern 4d, which is formed by an intransitive verb and a dative of pertinence, can be found in Esperanto, but it is not widely used. More often, this pattern is translated into pattern 1, where the dative of pertinence becomes an attribute of the subject. Thus pattern 4d might be translated into pattern 4d of Esperanto. It does not exist in English, however. On translation, the dative of pertinence becomes a possessive case as an attribute to the subject.

Pattern 4e is formed by a direct object and a dative of pertinence. This pattern can be found in German. It is also possible in Esperanto, but not frequently used. This pattern is considered to be clumsy by many speakers of Esperanto. Of course, pattern 4e can also be translated as pattern 3a in Esperanto, where the dative of pertinence becomes an attribute to the direct object. Pattern 4e is therefore most often translated into pattern 3a.

The same is true for pattern 4f, where an adverb of manner is added to the dative of pertinence and the direct object. Pattern 4f can only be found in German. On translation, it may become pattern 4e, i.e. the adverb is contained in the Esperanto or English verb, or pattern 3a, where also the dative of pertinence becomes an attribute to the direct object.

With pattern 4g, the sentence is formed by an intransitive verb, a dative of pertinence, and an object of manner. Again, this pattern can only be found in German and has to be translated into pattern 3a. The dative of pertinence becomes an attribute to the object of manner. Pattern 4h is formed by a transitive verb, a direct object, a dative of pertinence, and an object of manner. It is translated into pattern 3c in Esperanto.

Pattern 5 can only be found in German. It is formed by an intransitive verb and a genitive object. In Esperanto, this is translated into pattern 3a, i. e. the genitive object becomes the direct object in English or Esperanto, or into pattern 6a, if the genitive object is translated into a prepositional phrase.

The following table shows the classes of sentence patterns in an overall way:

0	1	2	3	4	5	6	7	8	9	10
Verb	NP_1 + Verb	NP_1 + Linking Verb + Subject comple-ment	NP_1 + Verb + Direct Object + ...	NP_1 + Verb+ Indirect Object Dative + ...	NP_1 + Verb + Indirect Object Genitive + ...	NP_1 + Verb + Prepositional Object + ...	NP_1 + Verb + Temporal Object	NP_1 + Verb + Spatial Object	NP_1 + Verb + Object of causality	NP_1 + Verb + Object of Manner + ...

6.2 The Sentence Patterns of the Single Languages

In this section the sentence patterns of the single languages are listed and examined more closely. Since German and English both belong to the Indo- European languages, and even to the Germanic languages, there are many similar patterns. In German, however, there is a greater variety of patterns due to its relatively free position of the words in the sentence. Most of the basic German sentence patterns were taken from the Duden grammar (Eisenberg [1998]). Some of them were added later to adapt to the English and Esperanto sentence patterns and to facilitate translation. The English sentence patterns were taken from the Advanced Learner's Oxford English Dictionary (Hornby[1992]). Some additional sentence patterns were added and divided into subpatterns to adjust them to the German patterns and to facilitate translation. Although the classifications were slightly changed for the English and German sentence patterns the sentences themselves were never changed. These alterations were solely made for technical reasons and do not affect language itself in any way.

The Esperanto sentence patterns are nowhere clearly defined. The *fundamento* does not even mention Esperanto syntax. By consensus, the sentences are said to be 'natural', without stating what this really implies. Apparently 'natural sentences' are sentences formed according to the sentence patterns of Indo-European languages, although some of them are considered wrong in Esperanto. Again, there are no explicit rules which forbid them, but they are avoided by convention. It seems that by some kind of tacit agreement, the language is used in a way that comes close to Romance languages in expression and vocabulary, and syntax highly resemble English or French syntax. But this is done only by custom or etiquette, and there are no strict rules. It would take psychological methods to investigate this question more closely, since this

2 b)	Linking verb with identifying prepositional phrase as a subject complement	BE + PP	b) PP	La **libro** estas pri studentoj.
2 c)	Linking verb with adjective as a subject complement	BE + AP	c) AP AP AP →ADJ	Mia mono estas for. Mia mono estas perdita. La rozo estas **bela**.
2 d)	Linking verb with adverb of place as a subject complement	BE + PP_S	d) PP_S	La libro estas sur la **tablo**.
2 e)	Linking verb with adverb of time as a subject complement	BE + PP_T	e) PP_T	La **renkonto** estos **morgaü**.
20	Linking verb with adjective phrase with a dependent prepositional object as a subject complement	BE + AP	f) AP→ADJ PP_{dep}	Li estas libera de ciuj zorgoj. Mi estas scivola pri tia **raporto**.
2 g)	Linking verb with adjective and dependent direct object as a subject complement	BE + AP	g) AP →ADJ + $NP_{4\ dep}$	La fendo estas dudek metrojn **longa**.
2 h)	Linking verb with adjective and dependent indirect object as a subject complement	BE + AP	h) AP →PP_M + $NP_{3\ dep}$	Tio estas **serva al** mi. La **laborilo** estas **utila** al mi. Li estas **simila** al **li**. Mi estas fremda al tiu viro. Li estas bonintenca al li. Li estas kapabla al tiu **krimo**.
3 a)	Transitive verb with direct object	Vt + dO	a) -	Li **legas** libron. Mi atendas **lin**. La **patrino varmigas** la supon. Li karesas mian vangon. Mi **memoras** lin.
3 b)	Transitive verb with direct object and prepositional object as an adjunct	Vt + dO + PP	b) PP	Li superas min je diligenteco. Li superas min por diligenteco. Mi **skribas** leteron pri **mia amiko**.
3 c)	Transitive verb with direct object and a spatial object as an adjunct	Vt + dO + PPs	c) PPs	Mi metas libron sur la tablon. Li metas sian manon sur mian **^sultron**. Hi **malsupren^jetis** lin sur la stuparon.
3 d)	Transitive verb with direct object and a temporal object as an adjunct	Vt + dO + PP_T	d) PP_T	Mi **prokrastis** la **renkonton ^gis** morgaü.
3 e)	Complex transitive verb with direct object and identifying nominative as an object complement	Vct + dO + NP_1	e) NP_1	Li **nomas** lin **mensogulo**. Hi elektis lin prezidanto.

7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	-	Li venös morgaü. Li venos somere. **Dum** la festo regis gajeco.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PPs	-	Li **logas** en **Berlino**. Li iras supren. Li logas Berline. Sur la **festherbejo** regis gajeco. Li **skias valen**. Li taksias hotelen.
9)	Intransitive verb with an object of causality as an adjunct	Vi + PPc	-	Li **venis** pro **amikeco**.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	a)-	Li parolas bone. Li kondutas bone. **Li fartas** malbone.
10 b)	Intransitive verb with an object of manner and a prepositional object as adjuncts	Vi+ PP_M + PP	b) PP	Li kondutas **amikece** vidalvide de **li**. **Koncerne lin** mi kondutas amikece
10 c)	Intransitive verb with an object of manner and a spatial object as adjuncts	Vi + PP + PPs	c) PP_S	Li **veturas al** hotelo taksie. Li veturas hotelen per taksio
10 d)	Transitive verb with a direct object and an object of manner with a dependent direct object as an adjunct	Vt + dO + PPs + NP_{4dep}	d) NP_4 + $NP_{4\ dep}$	Li ^jetas pilkon unu metron alten. Li ^jetas pilkon unu metron malproksimen.

Esperanto sentences tend to be rather short and simple. If it is possible to express the same idea by a verb and an adjective or by a single verb, for example, the short sentence with the single verb is preferred. Likewise, if something can be expressed by both an adverb and a prepositional phrase, the prepositional phrase is chosen. Sentences with many nested noun phrases as attributes tend to be avoided.

6.2.2 Sentence patterns German

In the case of the German sentence patterns, they were mostly taken from the Duden grammar (Eisenberg [1998]). Some of them were added later. Likewise, more adjective phrases than in Duden were listed and subdivided into different categories. This was necessary for programming reasons. Even if some structures are similar in meaning (never quite identical!) they have to be listed in different categories, since the translation algorithm works with sentence patterns.

	complement			
2 j)	Linking verb with adjective and dependent indirect object in the dative and dependent indirect object in the genitive as subject complement	**BE+ AP**	j) **AP→ADJ + $NP_{3\ dep}$+ $NP_{2\ dep}$**	Ich bin mir dessen bewußt.
2k)	Linking verb with an adjective with a dependent indirect object and a dependent prepositional object as subject complement	BE + AP	**k) AP →ADJ + $NP_{3\ dep}$ + PP_{dep}**	Er ist mir an Fleiß überlegen.
2 l)	Linking verb with spatial object and dependent prepositional object as subject complement	BE + **PP_{dep}** + PPs	1) **PP_{dep}** + PPs	Er ist in Wien wohnhaft.
2 m)	Linking verb with object in the second case as subject complement	BE **+ NP_2**	m) **NP_2**	Er ist dieser Meinung. Er ist des Teufels.
3 a)	Transitive verb with direct object	Vt + dO +	a)-	Er liest ein Buch.
3 b)	Transitive verb with direct object and a prepositional object as an adjunct	Vt + dO + PP	b) **PP**	Ich schreibe einen Brief über meinen Freund.
3 c)	Transitive verb with direct object with a spatial object as an adjunct	Vt + dO + **PP_S**	c) **PP_S**	Ich lege das Buch auf den Tisch.
3 d)	Transitive verb with direct object with a temporal object as an adjunct	Vt + dO + **PP_T**	d) **PP_T**	Ich verschob das Treffen auf morgen.
3e)	Complex transitive verb with direct object and identifying accusative as an object complement	**Vct + dO + NP_4**	e) **NP_4**	Er nannte ihn einen Lügner.
3 f)	Double transitive verb with a direct object and an indirect object (dative)	Vdt + dO + iO	f) **iO**	Ich gebe ihm das Buch.
3 g)	Double transitive verb with two direct objects	Vdt + dO + dO	g) **dO**	Ich lehre ihn die französische Sprache.
3 h)	Transitive verb with direct	Vt + dO +	h) **PP_M**	Er empfing mich freundlich.

4 f)	Complex transitive verb with a direct object with a dative of pertinence as object complement and an object of manner as an adjunct	**Vct** + dO + **PP_M** + **$NP_{3\ dep}$**	0 dO + **PP_M** + **$NP_{3\ dep}$**	Der Arzt richtet mir die Nase gerade.
4 g)	Intransitive verb with an object of space with a dative of pertinence as an adjunct	Vi + **PP_S** + **$NP_{3\ dep}$**	g) PPs + **NP_{3dep}**	Er klopft mir auf die Schulter.
4 h)	Double transitive verb with a direct object with a dative of pertinence as an object complement, and an object of space as an adjunct	Vdt + dO+ **PP_S + $NP_{3\ dep}$**	**h)** dO+ **PP_S**+ **$NP_{3\ dep}$**	Er legt mir die Hand auf die Schulter.
5)	Intransitive verb with genitive object	Vi + **NP_2**	-	Ich harre seiner. Wir gedenken der Toten.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	**a)** -	Ich schreibe über die Zeitung.
6 b)	Intransitive verb with two prepositional objects as two adjuncts	Vi + PP + PP	b) PP	Ich diskutiere mit ihm über das Buch.
7)	Intransitive verb with a temporal object as an adjunct	Vi + **PP_T**	-	Er kommt morgen.
8)	Intransitive verb with a spatial object as an adjunct	Vi + **PP_S**	-	Er wohnt in Berlin.
9)	Intransitive verb with an object of causality as an adjunct	Vi + **PP_C**	-	Er kam aus Freundschaft.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + **PP_M**	**a)** -	Das Kleid paßt gut.
10 b)	Intransitive verb with an object of manner and a prepositional object as two adjuncts	Vi+ **PP_M** + PP	**b) PP**	Er kam gerne mit uns.

patterns in English than in Esperanto, however, due to the rigid word order of English. The following table shows the English sentence patterns:

	Type	Structure of **VP**	+	**Examples**
1)	Intransitive verb without objects	Vi	-	It is raining.
2 a)	Linking verb with identifying nominative as a subject phrase	BE + NP_1	a) NP_1	He is a student.
2 b)	Linking verb with identifying prepositional phrase as a subject phrase	**BE + PP**	b) PP	The book is about students.
2 c)	Linking verb with adjective as a subject phrase	BE + AP	c) AP AP →ADJ	The rose is beautiful.
2 d)	Linking verb with adverb of place as a subject phrase	BE + PPs	d) PP_S	The book is on the table.
2e)	Linking verb with adverb of time as a subject phrase	BE + PP_T	e) PP_T	The meeting will be tomorrow.
20	Linking verb with adjective and dependent prepositional object as a subject phrase	BE + AP + PP_{dep}	f) AP→ ADJ + PP_{dep}	He is free of his sorrows. This is typical of him.
2 g)	Linking verb with adjective and dependent direct object as a subject phrase	BE + AP + $NP_{4\ dep}$	g) AP→ ADJ + NP_{4dep}	The fence is two meters long.
2 h)	Linking verb with adjective and dependent indirect object in the dative as a subject phrase	BE + AP + $NP_{3\ dep}$	h) AP→ ADJ + NP_{3dep}	The tool is useful to me. He is similar to him.
3 a)	Transitive verb with direct object	Vt + dO	a) -	He is reading a book.
3 b)	Transitive verb with direct object and prepositional object as an adjunct	Vt + dO + PP	b) PP	I write a letter about my friend.
3 c)	Transitive verb with direct object and spatial object as an adjunct	Vt + dO + PP_S	c) PP_S	I put the book on a desk. I show him into the room. They

4 b)	Intransitive verb with an indirect object and a prepositional object as adjuncts	Vi + iO+ PP	b) PP	He talks to me about the book. They tell us about the last events.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	a) -	He talks about the book.
6 b)	Intransitive verb with two prepositional objects as adjuncts	Vi + PP + PP	b) PP	They discuss with us about the book.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T		He will come tomorrow.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	-	The children have come home.
9)	Intransitive verb with an object of causality as an adjunct	Vi + PPc	-	He did it for friendship's sake.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	a) -	He behaves well. He goes by train. He came quickly.
10 b)	Intransitive verb with an object of manner and a prepositional object as adjuncts	Vi+ PP_M + PP	b) PP	He came with us gladly.
10 c)	Intransitive verb with an object of manner and a spatial object as adjuncts	Vi+ PP_M + PP_S	c) PP_S	He goes to London by train. They went to school by bus.
10 d)	Transitive verb with a direct object and an object of manner with a dependent direct object as an adjunct	Vt + dO + PP_M + NP_{4dep}	d) dO + PP_M + NP_{4dep}	He throws the ball two meters up.
10 e)	Intransitive verb with a spatial object and a dependent direct object as an adjunct	Vi + PP_S + $NP_{4\ dep}$	e) PP_S + $NP_{4\ dep}$	He goes down the stairs.

	adjuncts				
1)	Intransitive verb without objects or adjuncts	Vi	Li **bonkondutas**.	**3 o)**	He behaves himself.
1)	Intransitive verb without objects or adjuncts	Vi	Li bonkondutas.	10 a)	He behaves well.
1)	Intransitive verb without objects or adjuncts	Vi	Li **supreniras**.	8)	He goes up. He goes upstairs.
2 a)	Linking verb with identifying nominative as a subject complement	BE + NP_1	Li estas studento.	2 a)	He is a student.
2 b)	Linking verb with identifying prepositional phrase	BE + PP_1	La **libro** estas **pri studentoj**. Mi estas en lia servo. Mi estas je lia servo.	**2 b)**	The book is about students. I am at his service.
2 b)	Linking verb with identifying prepositional phrase	BE + PP_1	Mi estas en lia servo.	3 **a)**	I serve him
2 b)	Linking verb with identifying prepositional phrase	BE + PP_1	Mi estas en lia servo.	6 a)	I work for him
2 c)	Linking verb with adjective	BE + AP	La rozo estas **bela**.	**2 c)**	The rose is beautiful.
2 c)	Linking verb with adjective	BE + AP	Mia mono estas for. Mia mono estas perdita.	**2 f)**	I am rid of my money.
2 d)	Linking verb with adverb of place as an adjunct	BE + PP_S	La libro estas sur la **tablo**.	**2 d)**	The book is on the table.
2e)	Linking verb with adverb of time as an adjunct	BE + PP_T	La **renkonto** estos morgaü.	**2 e)**	The meeting will be tomorrow.
2 e)	Linking verb with adverb of time as an adjunct	BE + PP_T	La renkonto estos morgaü.	7)	The meeting takes place tomorrow.

	indirect object as an adjunct		al mi.		
3 a)	Verb with direct object	Vt + dO	Li legas libron. Mi memoras lin.	3 a)	He is reading a book. I remember him.
3 a)	Transitive verb with direct object	Vt + dO	Mi scias tion. Mi memoras tion.	1)	I know. I remember.
3 a)	Transitive verb with direct object	Vt + dO	Tio valoras la penon.	2 g)	This is worth the trouble.
3 a)	Transitive verb with direct object	Vt + dO	Mi ^satas muzicon.	4 a)	The music appeals to me.
3 a)	Transitive verb with direct object	Vt + dO	Mi atendis lin.	6 a)	I was waiting for him.
3 a)	Transitive verb with direct object	Vt + dO	La laboristo blankigas la muron.	3 i)	The worker paints the wall white.
3 a)	Transitive verb with direct object	Vt + dO	Li malsupreniras la stuparon.	10 e)	He goes down the stairs.
3 a)	Transitive verb with direct object	Vt + dO	Mi bedauras lin.	2 f)	I am sorry for him.
3 b)	Transitive verb with direct object and a prepositional object as an adjunct	Vt + dO + PP	Mi skribas leteron pri mia amiko. Li kulpas lin pro ^stelo.	3 b)	I write a letter about my friend. He accuses him of stealing.
3 b)	Transitive verb with direct object and prepositional object as an adjunct	Vt + dO + PP	El tio mi tute rekonas lin.	2 f)	This is typical of him.
3 b)	Transitive verb with direct object and prepositional object as an adjunct	Vt + dO + PP	El tio mi tute rekonas lin.	2 b)	This is like him.
3 c)	Transitive verb with direct object and spatial object as an adjunct	Vt + dO + PPs	Mi metas libron sur la tablon.	3 c)	I put a book on the desk.
3 c)	Transitive verb with direct object and spatial object as an adjunct	Vt + dO + PPs	Hi malsupren^jetis lin sur la stuparon.	10 f)	They threw him down the stairs.

	object and identifying prepositional phrase as an object complement	PP	konsideras **lin** kiel **amikon**.		considers him a friend.
3 l)	Complex transitive verb with direct object and an adjective phrase as an object complement	**Vct + dO+** AP	Hi konsideras lin kiel inteligentan.	**3 l)**	They consider him as intelligent.
4 a)	Intransitive verb with an indirect object as an adjunct	Vi + iO	La **muziko pla^cas al** mi.	4 a)	The music appeals to me.
4 a)	Intransitive verb with an indirect object as an adjunct	Vi + iO	Li **similas al li**. La laborilo **servas** al mi. Tio servas al mi.	**2 h)**	He is similar to him. The tool is useful to me. This is helpful to me.
4 a)	Intransitive verb with an indirect object as an adjunct	Vi + iO	Li kapablas al tiu **krimo**.	**2 f)**	He is capable of this crime.
4 a)	Intransitive verb with an indirect object as an adjunct	Vi + iO	Li similas al li. La laborilo servas al mi. Tio servas al mi.	3 a)	He resembles him. The tool serves me. This helps me.
4 a)	Intransitive verb with an indirect object as an adjunct	Vi + iO	Li similas al mi.	30	He bears resemblance **to me**.
4 b)	Intransitive verb with an indirect object and a prepositional object as adjuncts	Vi + **iO+ PP**	Mi parolas al li pri la **libro**.	**4 b)**	I speak to him about the book.
4 d)	Intransitive verb with a dative of pertinence as a subject complement	Vi + $NP_{3\ dep}$	Al la **infano** la mano sangas.	1)	The child's hand is bleeding.
4 e)	Complex transitive verb with a direct object and a dative	**Vct** + NP_4 + $NP_{3\ dep}$	Li karesas la vangon al mi. La **kuracisto** rektigas la nason **al**	3 a)	He strokes my cheek. The doctor straightens my nose.

8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	Li **logas** en **Berlino**. Li logas Berline. Li iras supren.	8)	He lives in Berlin. He goes up. He goes upstairs.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	Sur la festherbejo regis gajeco. Li taksias **hotelen**. Li **skias valen**.	10 c)	At the meeting ground things were going on lively. He goes to the hotel by taxi. He goes down into the valley.
9)	Intransitive verb with an object of causality as an adjunct	Vi + PP_C	Li **venis** pro **amikeco**.	9)	He came for **friendship's** sake.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Li parolas bone. Li kondutas bone.	10 a)	He speaks well. He behaves well.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Li kondutas bone.	**3 m)**	He behaves himself well.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Li kondutas bone.	**3 o)**	He behaves himself.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Li **fartas** bone.	**2 c)**	He is well.
10 b)	Intransitive verb with an object of manner and a prepositional object as adjuncts	Vi + PP_M + PP	Li parolas bone **pri** la gazeto.	10 b)	He speaks well about the paper.
10 b)	Intransitive verb with an object of manner and a prepositional object as adjuncts	Vi + PP_M + PP	Li kondutas **amikece** vidalvide de **li**. **Koncerne lin** li kondutas amikece	**3 n)**	He behaves friendly towards him.
10 c)	Intransitive verb with an object of manner and a spatial object as	**Vi+** PP_M + PP_S	Li veturas **al hotelo** taksie. **Li veturas** hotelen per taksio.	10 c)	He goes to the hotel by taxi.

			Esperanto	to	German
no	Type	Structure of VP	Examples in Esperanto	no	Examples in German
0	Intransitive verb without subject and object or adjunct	Vi	Pluvas.	1)	Es regnet.
1)	Intransitive verb without objects and adjuncts	Vi	Li venas.	1)	Er kommt.
1)	Intransitive verb without objects and adjuncts	Vi	Li scias.	3 a)	Er weiß es.
1)	Intransitive verb without objects and adjuncts	Vi	La mano de la infano sangas.	4 d)	Dem Kind blutet die Hand.
1)	Reflexive verb without objects and adjuncts	Vi	Li ^gojas.	3 o)	Er freut sich.
1)	Intransitive verb without objects and adjuncts	Vi	Mi bedauras.	4 c)	Es tut mir leid.
1)	Intransitive verb without objects and adjuncts	Vi	La rozo belas.	2 c)	Die Rose ist schön.
1)	Intransitive verb without objects and adjuncts	Vr	Li bonkondutas.	3 m)	Er benimmt sich gut.
1)	Intransitive verb without objects and adjuncts	Vi	Li supreniras.	8)	Er geht hinauf.
1)	Intransitive verb without objects and adjuncts	Vi	Tio konvenas.	10 a)	Das paßt gut.
2 a)	Linking verb with an identifying nominative as a subject complement	BE + NP_1	Li estas studento.	2a)	Er ist ein Student.
2 b)	Linking verb with an identifying	BE + PP	La libro estas pri	2 b)	Das Buch ist über

	dependent prepositional object as a subject complement	PP_{dep}	estas tipo por li. Mi estas scivola pri tia raporto.		bezeichnend für ihn. Ich bin auf deinen Bericht gespannt. Das ist typisch für ihn.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PPdep	Li estas libera de ciuj zorgoj.	2g)	Er ist seine Sorgen los.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PPdep	Mi estas rememorante pri tio. Li estas libera de ciuj zorgoj.	2 i)	Ich bin dessen eingedenk. Er ist seiner Sorgen ledig.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PPdep	Mi estas rememorante pri tio.	3 b)	Ich erinnere mich daran.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PPdep	Mi estas rememorante pri tio.	3 o)	Ich erinnere mich.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PPdep	Tio estas tipo por li.	4 c)	Das sieht ihm ähnlich.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PP_{dep}	Mi estas rememorante pri tio.	6 a)	Ich denke daran.
20	Linking verb with an adjective with a dependent prepositional	BE + AP + PPdep	Mi estas rememorante pri tio.	3 j)	Ich erinnere mich dessen.

3 a)	Transitive verb with direct object	Vt + dO	Mi scias tion.	1)	Ich **weiß**.
3 a)	Transitive verb with direct object	Vt + dO	Tio **valoras** la penon.	**2 g)**	Das ist die Mühe wert.
3 a)	Transitive verb with direct object	Vt + dO	Mi memoras **lin**.	**3 b)**	Ich erinnere mich an ihn.
3 a)	Transitive verb with direct object	Vt + dO	Mi atendis lin.	6 a)	Ich wartete auf ihn.
3 a)	Transitive verb with direct object	Vt + dO	Mi memoras lin. Mi atendas lin.	5)	Ich gedenke seiner. Ich harre seiner.
3 a)	Transitive verb with direct object	Vt + dO	Mi memoras lin.	**3 j)**	Ich erinnere mich seiner.
3 a)	Transitive verb with direct object	Vt + dO	Mi memoras tion. Tio valoras la penon.	**2 i)**	Ich bin dessen eingedenk. Das ist der Mühe wert.
3 a)	Transitive verb with direct object	Vt + dO	Mi memoras tion.	3 o)	Ich erinnere mich.
3 a)	Transitive verb with direct object	Vt + dO	Li **longi^gis** la **interparolon**.	**3 d)**	Er zog das Gespräch in die Länge.
3 a)	Transitive verb with direct object	Vt + dO	La **laboristo blankigas** la **muron**. La patrino **varmigas** la supon.	**3 i)**	Der Arbeiter macht die Mauer weiß Die Mutter macht die Suppe warm.
3 a)	Transitive verb with direct object	Vt + dO	Li karesas **mian** vangon.	**4 e)**	Er streichelt mir die Wange.
3 a)	Transitive verb with direct object	Vt + dO	La **kuracisto** rektigas mian nazon.	**4 f)**	Der Arzt richtet mir die Nase gerade.
3 a)	Transitive verb with direct object	Vt + dO	Li batelas mian **^sultron**.	4g)	Er klopft mir auf die Schulter.
3 a)	Transitive verb with direct object	Vt + dO	Li batelas mian **^sultron**.	8)	Er klopft auf meine Schulter.
3 a)	Transitive verb with direct object	Vt + dO	Li **malsupreniras** la stuparon.	10 e)	Er geht die Stiege hinunter.
3 a)	Transitive verb with direct object	Vt + dO	Mi bedauras lin.	**4 c)**	Er tut mir leid.
3 a)	Transitive verb with direct object	Vt + dO	Li favoras lin.	**2 h)**	Er ist ihm hold.

	identifying nominative as an object phrase				
3 e)	Complex transitive verb with direct object and identifying nominative as an object phrase	**Vct + dO + NP_1**	**Ili** elektis lin prezidanto.	**3 k)**	Sie wählten ihn zum Präsident. Sie wählten ihn als Präsident.
3 f)	Double transitive verb with a direct object and an indirect object (dative)	Vdt + dO + iO	Mi donas la libron **al li**.	30	Ich gebe ihm das Buch.
30	Double transitive verb with a direct object and an indirect object (dative)	Vdt + dO + iO	Mi **instruas** francan **lingvon al li**.	**3 g)**	Ich lehre ihn die französische Sprache.
3 h)	Transitive verb with a direct object and an object of manner as an adjunct	Vt + dO + **PP_M**	Li ricevis min agrable. Li traktas lin kruele.	**3 h)**	Er empfing mich freundlich. Er behandelt ihn grausam.
3 h)	Transitive verb with direct object and object of manner as an adjunct	Vt + dO + **PP_M**	Li traktas lin kruele.	10 b)	Er handelt grausam an ihm.
3 i)	Complex transitive verb with an object of manner with a dependent direct object as an object complement	Vt **+ PP_M + NP_{4dep}**	La **laboristo** faras la muron **blanka**.	**3 i)**	Der Arbeiter macht die Mauer weiß.
3k)	Complex transitive verb with direct object and identifying prepositional phrase as an object complement	**Vct + dO+ PP**	Hi elektis lin kiel **prezidanton**. Li konsideras lin kiel amikon.	**3 k)**	Sie wählten ihn zum Präsident. Sie halten ihn für einen Freund.
3 k)	Complex transitive verb with direct object and	**Vct + dO+ PP**	Hi **nomas** lin kiel amikon.	**3 k)**	Sie nennen ihn einen Freund.

	pertinence as a subject complement				
4 e)	Complex transitive verb with a direct object with a dative of pertinence as an object complement	**Vct+ dO + NP_3** **dcp**	Li karesas la vangon **al** mi.	**4 e)**	*Er* streichelt mir die Wange.
4 e)	Complex transitive verb with a direct object with a dative of pertinence as an object complement	**Vct+ dO + NP_3** dcp	La **kuracisto rektigas** la nason al mi.	**4 f)**	Der Arzt richtet mir die Nase gerade.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Mi **skribas pri** la gazeto.	6 a)	Ich schreibe über die Zeitung.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Li koleras kontraü. **li**.	2h)	Er ist ihm gram.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Mi memoras pri li.	**3 b)**	Ich erinnere mich an ihn.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Mi **bonkondutas vidalvide** de li.	**3 n)**	Ich benehme mich gut ihm gegenüber.
6 a)	Intransitive verb with a prepositional object as an adjunct	**Vi + PP**	Mi memoras pri li.	**3 o)**	Ich erinnere mich.
6 a)	Intransitive verb with a prepositional object as an	Vi + PP	Mi memoras pri li.	**3 j)**	Ich erinnere mich seiner.

	adjunct				
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Li parolas bone.	10 a)	Er spricht gut.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Li kondutas bone.	3 m)	Er benimmt sich gut.
10 a)	Intransitive verb with an object of manner as an adjunct		Li fartas malbone.	4 c)	Es geht ihm schlecht.
10 b)	Intransitive verb with an object of manner and a prepositional object as adjuncts	Vi+ PP_M + PP	Li parolas bone pri la gazeto.	10 b)	Er spricht gut über die Zeitung.
10 b)	Intransitive verb with an object of manner and a prepositional object as adjuncts	Vi+ PP_M + PP	Li kondutas amikece vidalvide de li. Koncerne lin li kondutas amikece.	3 n)	Er verhält sich freundschaftlich ihm gegenüber.
10 c)	Intransitive verb with an object of manner and a spatial object as adjuncts	Vi+ PP_M + PPs	Li veturas al hotelo taksie. Li veturas hotelen per taksio.	10 c)	Er fährt mit dem Taxi ins Hotel. Er fährt mit dem Taxi zum Hotel.
10 d)	Complex transitive verb with a direct object and an object of manner with a dependent direct object as an object complement	Vct + PPs + dO + dO_{dep}	Li ^jetas pilkon unu metron alten. Li ^jetas pilkon unu metron malproksimen.	10 d)	Er wirft den Ball einen Meter hoch. Er wirft den Ball einen Meter weit.

In Esperanto most sentences consist of either a subject with a verb or subject, verb, and direct or indirect object. Among the sentences with an object, sentences with direct objects occur most frequently. The verbs express meaning that in German must often be expressed by more complex noun phrases, adjective phrases, or adverbs. Thus Esperanto sentences tend to be more concise than German sentences. Especially patterns 1 and 3a, to a lesser degree also 6a,

2c)	Linking verb with adjective as a subject complement	BE + AP	Mein Geld ist weg. Die Rose ist schön.	**2 c)**	Mia mono estas for. Mia mono estas perdita. La rozo estas **bela**.
2 c)	Linking verb with adjective as a subject complement	BE + AP	Die Rose ist schön.	1)	La rozo **belas**.
2 d)	Linking verb with adverb of place as a subject complement	BE + PP_S	Das Buch ist auf dem Tisch.	**2 d)**	La **libro** estas sur **la tablo**.
2 e)	Linking verb with adverb of time as a subject complement	BE + PP_T	Das Treffen ist morgen.	**2 e)**	La **renkonto** estos morgaü.
2e)	Linking verb with adverb of time as a subject complement	BE + PP_T	Das Treffen ist morgen.	**7)**	La renkonto okazos morgaü.
20	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + PP_{dep}	Das ist typisch **für** ihn. Ich bin auf deinen Bericht gespannt. Er ist von seinen Sorgen frei.	**2 f)**	Tio estas tipo por **li**. Mi estas scivola **pri** tia **raporto**. Li estas libera de ciuj **zorgoj**.
20	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + PPdep	Ich bin bei ihm angestellt.	**2 b)**	Mi estas en **lia** servo.
20	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + PP_{dep}	Er ist zu diesem Verbrechen fähig.	**2 h)**	Li estas kapabla **al** tiu **krimo**.
20	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + PPdep	Das ist bezeichnend **für** ihn. Das ist typisch **für** ihn.	**3 b)**	El tio **mi** tute rekonas **lin**.
20	Linking verb with adjective and dependent prepositional object as a subject	BE + AP + PP_{dep}	Er ist zu diesem Verbrechen fähig.	4 a)	Li kapablas al tiu krimo.

	adjective and dependent indirect object in the dative as a subject complement	$NP_{3\ dep}$			
2 i)	Linking verb with adjective and dependent indirect object in the genitive as a subject complement	BE + AP + $NP_{2\ dep}$	Er ist dieses Verbrechens fähig.	**2 h)**	Li estas kapabla **al** tiu **krimo**.
2 i)	Linking verb with adjective and dependent indirect object in the genitive as a subject complement	BE + AP + $NP_{2\ dep}$	Er ist seiner Sorgen ledig. Ich bin dessen eingedenk.	**2 f)**	Li estas libera de ciuj zorgoj. Mi estas **rememorante pri** tio.
2 i)	Linking verb with adjective and dependent indirect object in the genitive as a subject complement	BE + AP + $NP_{2\ dep}$	Er ist dieses Verbrechens fähig.	4 a)	Li kapablas al tiu krimo.
2 i)	Linking verb with adjective and dependent indirect object in the genitive as a subject complement	BE + AP + $NP_{2\ dep}$	Das ist der Mühe wert. Ich bin dessen eingedenk. Ich bin dessen gewärtig.	3 a)	Tio **valoras la** penon. Mi memoras tion. Mi atendas tion. Mi ekvidas tion.
2 i)	Linking verb with adjective and dependent indirect object in the genitive as a subject complement	BE + AP + $NP_{2\ dep}$	Ich bin dessen eingedenk.	6 a)	Mi memoras pri tion.
2 j)	Linking verb with adjective and dependent indirect object in the dative and dependent indirect object in the genitive as a subject complement	BE + AP + $NP_{3\ dep}$ + $NP_{2\ dep}$	Ich wurde mir dessen bewußt.	6 a)	Mi **konscii^gis** pri tion.
2 k)	Linking verb with adjective and a	BE + AP + $NP_{3\ dep}$ +	Er ist mir an Fleiß überlegen.	**3 b)**	Li **superas min je** diligenteco. Li superas

3 c)	Transitive verb with direct object with spatial object as an adjunct	Vt + dO + PPs	Ich lege das Buch auf den Tisch. Er legt seine Hand auf meine Schulter.	**3 c)**	Mi metas libron sur **la** tablon. Li metas sian **manon** sur **mian ^sultron**.
3 d)	Transitive verb with direct object with temporal object as an adjunct	Vt + dO + **PP_T**	Ich verschob das **Treffen** auf morgen.	**3 d)**	Mi **prokrastis** la renkonton **^gis** morgaü.
3 d)	Transitive verb with direct object with temporal object as an adjunct	Vt + dO + **PP_T**	Er zog das Gespräch in die Länge.	3 a)	Li **longi^gis** la **interparolon**.
3e)	Complex transitive verb with direct object and identifying accusative	**Vct + dO + NP_4**	Er nennt ihn einen Lügner.	**3 e)**	Li **nomas lin mensogulo**.
3 e)	Complex transitive verb with direct object and identifying accusative	**Vct + dO + NP_4**	Er nennt ihn einen Lügner.	**3 k)**	Li nomas lin kiel **mensogulon**.
30	Double transitive verb with a direct object and an indirect object (dative)	Vdt + dO + iO	Ich gebe ihm das Buch.	**3 f)**	Mi donas la libron al li.
3g)	Double transitive verb with two direct objects	Vdt + dO + dO	Ich lehre ihn die französische Sprache.	**3 f)**	Mi **instruas** francan **lingvon** al li.
3 h)	Transitive verb with direct object and object of manner as an adjunct	Vt + dO + **PP_M**	Er empfing ihn freundlich.	**3 h)**	Li **ricevis** lin **agrable**.
3 i)	Complex transitive verb with an object of manner and a dependent direct object as an adjunct	**Vct + PP_M + NP_4** dep	Der Arbeiter macht die Mauer weiß.	3 0	La laboristo faras la muron **blanka**.
3 i)	Complex transitive verb with an object of manner and a dependent direct object as an adjunct	**Vct + PP_M + NP_4** dep	Die Mutter macht die Suppe warm. Der Arbeiter macht die Mauer weiß.	3 a)	La patrino **varmigas** la supon. La laboristo **blankigas** la muron. La laboristo **blankpentras** la muron.

	and a prepositional object as adjuncts	+ PP	gegenüber. Ich verhalte mich ihm gegenüber freundlich.	b)	**Koncerne lin mi** kondutas **amikece**
3 o)	Reflexive verb	Vr	Ich freue mich.	1)	Mi **^gojas**.
3 o)	Reflexive verb	Vr	Ich erinnere mich.	3 a)	Mi memoras tion.
3 o)	Reflexive verb	Vr	Ich erinnere mich.	6 a)	Mi memoras **pri** tion.
3 o)	Reflexive verb	Vr	Ich erinnere mich.	**2 f)**	Mi estas rememorante pri tion.
4 a)	Intransitive verb with an indirect object	Vi + iO	Die Musik gefällt mir.	4 a)	Muzico **pla^cas al** mi.
4 a)	Intransitive verb with an indirect object	Vi + iO	Das hilft mir. Das Werkzeug nützt mir. Er ist mir gewogen.	2h)	Tio estas **serva** al mi. La **laborilo** estas **utila** al mi. Mi simpatias al **li**.
4 a)	Intransitive verb with an indirect object	Vi + iO	Die Musik gefällt mir.	3 a)	Mi **^satas** muzicon.
4 a)	Intransitive verb with an indirect object	Vi + iO	Ich grolle ihm.	6 a)	Mi koleras **kontraŭ**. li.
4 b)	Intransitive verb with an indirect object and a prepositional object as an adjunct	Vi + iO+ PP	Er spricht mit mir über das Buch.	**4 b)**	Li parolas al mi pri la **libro**.
4 b)	Intransitive verb with an indirect object and a prepositional object **as** an adjunct	Vi + iO+ PP	Ich stehe ihm zu Diensten. Ich stehe ihm zur Verfügung.	**2 b)**	Mi estas en lia servo. Mi estas je lia servo.
4 c)	Intransitive verb with an indirect object and an object of manner as an adjunct	Vi + iO + PP_M	Es tut mir leid. Es geht ihm gut.	1)	Mi bedauras. Li **bonfartas**.
4 c)	Intransitive verb with an indirect object and an object of manner as an adjunct	Vi + iO + PP_M	Das sieht ihm ähnlich.	**2 f)**	Tio estas tipo por li.
4 c)	Intransitive verb with an indirect	Vi + iO +	Er tut mir leid.	3 a)	Mi bedauras lin.

	of pertinence as an object complement and an object of space as an adjunct	dep			
4 g)	Intransitive verb with an object of space with a dative of pertinence as an adjunct	Vi + PP_S + $NP_{3\ dep}$	Er klopft mir auf die Schulter.	3 a)	Li batelas mian **^sultron**.
4 h)	Complex transitive verb with a direct object with a dative of pertinence as an object complement, and an object of space as an adjunct	**Vct** + dO+ PP_S + NP_3 dep	Er legt mir die Hand auf die Schulter.	**3 c)**	**Li** metas sian manon sur mian **^sultron**.
5)	Intransitive verb with genitive object	Vi + NP_2	Ich gedenke seiner. Ich harre seiner.	3 a)	Mi memoras **lin**. Mi atendas lin.
5)	Intransitive verb with genitive object	Vi + NP_2	Ich gedenke seiner.	6 a)	Mi memoras **pri li**.
5)	Intransitive verb with genitive object	Vi + NP_2	Ich gedenke seiner.	**2 f)**	Mi estas **rememorante** pri li.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Ich schreibe über die Zeitung.	6 a)	Mi **skribas** pri **la** gazeto.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Ich stehe in seinem Dienst.	**2 b)**	Mi estas en **lia servo**.**Mi** estas je lia servo.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Ich warte auf ihn.	3 a)	Mi atendas lin.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Ich denke an ihn.	**2 f)**	Mi estas rememorante **pri li**..
6 b)	Intransitive verb with two prepositional objects as adjuncts	Vi + PP+ PP	Ich diskutiere mit ihm über das Buch.	**6 b)**	Mi **diskutas kun** li pri la **libro**.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	Ich komme morgen. Ich komme im Sommer.	7)	Mi venös **morgaŭ**. Mi venös somere.
7)	Intransitive verb	Vi + PP_T	Das Treffen findet	**2 e)**	La **renkonto** estos

10 **d)**	Complex transitive verb with a direct object and an object of manner with a dependent direct object as an object complement	Vt + dO + **PP_S** + **dO_{dep}**	Er wirft den Ball einen Meter hoch. Er wirft den Ball einen Meter weit.	10 **d)**	Li **^jetas** pilkon unu metron alten. Li **^jetas** pilkon unu metron malproksimen.
10 e)	Intransitive verb with a spatial object with a dependent direct object as an adjunct	Vi + **PP_S** + dOdep	Er geht die Stiege hinunter.	3 a)	Li **malsupreniras la stuparon**.
10 e)	Intransitive verb with a spatial object with a dependent direct object as an adjunct	Vi + **PP_S** + **dO_{dep}**	Er geht die Stiege hinunter. Er fährt ins Tal hinunter.	8)	Li malsupreniras sur la stuparon. Li **skias valen**.
10 0	Complex transitive verb with a direct object and a spatial object with a dependent direct object as an adjunct	**Vct** +dO + PPs + **dO_{dep}**	Sie warfen ihn die Treppe hinunter.	**3 c)**	**Ili malsupren^jetis lin** sur la stuparon.

A great number of German sentences can be translated into pattern 1 or pattern **3 a,** which are also the most frequently used sentence patterns in Esperanto. In most cases, however, there are several possibilities for each sentence pattern to be mapped to an Esperanto pattern. Very often these possibilities are equivalent, as for example *Li **bonfartas.Li fartasbone.*** for *Es geht ihm gut.* in German or *He is **well.*** in English. Apart from stylistic matters, there are no differences between those two Esperanto sentences. In Esperanto, the first example would be considered as more elegant.

Some German sentence patterns cannot be translated directly into Esperanto, as for example the ones with genitive objects. Others can be used also in **Esperanto,** but they are not common ones, as for example pattern 3i, which is considered as primitive in Esperanto, or patterns 4d and 4e, which can be translated literally into Esperanto, but do not constitute prevalent sentence patterns in Esperanto. Normally Esperanto does not make use of datives of pertinence. In this case Esperanto can be adapted to the German language.

2 b)	Linking verb with identifying prepositional phrase as a subject complement	BE + PP	This is like him.	**2 f)**	Tio estas tipo por **li**.
2 b)	Linking verb with identifying prepositional phrase as a subject complement	BE + PP	This is like him.	**3 b)**	El tio mi tute rekonas **lin**.
2c)	Linking verb with adjective as a subject complement	**BE** + AP	The rose is beautiful.	**2 c)**	La rozo estas **bela**.
2c)	Linking verb with adjective as a subject complement	BE + AP	I am happy. I am sorry. The rose is beautiful. I am well.	1)	Mi **^gojas**. Mi bedauras. La rozo **belas**. Mi **bonfartas**.
2 c)	Linking verb with adjective as a subject complement	BE + AP	I am well.	10 a)	Mi **fartas** bone.
2 d)	Linking Verb with adverb of place as a **subject** complement	BE + $\mathbf{PP_S}$	The book is on the table.	**2 d)**	La **libro** estas sur la **tablo**.
2 e)	Linking verb with adverb of time as a subject complement	BE + $\mathbf{PP_T}$	The meeting will be tomorrow.	**2 e)**	La **renkonto** estos morgaü.
2 e)	Linking verb with adverb of time as a subject complement	BE + $\mathbf{PP_T}$	The meeting will be tomorrow.	7)	La renkonto okazos morgaü.
2 f)	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + $\mathbf{PP_{dep}}$	He is free of his sorrows. This is typical of him.	**2 f)**	Li estas libera de ciuj **zorgoj**. Tio estas tipo por li.
20	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + $\mathbf{PP_{dep}}$	I am rid of my money.	2c)	Mia mono estas for. Mia mono estas perdita.
20	Linking verb with adjective and dependent prepositional object	BE + AP + PPdep	He is capable of this crime.	**2 h)**	Li estas kapabla **al** tiu **krimo**.

	object in the dative as a subject complement		stranger to me.		estas stranga por mi.
2 h)	Linking verb with an adjective and dependent indirect object in the dative as a subject complement	BE + AP + $NP_{3\ dep}$	The tool is useful to me. He is similar to him.	4 a)	La **laborilo servas al** mi. Li similas al **li**.
3 a)	Transitive verb with direct object	Vt + dO	He is reading a book. I like the music. I remember him.	3 a)	Li **legas** libron. Mi **^satas** muzicon. Mi memoras **lin**.
3 a)	Transitive verb with direct object	Vt + dO	I serve him.	**2 b)**	Mi estas en **lia** servo.
3 a)	Transitive verb with direct object	Vt + dO	The tool serves me. This helps me.	**2 f)**	La laborilo estas serva por mi. La laborilo estas **utila** por mi. Tio estas utila por mi.
3 a)	Transitive verb with direct object	Vt + dO	The tool serves me. This helps me. He resembles me.	**2 h)**	La laborilo estas serva al mi. La laborilo estas utila al mi. Li estas **simila** al mi.
3 a)	Transitive verb with direct object	Vt + dO	The tool serves me. This helps me. He resembles me. I like the music. The doctor straightens my nose. He strokes my cheek.	4 a)	La laborilo servas al mi. Tio estas serva al mi. Li similas al mi. La muziko **pla^cas** al mi. La **kuracisto rektigas mian** nazon. Li karesas **mian** vangon.
3 a)	Transitive verb with direct object	Vt + dO	The doctor straightens my nose. He strokes my cheek.	**4 e)**	La kuracisto rektigas la nazon al mi. Li karesas la vangon al mi.
3 a)	Transitive verb with direct object	Vt + dO	I remember him.	6 a)	Mi memoras **pri** li.
3 a)	Transitive verb with direct object	Vt + dO	I remember him.	**2 f)**	Mi estas rememorante **pri li**.
3 b)	Transitive verb with direct object and prepositional object as an adjunct	Vt + dO + PP	I write a letter about my friend.	**3 b)**	Mi **skribas** leteron pri **mia amiko**.

	verb with a direct object and an adjective as an object complement	AP	the wall white. He dyes his hair black.		muron **blanka**. Li **tinkturas** la **hararojn nigraj**.
3 i)	Complex transitive verb with a direct object and an adjective as an object complement	Vt + dO + AP	Mother paints the table white.	3 a)	La **patrino blankpentras** la tablon.
3k)	Complex transitive verb with direct object and prepositional phrase as an object complement	Vi + NP_4+ PP	They elected him for president.	**3 e)**	Hi **elektis lin** prezidanto.
3k)	Complex transitive verb with direct object and prepositional phrase as an object complement	Vi + NP_4+ PP	They elected him as president.	**3 k)**	Hi elektis lin kiel prezidanton.
3 l)	Complex transitive verb with direct object and an adjective phrase as an object complement	Vi + NP_4+ AP	They considered him intelligent.	**3 l)**	Hi **konsideris** lin kiel **inteligentan**.
3m)	Reflexive verb with direct object and an object of manner as an adjunct	Vr + NP_4+ PP_M	He behaves himself well.	1)	Li **bonkondutas**.
3m)	Reflexive verb with direct object and an object of manner as an adjunct	Vr + NP_4+ PP_M	He behaves himself well.	10 a)	Li kondutas bone.
3 n)	Reflexive verb with direct object and an object of manner and a prepositional phrase as adjuncts	Vr + NP_4+ PP_M + PP	He behaves himself well towards him.	6 a)	Li bonkondutas vidalvide de **li**.
3 n)	Reflexive verb with direct object and an object of manner and a prepositional	Vr + NP_4+ PP_M + PP	He behaves himself in a friendly way towards me.	10 b)	Li kondutas amikeze vidalvide de mi.

9)	Intransitive verb with an object of causality as an adjunct	Vi + **PP_C**	He did it for friendship's sake.	9)	Li **faris** tion pro **amikeco**.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + **PP_M**	He goes by taxi. He came quickly.	10 a)	Li iras taksie. Li **venis** rapide.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + **PP_M**	He goes by taxi.	1)	Li taksias.
10 b)	Intransitive verb with an **object** of manner and a prepositional object as adjuncts	**Vi+ PP_M** + PP	He went to the hotel by taxi.	10 b)	Li iris hotelen **kun** taksio.
10 c)	Intransitive verb with an object of manner and a spatial object as adjuncts	**Vi+ PP_M** + PPs	He goes to the hotel by taxi.	10 c)	Li iras hotelen taksie. Li iras hotelen kun taksio.
10 c)	Intransitive verb with an object of manner and a spatial object as adjuncts	**Vi+ PP_M** + PPs	He goes to the hotel by taxi.	10 a)	Li taksias hotelen.
10 **d)**	Complex transitive verb with a direct object and a spatial object with a dependent direct object as an object complement	**Vct** + dO + PPs **+NP_4** dep	He throws the ball one **meter** high. He throws the ball one meter away.	10 d)	Li **^jetas** pilkon unu metron alten. Li **^jetas** pilkon unu metron malproksimen.
10 e)	Intransitive verb with a spatial object and a dependent direct object as an adjunct	Vi + PPs + **$NP_{4\ dep}$**	He goes down the stairs.	3 a)	Li **malsupreniras** la stuparon.
10 e)	Intransitive verb with a spatial object and a dependent direct object as an adjunct	Vi + PPs + **$NP_{4\ dep}$**	He goes down the stairs.	**3 c)**	Li malsupreniras sur la stuparon.
10 0	Complex transitive verb with a direct object and a spatial object with a	**Vct** + dO + PPs **+NP_4** dep	They threw him down the stairs.	**3 c)**	Hi **malsupren^jetis lin** sur la stuparon.

7 The Translation Algorithm

The following section shows how translation based on sentence patterns works. First, the working of the algorithm will be shown for some selected patterns on translation from Esperanto into German and from German into Esperanto. Since it has become clear from the translation tables and matrices that the patterns 1 and 3a are the most heavily used sentence patterns of all languages under consideration, patterns 1 and 3 were selected for closer examination. Likewise, pattern 0 that exists only in Esperanto was added, in order to show in what way it is mapped to the other languages. As all instances of pattern 2 form an exception in so far that not only the valence of the main verb of the sentence, but also the valence of the adjective must be considered, pattern 2 was also included into the selected patterns. The translations from Esperanto to German and from German to Esperanto were chosen because German contains the wider variety of sentence patterns, especially the sentences of pattern 2 that include nearly all the complex adjective phrase patterns. Of course, this algorithm works exactly the same way with the translation from Esperanto to English as with the translation from English to Esperanto, therefore a demonstration with the selected patterns above is sufficient for understanding.

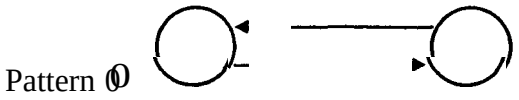
7.1 Selected Patterns

7.1.1 Pattern 0

(only in Esperanto)
verb valence 0

$S \rightarrow NP\ VP$
$NP \rightarrow \varepsilon$
$VP \rightarrow Vi$

$S \rightarrow NP\ VP$
$NP \rightarrow N$
$VP \rightarrow Vi$

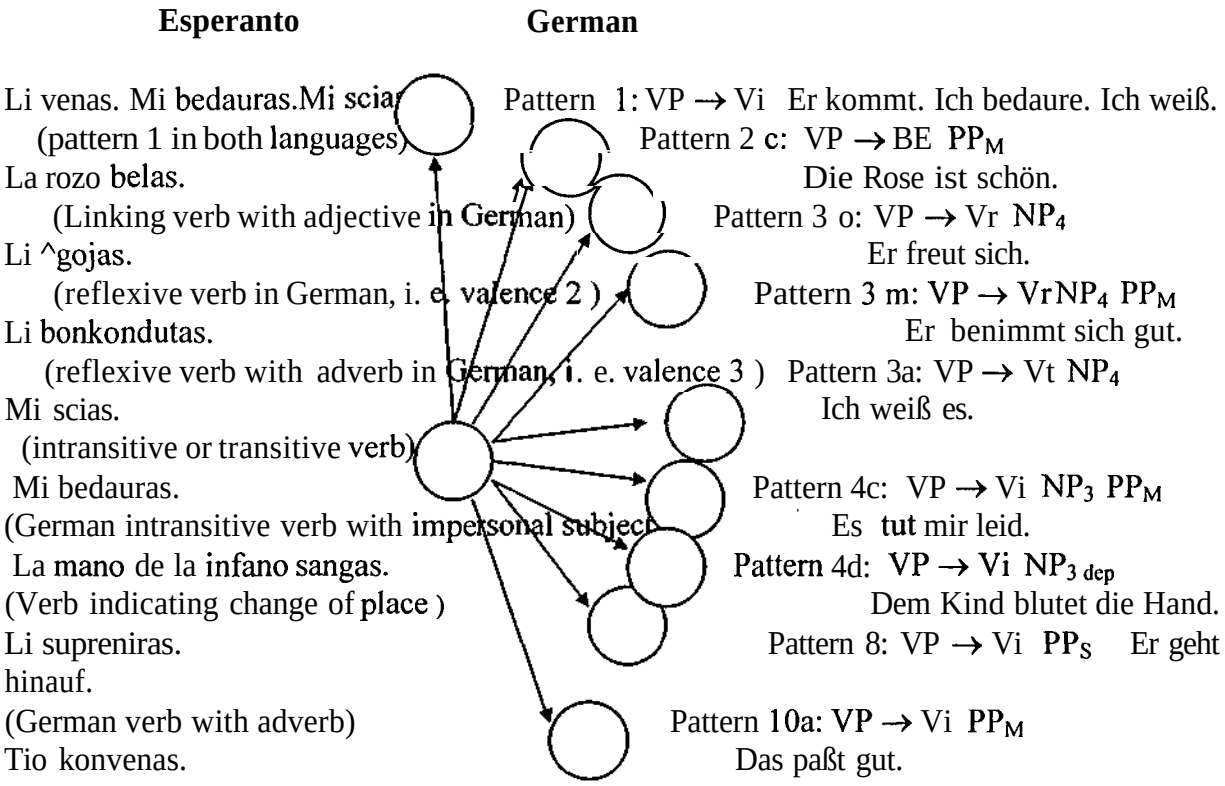


Pattern 0
Pluvas.

Pattern 1
Es regnet.

Pluvas.
Es regnet.

This pattern can only be found in Esperanto. It corresponds to a similar pattern in Romance languages, e. g. in Italian, but certainly not in English or German. The valence of the verb is 0, since these verbs neither take subjects nor any other components, but stand alone in the sentence. Verbs referring to weather usually take this pattern. All verbs with valence 0 in Esperanto have valence 1 in English and German.



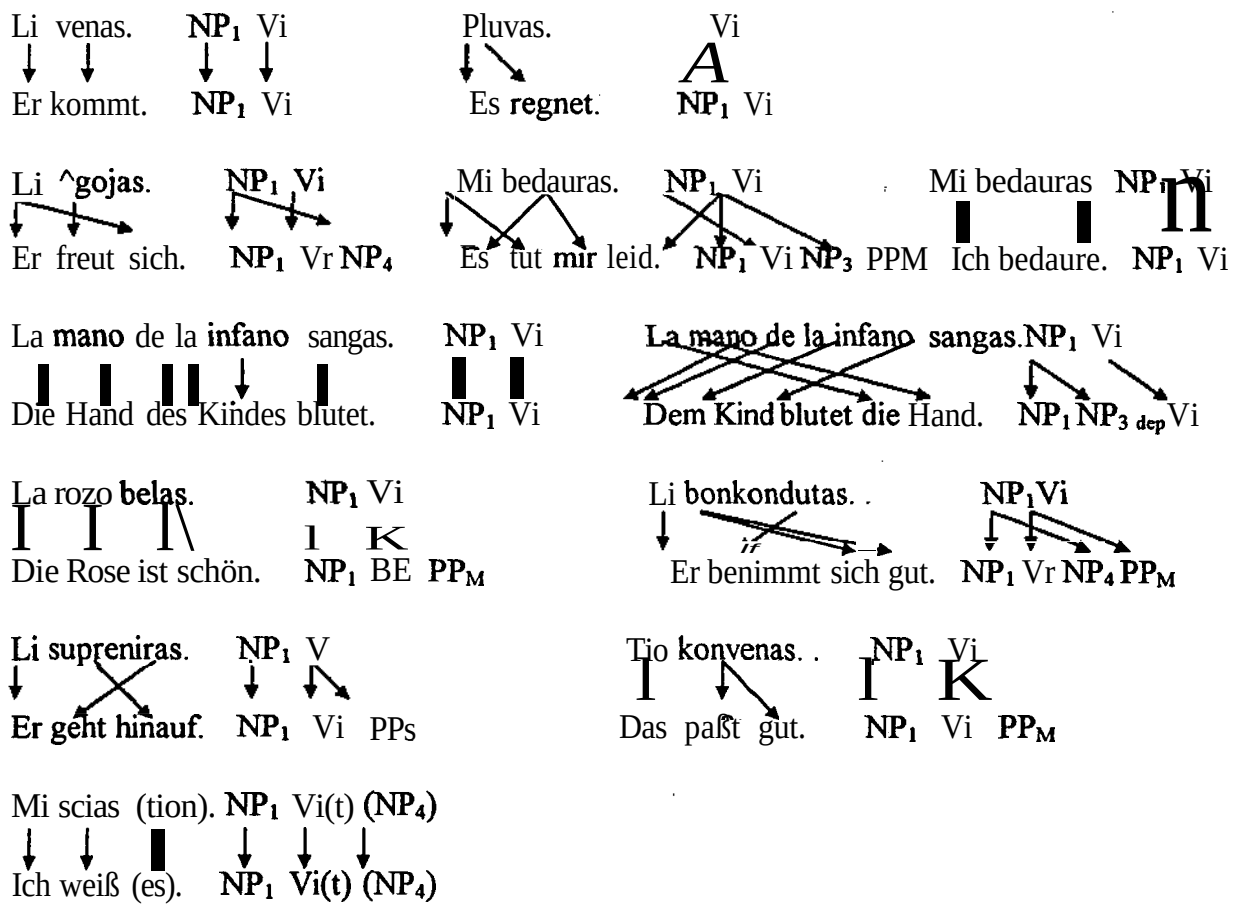
Intransitive verbs usually take this pattern. In German and English this is the shortest possible sentence pattern. In Esperanto, this pattern is very often used. In many cases, sentences with a verb, often a reflexive verb, and an adjective or an adverb, can be translated by a single intransitive verb in Esperanto. Sentences of this kind seem to be most popular and are considered as most elegant style. Generally, the shorter a sentence pattern, the more often it will be used in Esperanto.

7.1.2.2 German to Esperanto

There are far less pattern one sentences in German than in Esperanto. They are made up by intransitive verbs. Verbs mostly referring to the weather with impersonal subjects can be translated as pattern 0 verbs into Esperanto. In fact, all Esperanto pattern 0 verbs correspond to German pattern 1 verbs. Second, Esperanto intransitive verbs are often translated into German pattern one verbs. Some verbs that can be used as transitive verbs as well as intransitive verbs, as for example verbs of feeling, believing, or knowing, may also be translated into pattern 1 sentences as well as pattern 3a sentences. This is shown by the figure below.

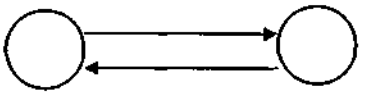
Likewise, as with German sentences when they are translated into Esperanto, one Esperanto verb may subsume a German verb with several components, for example adverbs or reflexive pronouns.

This will depicted in the following section. It is necessary to find first the verb and then the remaining components of the sentence. They are stored in a **buffer**. By the valence of the verb, the pattern of the sentence is determined. In this section, pattern 0 and pattern 1 sentences are shown together, as Esperanto pattern 0 sentences have to be translated into German pattern 1 sentences in any case. Pattern 0 sentences consist of only one verb, pattern 1 sentences consist of a noun phrase and a verb. These are stored in a buffer. Next, the various components are looked up in a German-Esperanto dictionary and translated. The translated words are stored in a second buffer. The valences of the words of the target language are looked up and the translated components arranged in their correct positions. In the end they are output on the screen and stored in a file. The following examples show in what way the words may be translated and arranged in their correct positions. The arrows indicate where after translation of the source language the corresponding element in the target language can be found.



VP → BE NP_1 VP → BE NP,
verb valence 2

Pattern 2 a
Li estas studento.



Pattern 2 a
Er ist (ein) Student.

This pattern can be found in Esperanto as well as in German and English. It never changes on translation, and there are no other possibilities of translating it.

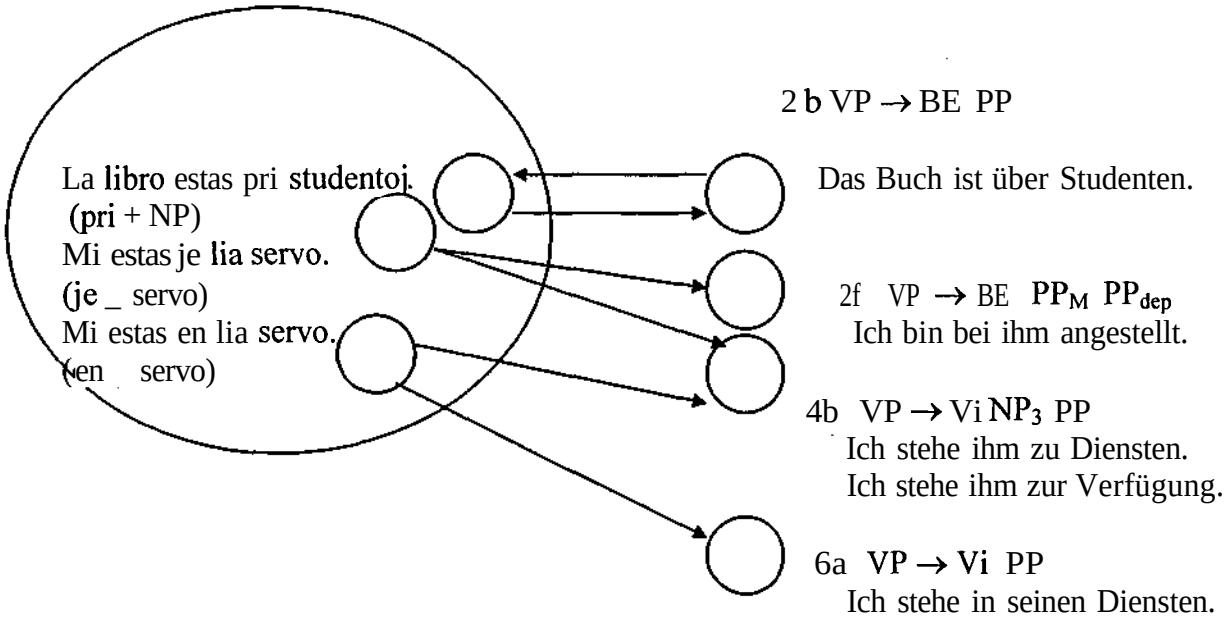
2 b)

(linking verb with identifying prepositional phrase)

There are several ways of translating sentences containing a linking verb with an identifying prepositional phrase, as this pattern has a wider variety in German. Especially in German it is very popular. Pattern 2b sentences can be translated with identifying prepositional phrases again (pattern 2b), but also with a linking verb and an adjective with a dependent noun phrase (pattern 2f). Likewise, it is possible to translate the linking verb with the identifying prepositional phrase by a full verb with a prepositional phrase (pattern 6a) or an indirect object in the dative with a prepositional phrase (pattern 4b).

Esperanto **German**

S → NP VP
NP → N
VP → BE PP
verb valence 2

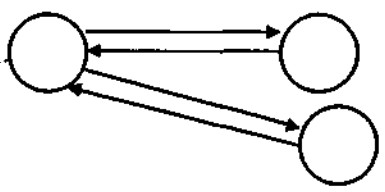


2 e)
(linking verb with adverb of time)

Esperanto **German**

S → NP VP **S → NP VP**
VP → BE PP_T **VP → BE PP_T**
verb valence 2
adverb (phrase) valence 0

Pattern 2 e
La **renkonto** estos morgaŭ.



Pattern 2 e
Das **Treffen** ist morgen.
Pattern 7
Das Treffen findet morgen statt.

This sentence pattern is formed by a linking verb and a temporal object. The linking verb has valence 2, like all linking verbs, and the valence of the adverb of time is 0, since it does not require any other components. This pattern can be found in Esperanto as well as in German and English. Alternatively, the linking verb can be translated by an intransitive verb. Thus Esperanto pattern 2e sentences can be translated into German pattern 2e again, or by sentences with an intransitive verb and an adverb of time, i. e. pattern 7 sentences. Likewise, Esperanto pattern 7 sentences can be translated into German pattern 2e sentences.

2 f)
(linking verb with adjective and dependent prepositional phrase)

This sentence pattern is formed by a linking verb and an adjective with a dependent prepositional phrase. The linking verb has valence 2, like all linking verbs, and the valence of the adjective is **1,** since it requires a prepositional phrase. In Esperanto adjectives with dependent prepositional phrases generally have the valence 1, which means that one phrase, usually a prepositional phrase, may depend on that adjective. Of course, this pattern may be translated into a prepositional phrase again (pattern **2f)**. In **German,** however, this need not necessarily be a prepositional phrase. It is possible that the Esperanto dependent prepositional phrase is translated as a direct object (pattern 2g) or into an indirect object in the genitive (pattern 2i). On the other hand, the linking verb may be translated into a full verb, the depending adjective into a depending adjective again, and the prepositional phrase as an indirect object in the dative (pattern 4c). The Esperanto linking verb with the adjective may also be translated into a reflexive verb, forming pattern 3 o (pattern 3 o). If the Esperanto depending prepositional object is translated as a prepositional phrase in German, we achieve

Pattern 2 g

(linking verb with adjective and dependent direct object)

Esperanto

$S \rightarrow NP\ VP$

$VP \rightarrow BE\ PP_M\ NP_{4\ dep}$

verb valence 2

adjective valence 1

La fendo estas du metrojn **longa**.

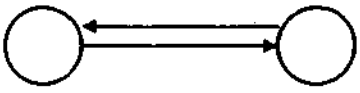
Pattern 2 g

German

$S \rightarrow NP\ VP$

$VP \rightarrow BE\ PP_M\ NP_{4\ dep}$

Der Spalt ist zwei Meter lang.



This sentence pattern is formed by a linking verb and an adjective with a dependent direct object. The linking verb has valence 2, like all Unking verbs, and the valence of the adjective is 1, since it requires a direct object. This pattern can be found in Esperanto as well as in German and English. It never changes on translation, and there are no other possibilities of translating it.

2 h)

(linking verb with adjective and dependent indirect object)

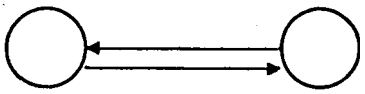
This sentence pattern is formed by a linking verb and an adjective with a dependent indirect object. The linking verb has valence 2, like all linking verbs, and the valence of the adjective is 1, since it requires an indirect object. In Esperanto adjectives with a dependent indirect object (in the dative) generally have the valence **1,** which means that one noun phrase, usually a prepositional phrase, may depend on the adjective. Of course, this pattern may be translated into a linking verb with an adjective and a dependent indirect object in the dative again (pattern 2h). In German, however, this need not necessarily be an indirect object in the dative . It is possible that the Esperanto dependent prepositional phrase **is** translated as a prepositional phrase (pattern **2f)** or into an indirect object in the genitive (pattern 2i). The latter would not be possible in Esperanto, only in German, and even in German, these genitive objects tend to disappear. On the other hand, the linking verb and the dependent adjective may be translated into a full verb, while the indirect object in the dative in Esperanto remains an indirect object in the dative (pattern 4a).

This pattern can be found in Esperanto as well as in German and English. It never changes on translation, and there are no other possibilities of translating it.

2 b)
(linking verb with identifying prepositional phrase)

German	**Esperanto**
S → NP VP	**S → NP VP**
VP → BE PP	VP → BE PP
verb valence 2	

Pattern 2 b
Das Buch ist über Studenten.



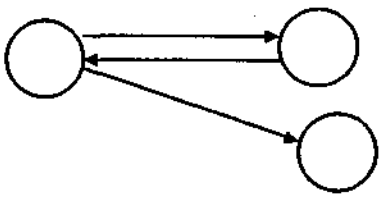
Pattern 2 b
La **libro** estas **pri studentoj**.

German sentences with linking verbs and a prepositional phrase are translated by the same sentence pattern in Esperanto. This pattern is popular in both languages, but especially in Esperanto, where not as many indirect objects are used as in German. Thus many German sentence patters 2 can be translated into Esperanto 2b.

2c)
(linking verb with adjective phrase)

German	**Esperanto**
S → NP VP	
VP → BE PP_M	
verb valence 2	
adjective (phrase) valence 0	

Die Rose ist schön.



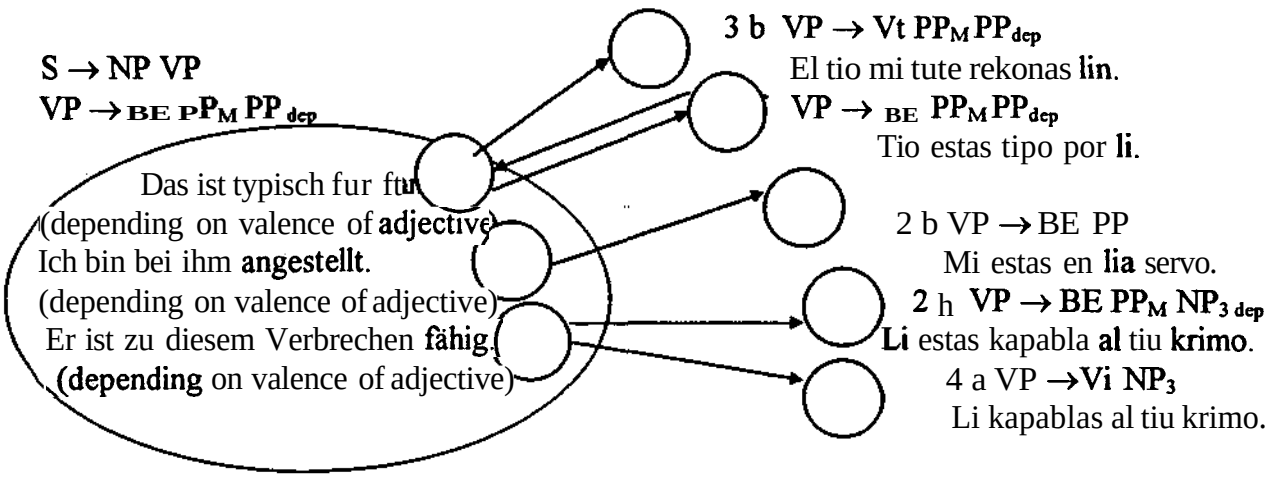
2 c **VP → BE PP_M**
La rozo estas **bela**.

1 **VP →** Vi
La rozo **belas**.

This sentence pattern is formed by a linking verb and an adjective (phrase). The linking verb has valence 2, like all linking verbs, and the valence of the adjective is 0, since it does not require any other components. In many cases, it is equally possible to translate the German pattern 2c, i.e. a linking verb with an adjective, into Esperanto pattern 2c as well as into Esperanto pattern **1**. In the latter, the intransitive verb expresses both the linking verb and the adjective.

2 f)
(linking verb with adjective and dependent prepositional phrase)
German **Esperanto**

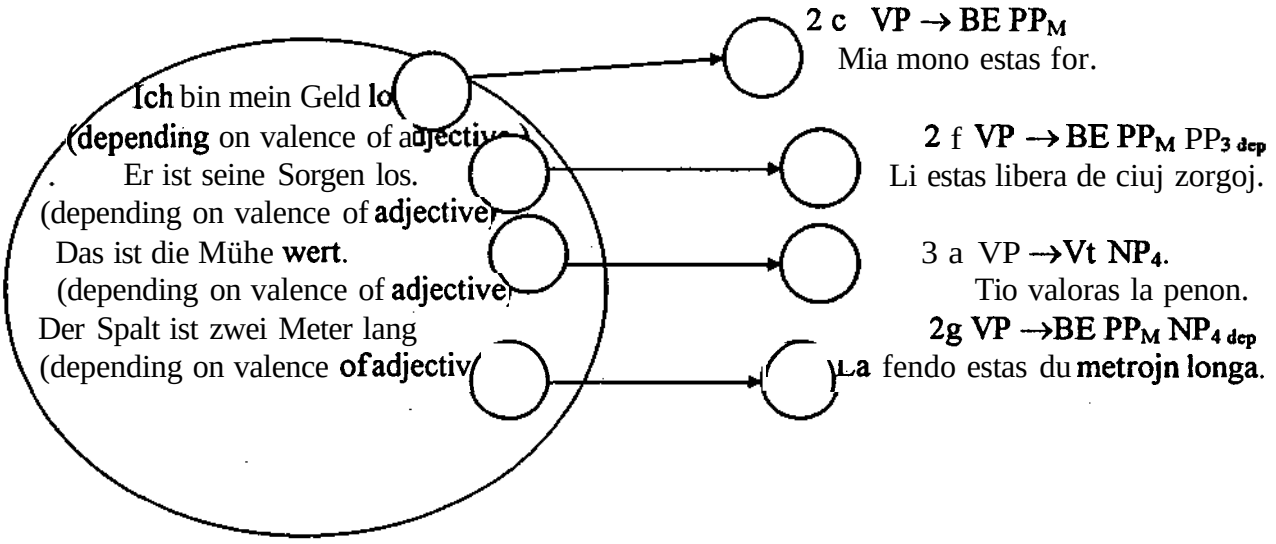
verb valence 2
adjective (phrase) valence 1



This sentence pattern is formed by a linking verb and an adjective with a dependent prepositional phrase. The linking verb has valence 2, like all linking verbs, and the valence of the adjective is 1, since it requires a prepositional phrase. Sentence patterns with linking verbs and complex prepositional phrases are often used in German. They can be translated in many possible ways in Esperanto. Either they take the same pattern with a linking verb and an adjective with one dependent prepositional phrase (pattern **2f),** or the German dependent prepositional phrase can be translated into an Esperanto indirect object (pattern 2h). It is also possible that the German pattern 2f is translated into a linking verb and a prepositional phrase without an adjective in Esperanto (pattern 2b), which means that the German dependent prepositional phrase is translated into a possessive pronoun as a determiner for the noun in the Esperanto prepositional phrase. Likewise the linking verb and the adjective can be translated into an intransitive verb in Esperanto, while the dependent prepositional phrase becomes an indirect object. Thus we obtain pattern 4a. If it is possible to translate the adjective together with the linking verb into a full verb in Esperanto, this is usually done, since sentences with full verbs are considered as better style than sentences with linking verbs. In contrast to most other pattern 2 sentences, where, beside the usual linking verbs, only intransitive verbs may be used for translation, this pattern may also take transitive verbs, where the German prepositional phrase becomes the direct object in Esperanto, the German subject becomes a prepositional phrase in Esperanto, and the German linking verb together with the adjective are expressed by a transitive verb in Esperanto. Thus, pattern 2f can also be translated into pattern

German **Esperanto**

S → NP VP
VP → BE PP_M $NP_{4\ dep}$
verb valence 2
adjective (phrase) valence 1



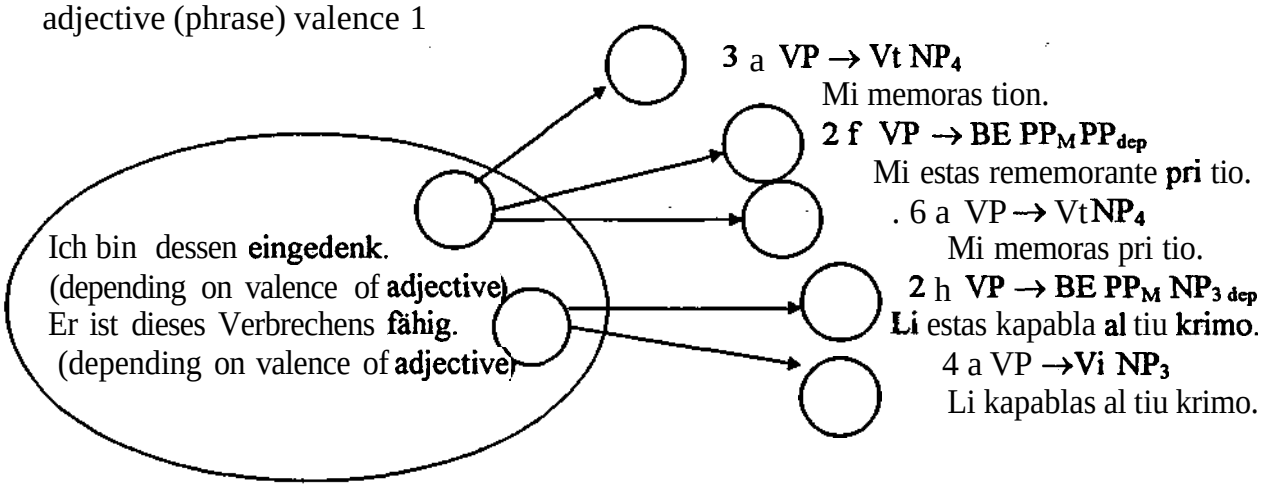
2h)
(linking verb with adjective and dependent indirect object in the dative)

This sentence pattern is formed by a linking verb and an adjective with a dependent indirect object in the dative. The linking verb has valence 2, like all linking verbs, and the valence of the adjective is 1, since it requires an indirect object. Again, this pattern is often used in German, though not as often as pattern 2g. The same is true for Esperanto, where indirect objects are used even more rarely. (It is much harder to find verbs requiring exclusively indirect objects in Esperanto than in German.) Nevertheless, German sentences with a linking verb and a dependent indirect object can be translated into the same pattern (pattern 2g) in Esperanto. More often, however, since this is considered as much better style, the German linking verb together with the adjective is translated into an Esperanto full verb expressing both. If this verb is a transitive verb and the German indirect object becomes a direct object in Esperanto (pattern 3 a), pattern 3a is obtained, if the verb is an intransitive verb and the German indirect object also remains one in Esperanto (pattern 4a), this results in pattern 4a, and if the verb is an intransitive verb and the German indirect object is translated into a prepositional phrase in Esperanto (pattern 6a), we get pattern 6a. If it is possible to translate the adjective together with the linking verb into a full verb in Esperanto, this is usually done, since sentences with full verbs are considered as stylistically better than sentences with linking verbs. For this

Esperanto (pattern **3** a), we achieve pattern **3** a, if the verb is an intransitive verb and the genitive object becomes an indirect object (in the dative) in Esperanto, we obtain pattern **4a,** and if the genitive object becomes a prepositional object, this results in pattern 6a. Each of these patterns is considered as excellent style. The exact way a German pattern 2i sentence is translated into Esperanto depends on the linking verbs and the valences of the adjectives in both the source and the target language.

German **Esperanto**

S → NP VP
VP → BE PP_M $NP_{2\ dep}$
verb valence 2
adjective (phrase) valence 1



2 j)
(linking verb with adjective, dependent indirect object in the dative and dependent object in the genitive)

This sentence pattern is formed by a linking verb and an adjective with a dependent prepositional phrase. The linking verb has valence 2, like all linking verbs, and the valence of the adjective is 2, since it requires a genitive object and a dative object. Again, sentences with a linking verb and an adjective with a dependent indirect object in the dative and a dependent object in the genitive are possible only in German. Genitive objects, whether dependent or not, can only be found in German in the first place. Secondly, adjectives with a valence more than one can only be found in German. In this sentence pattern, the adjective has to have valence two, since both a genitive object and a dative object depend on it. English and Esperanto adjectives can only have valence 0 (with no other depending complements) or one (one depending complement, as shown in the sentence patterns above).

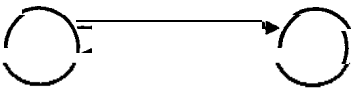
2 l)
(linking verb with an object of space and dependent prepositional phrase)

This sentence pattern is formed by a linking verb and an adjective with a dependent prepositional phrase. The linking verb has valence 2, like all linking verbs, and the valence of the adjective is 1, since it requires a prepositional phrase. Although pattern 21, which contains a linking verb with an object of space and dependent prepositional phrase, can be regarded as relatively simple compared to patterns 2j and 2k above, it can only be found in German, and there especially in official documents. In Esperanto it is translated into pattern 8, i. e. into an intransitive verb with a spatial object (pattern 8), where the Esperanto verb expresses the German linking verb and the spatial object, and the German prepositional phrase is translated into an Esperanto spatial object. There is no other alternative for translation.

German
S → NP VP
VP → BE **PP_S PP_{dep}**
verb valence 2
adverb (phrase) valence 1

Esperanto
S → NP VP
VP → Vi **PP_S**

Pattern 2 1
Er ist in Wien wohnhaft.



Pattern 8
Li logas Viene. Li logas en Vieno.

Again, this sentence pattern is only possible in **German,** since genitive objects can only be found in German. These sentences are invariably translated into pattern **3** a, where the German linking verb is translated into a transitive verb in Esperanto and the German genitive object into an Esperanto direct object (pattern **3a)**. There are no alternatives.

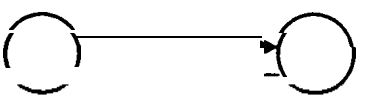
German

S → NP VP
VP → BE **NP_2**
verb valence 2

Esperanto

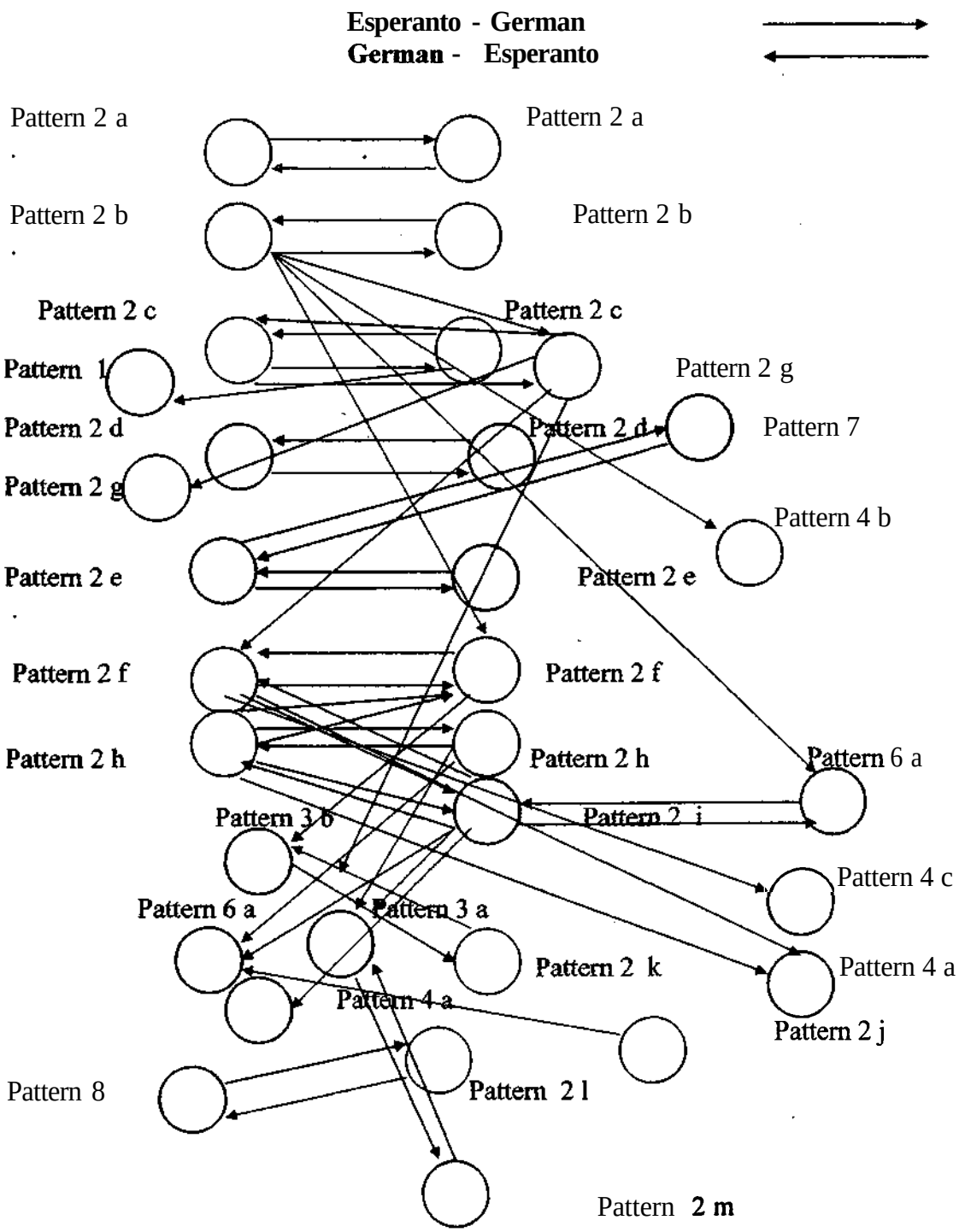
S → NP VP
VP → Vt **NP_4**

Pattern 2 m
Er ist anderer Meinung.



Pattern 3 a
Li **havas alian** opinion.

7,1.3.3 Both directions



With Pattern 2 sentences, verbs designating states or changes of states of the subject are used. Since they can not be looked upon as **full** verbs, but as linking verbs, they can only be used together with either noun phrases or adjectives as subject complements. In this way they can be regarded as having valence two.

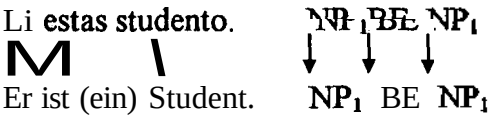
With linking verbs, however, the subject complements have to be taken into account. With noun phrases, their respective cases must be considered. With adjectives, the valences of the

respective adjectives have to be looked up and examined very closely. Thus the subpatterns of pattern two must be found by looking up the verbs as well as the valences of the adjectives and the cases of the noun phrases in order to assign them the correct subpatterns.

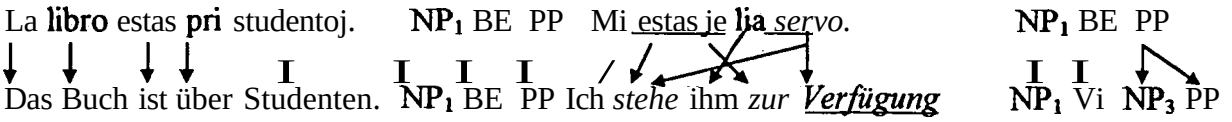
7.1.3.4 Translation

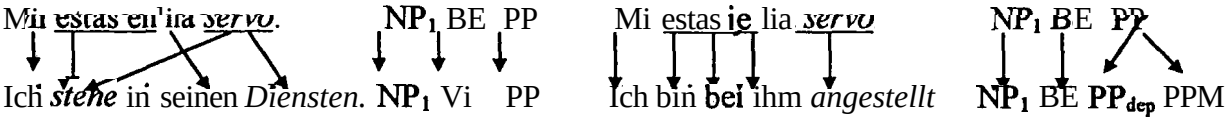
In this section, the translation of pattern two sentences will be shown. Again, the verbs have to be looked up. Since the sentences are pattern two, their valences have to be two. Then the components are examined and stored in a buffer. If the components are noun phrases, they can normally be translated without having to look into the dictionary for a second time. Only the sentence pattern with the noun phrase in the genitive of the German pattern 2m has to be translated by pattern **3 a,** thus using another kind of verb. With adjectives, the valences of the adjectives have to be looked up. The components of the adjective phrases have to be found and stored in a buffer in the **correct** positions.

2a NP_1 BE NP_1

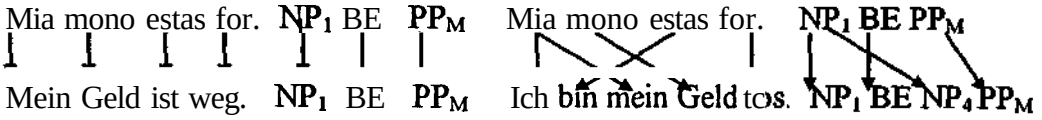


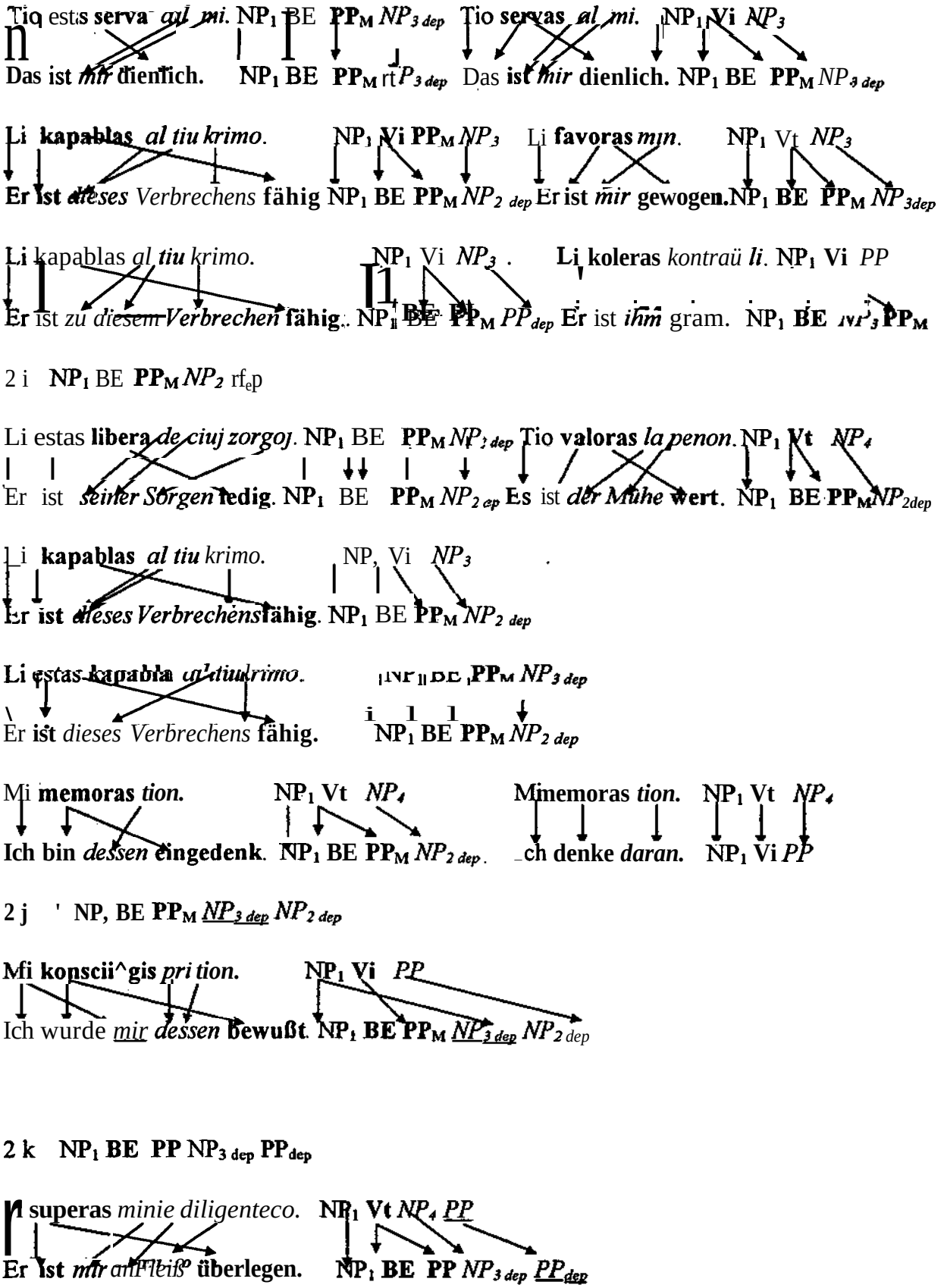
2b NP_1 BE PP





2c NP_1 BE PP_M




Tio estas serva al mi. NP1 BE PPM NP3 dep Tio servas al mi. NP1 Vi NP3
Das ist mir dienlich. NP1 BE PPM NP3 dep Das ist mir dienlich. NP1 BE PPM NP3 dep
Li kapablas al tiu krimo. NP1 Vi PPM NP3 Li favoras min. NP1 Vt NP3
Er ist dieses Verbrechens fähig NP1 BE PPM NP2 dep Er ist mir gewogen. NP1 BE PPM NP3dep
Li kapablas al tiu krimo. NP1 Vi NP3 . Li koleras kontraü li. NP1 Vi PP
Er ist zu diesem Verbrechen fähig. NP1 BE PPM PPdep Er ist ihm gram. NP1 BE NP3 PPM
2 i NP1 BE PPM NP2 rfep
Li estas libera de ciuj zorgoj. NP1 BE PPM NP2 dep Tio valoras la penon. NP1 Vt NP4
Er ist seiner Sorgen ledig. NP1 BE PPM NP2 ep Es ist der Mühe wert. NP1 BE PPM NP2dep
Li kapablas al tiu krimo. NP1 Vi NP3
Er ist dieses Verbrechens fähig. NP1 BE PPM NP2 dep
Li estas kapabla al tiu krimo. NP1 BE PPM NP3 dep
Er ist dieses Verbrechens fähig. NP1 BE PPM NP2 dep
Mi memoras tion. NP1 Vt NP4 Mi memoras tion. NP1 Vt NP4
Ich bin dessen eingedenk. NP1 BE PPM NP2 dep. Ich denke daran. NP1 Vi PP
2 j NP1 BE PPM NP3 dep NP2 dep
Mi konscii^gis pri tion. NP1 Vi PP
Ich wurde mir dessen bewußt. NP1 BE PPM NP3 dep NP2 dep
2 k NP1 BE PP NP3 dep PPdep
Li superas minie diligenteco. NP1 Vt NP4 PP
Er ist mir an Fleiß überlegen. NP1 BE PP NP3 dep PPdep

3 a)
(transitive verb with direct object)

As mentioned above, pattern **3** a is, perhaps together with pattern **1,** the most often used sentence pattern in Esperanto. It contains a transitive verb with a direct object. The valence of the verb is 2, since it requires a subject and a direct object. As the figure below shows, Esperanto pattern **3** a sentences can be translated in many German sentence patterns. Of course, it is possible to translate them into the German pattern **3a,** i. e. again as sentences with a transitive verb and a direct object (pattern **3** a). If the Esperanto transitive verb is translated into a German reflexive or transitive verb with a prepositional phrase, this results in a German pattern 3b sentence (pattern 3b). If the corresponding German verb is purely reflexive, i. e. it can never take a direct object different from the subject, this results in a German pattern **3o** sentence (pattern 3o). In Esperanto, purely reflexive verbs do not exist. Pattern 3j is obtained if a genitive object is added to the reflexive verb (pattern 3j), since the transitive verb overrides the reflexive verb. Likewise, if a German transitive verb takes a genitive object, pattern 3j is obtained. **In** Esperanto, both patterns do not exist, since there are neither purely reflexive verbs nor genitive objects. If a prepositional phrase is added instead of the genitive object (pattern 3b), we achieve pattern 3b. The latter pattern is used more often, and pattern 3j tends to disappear. When the Esperanto direct object is translated as a German temporal object, pattern 3d is obtained. Pattern 3a sentences can also be translated into sentences with a transitive verb and an adjective with a dependent direct object (pattern 3i). This pattern also exists in Esperanto, but it is considered as bad style.

Some transitive verbs can be also used as intransitive verbs and translated into sentences with one intransitive **verb(pattern** 1), thus forming pattern 1 in German. **All** these pattern 1 sentences can easily be replaced by pattern **3** a sentences in Esperanto as well as in German.

Another possible way of translating Esperanto pattern **3** a sentences is to use a linking verb with an adjective and a dependent object. Depending on the valence of the adjective this may be a direct object (pattern 2g), an indirect object in the dative (pattern 2h), or an indirect object in the genitive (pattern 2i), or the subject complement can simply consist of a linking verb with a genitive object (pattern 2m).

Esperanto pattern **3** a sentences can also be translated into pattern 4 sentences, which contain an intransitive verb and an indirect object (in the dative). If the Esperanto pattern 3a sentence is translated into a sentence with an intransitive verb and an indirect object in the dative

3a)

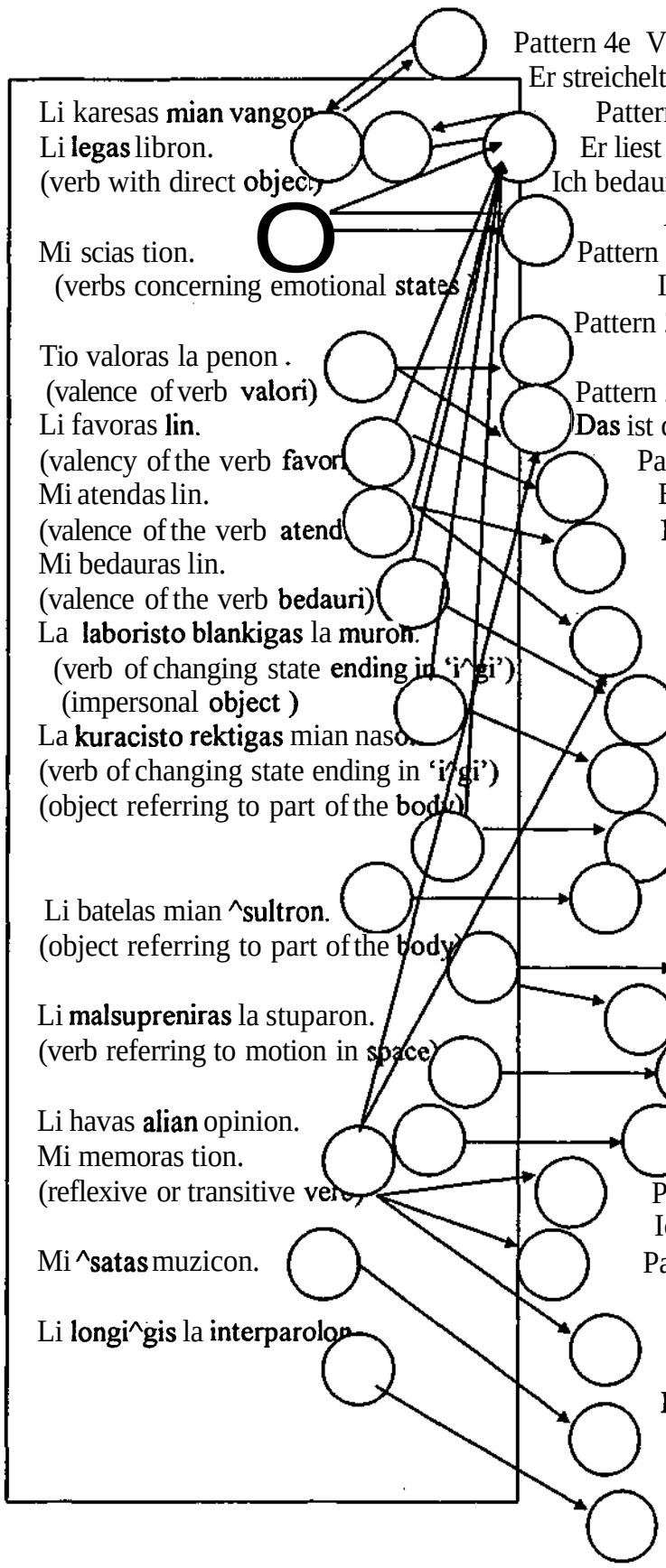
Esperanto

S → NP VP

VP → Vt NP_4

verb valence 2

German



Li karesas **mian vangon**.
Li **legas** libron.
(verb with direct **object**)

Mi scias tion.
(verbs concerning emotional **states**)

Tio valoras la penon .
(valence of verb **valori**)
Li favoras **lin**.
(valency of the verb **favori**)
Mi atendas lin.
(valence of the verb **atendi**)
Mi bedauras lin.
(valence of the verb **bedauri**)
La **laboristo blankigas** la **muron**.
(verb of changing state **ending in 'i^gi'**)
(impersonal **object**)
La **kuracisto rektigas** mian nason.
(verb of changing state ending in **'i^gi'**)
(object referring to part of the **body**)

Li batelas mian **^sultron**.
(object referring to part of the **body**)

Li **malsupreniras** la stuparon.
(verb referring to motion in **space**)

Li havas **alian** opinion.
Mi memoras tion.
(reflexive or transitive **verbs**)

Mi **^satas** muzicon.

Li **longi^gis** la **interparolon**.

Pattern 4e VP → Vt PP_M $NP_{4\ dep}$
Er streichelt mir die Wange.

Pattern 3 a **VP →** Vt **NP_4**
Er liest ein Buch. Ich weiß es. Er begünstigt ihn. Ich bedaure ihn. Der Arbeiter weißt die Mauer.Der Arzt richtet meine Nase gerade.

Pattern 1 VP → Vi
Ich weiß.

Pattern 2g VP → BE PP_M $NP_{4\ dep}$
Das ist die Mühe wert.

Pattern 2i VP → BE PP_M $NP_{2\ dep}$
Das ist der Mühe wert. Ich bin dessen eingedenk.

Pattern 2h VP → BE PP_M $NP_{3\ dep}$
Er ist ihm gewogen.

Pattern 6a **VP → Vi PP**
Ich warte auf ihn.

Pattern 5 VP → **Vi NP_2**
Ich harre seiner.

Pattern 4c VP → Vi PP_M $NP_{3\ dep}$
Er tut mir leid.

Pattern 3i VP → **Vt PP_M NP_4**
Der Arbeiter macht die Mauer weiß.

Pattern 4f VP → Vt PP_M $NP_{3\ dep}$ NP_4
Der Arzt richtet mir die Nase gerade.

Pattern 4g VP → Vi PP_S $NP_{3\ dep}$
Er klopft mir auf die Schulter.

Pattern 8 VP → V PP_S
Er klopft auf meine Schulter.

Pattern **10e** VP → **V PP_S $NP_{4\ dep}$**
Er geht die Stiege hinunter.

Pattern 2 m **VP → V NP_2**
Er ist anderer Meinung.

Pattern **3** b **VP → Vr NP_4 PP_M**
Ich erinnere mich daran.

Pattern 3j VP → **Vr NP_4 NP_2**
Ich erinnere mich dessen.

Pattern **3** o **VP → Vr NP_4**
Ich erinnere mich

Pattern 4a **VP → Vi NP_3**
Die Musik gefallt mir.

Pattern 3d **VP →** Vi **NP_3**
Er zog das Gespräch in die Länge.

3 c)
(transitive verb with direct object and spatial object)

Pattern 3c sentences are also often used in Esperanto, most probably to the same extent as pattern 3b sentences. They contain a transitive verb with a direct object and a spatial object. The valence of the verb is 3, since it requires a subject, a direct object, and a spatial object. This sentence pattern can also be found in German very often, so that Esperanto pattern 3c sentences are very often translated into German pattern 3c sentences.

Furthermore, it is possible to translate Esperanto pattern 3b sentences into German sentences containing a transitive verb, a direct object, a spatial object, and a dative of pertinence which is formed by a determiner of the Esperanto spatial object. (pattern 4h). All the other components remain the same components in Esperanto as well as in German.

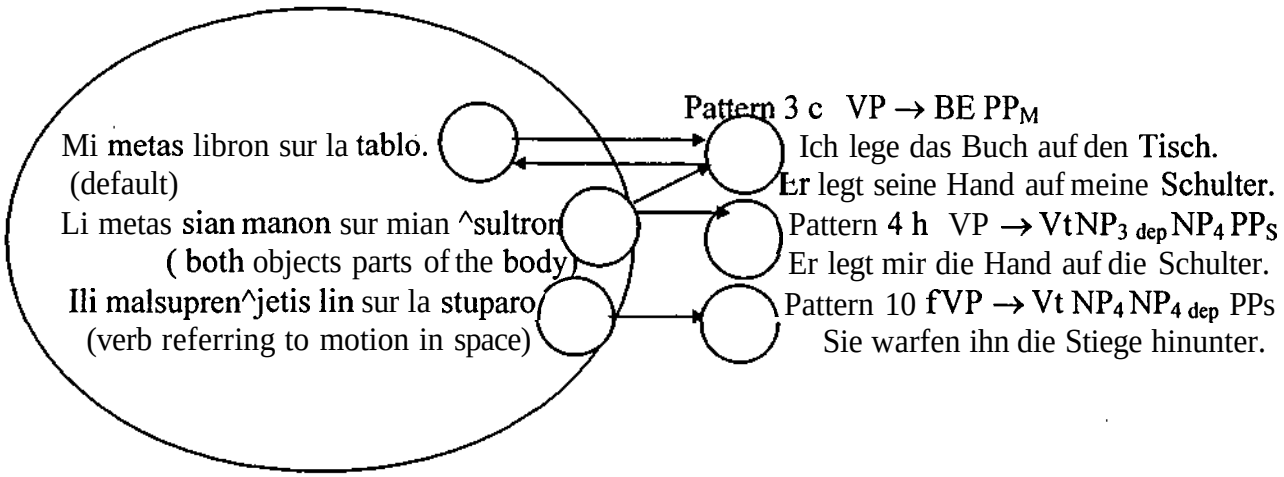
The Esperanto verb can also be expressed by a transitive verb and an adverb of space in German, the object of space becomes a direct object dependent on this adverb of space, while the Esperanto direct object remains a direct object also in German. The German sentence then contains a transitive verb, a direct object, and a spatial object with a dependent direct object (pattern 10f).

The way a pattern 3c sentence is translated depends on the transitive verb of the source language, and the valence(s) of the possible verb(s) of the target language.

3 c)

Esperanto **German**

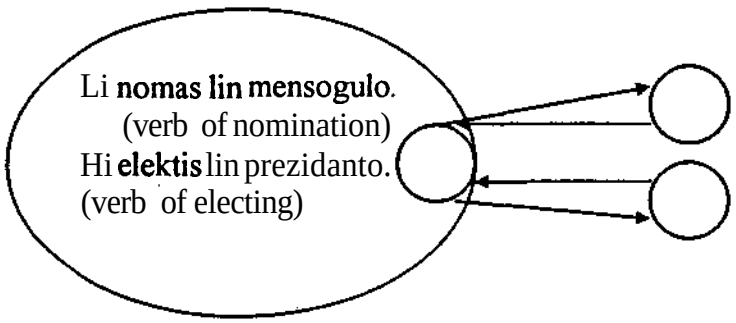
$S \rightarrow NP\ VP$
$VP \rightarrow Vt\ NP_4\ PP_S$
verb valence 3



3 e)

Esperanto **German**

S → NP VP
VP → Vct NP_4 NP_1
verb valence 3



Pattern 3 e **VP → Vct NP_4 NP_4**
Er nennt ihn einen Lügner.
Pattern 3 k VP → Vct NP_4 PP
Sie wählten ihn zum Präsident.

3 f)
(double transitive verb with a direct object and an indirect object)

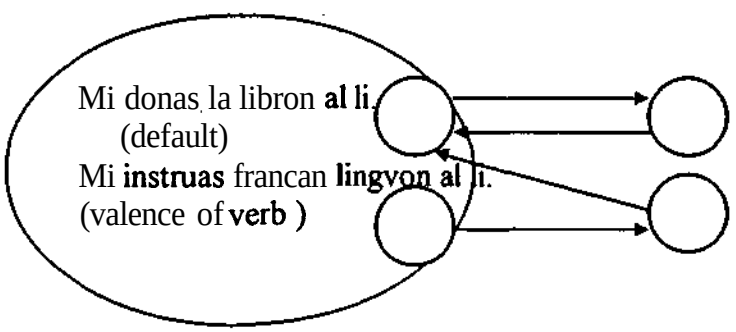
Pattern 3f sentences contain a double transitive verb, which means that it refers both to a direct object and an indirect object. Sentences of pattern 3f can be found in Esperanto as well as in English and German, and they are used frequently in all three languages. In most cases, pattern 3f sentences are translated into pattern 3f sentences again. In German there are a few sentences that take a second direct object instead of the indirect object, thus forming pattern 3g. Some of the Esperanto pattern **3** f sentences may be translated into German pattern **3** g sentences therefore. German pattern 3g sentences exist, but they are not common and are likely to disappear sooner or later. The valence of the verb is 3, since it requires a subject, a direct object, and an indirect object.

The way a pattern 3f sentence is translated depends on the transitive verb of the source language, and the valence(s) of the possible verb(s) of the target language.

3 f)

Esperanto **German**

S → NP VP
VP → VP → Vdt NP_4 NP_3
verb valence 3



Pattern 3 f VP → Vdt NP_4 NP_3
Ich gebe ihm das Buch.
Pattern 3 g VP → Vdt NP_4 NP_4
Ich lehre ihn die französische Sprache.

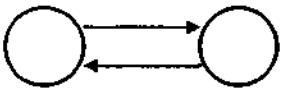
Esperanto **German**

3i)

$S \rightarrow NP\ VP$
$VP \rightarrow V\ NP_{4\ dep}\ PP_M$
verb valence 2

$S \rightarrow NP\ VP$
$VP \rightarrow V\ NP_{4\ dep}\ PP_M$

Pattern 3 i
La **laboristo** faras la **muron** blanka.



Pattern 3 i
Der Arbeiter macht die Mauer weiß.

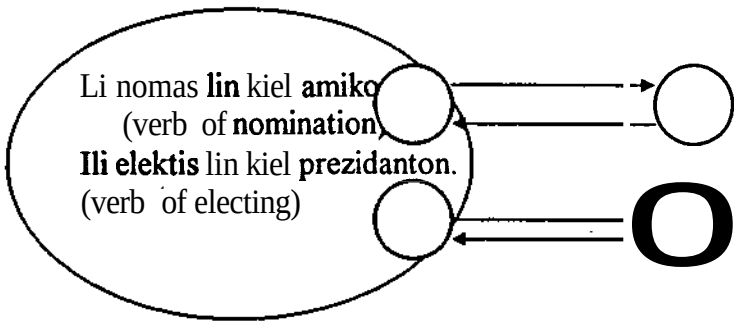
3 k)
(Complex transitive verb with a direct object and an identifying prepositional phrase)

Pattern **3k** sentences **contain** a complex transitive verb, a direct object, and an identifying prepositional phrase as an object complement in Esperanto. Complex transitive verbs require both a direct object and an object complement. The valence of such verbs is 3, since they require a subject, a direct object, and an identifying prepositional phrase as an object complement. This sentence pattern also exists in **German,** and Esperanto pattern 3k sentences are often translated into German pattern 3k sentences. As an alternative, it is also possible to translate the Esperanto prepositional phrase into a German identifying noun phrase in the accusative, which yields a sentence containing a complex transitive verb, a direct object, and an identifying noun phrase in the accusative as an object complement (pattern **3e)**.

The way a pattern 3k sentence is translated depends on the transitive verb of the source language, and the valence(s) of the possible verb(s) of the target language.

3 k)
Esperanto **German**

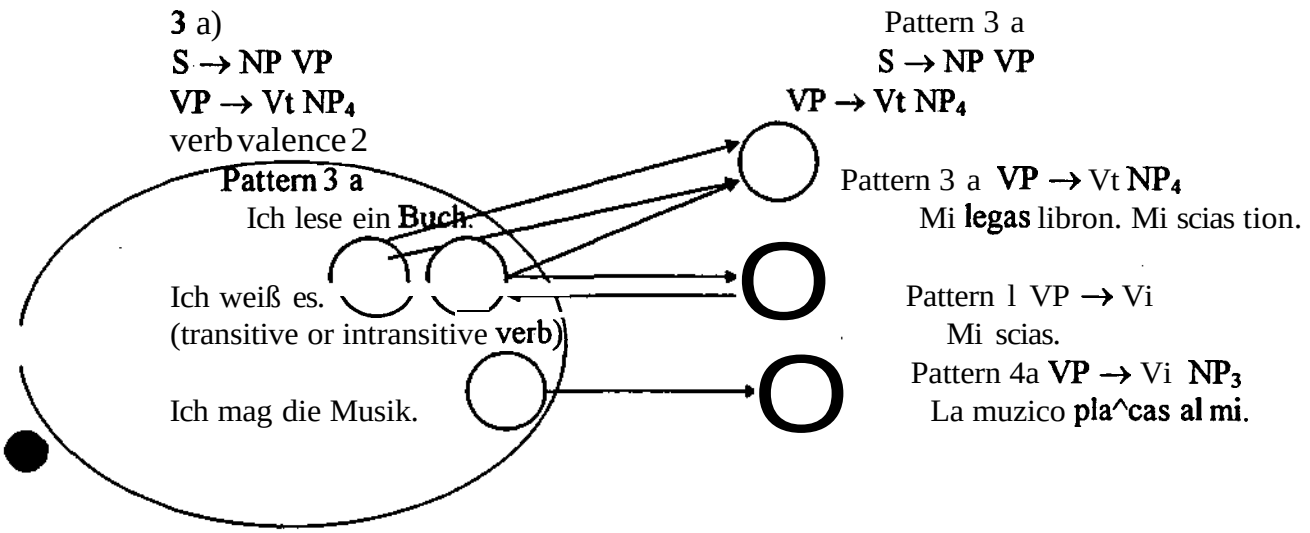
$S \rightarrow NP\ VP$
$VP \rightarrow V\ NP_4\ PP$
verb valence 3



Pattern 3 e $VP \rightarrow V\ NP_4\ NP_4$
Er nennt ihn einen Freund.
Pattern 3 k $VP \rightarrow V\ NP_4\ PP$
Sie wählten ihn zum Präsident.

Some German verbs, however, require a direct object, whereas the take an indirect object in the dative in Esperanto(pattern 4a). These form Esperanto pattern 4a sentences.

German **Esperanto**



3 b)
(Transitive verb with a direct object)

Pattern 3b sentences are often used in German. They contain a transitive verb, a direct object different from the subject, and a prepositional object. The valence of such transitive verbs is 3, since they require a subject, a direct object, and a prepositional object. Of course, German pattern 3b sentences can be translated into Esperanto pattern 3b sentences, since this pattern is quite common in both languages. Alternatively, it is possible with certain verbs to translate the German prepositional object into an Esperanto indirect object, thus obtaining a sentence with a transitive verb, a direct object, and an indirect object (pattern 3f) in Esperanto. In some cases, pattern 3b sentences can also be translated by a linking verb and an adjective phrase with a dependent prepositional object (pattern 2f).

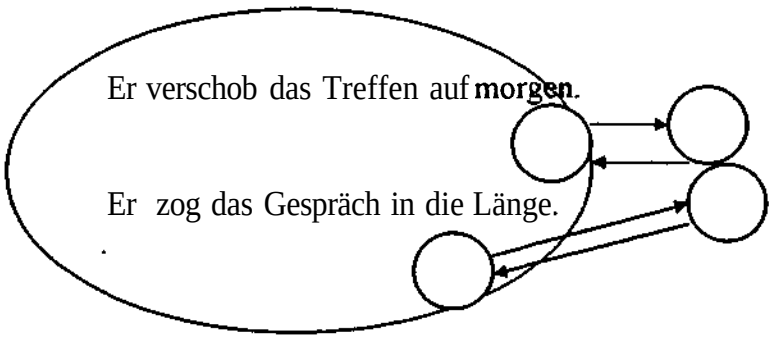
The exact way how a given sentence can be translated from German into Esperanto depends on the valence of the verbs both of the source language and the target language.

sentences in most cases. With certain German 3d sentences, however, the German verb and temporal object can be expressed by an Esperanto verb, while the direct object remains a direct object in both languages. Thus an Esperanto sentence with a transitive verb and a direct object (pattern 3a) is obtained.

The exact way of translating a German pattern 3d sentence depends on the valence of the verbs of both the source language and the target language.

German Esperanto

3 d)
S → NP VP
VP → Vt NP_4 PP_T
verb valence 3



Pattern 3 d **VP → Vt NP_4 PP_T**
Li **prokrastis la renkonton ^gis** morgaü.
Pattern 3 a VP → Vt **NP_4**
Li **longi^gis** la **interparolon.**

3 e)
(Complex transitive verb with a direct object as an object **complement)**

Pattern **3e** sentences contain a complex transitive verb, a direct object different from the subject, and a direct object as an object complement. Complex transitive verbs always refer to a direct object and an object complement. The valence of complex transitive verbs is 3, since they require a subject, a direct object and an object complement. This sentence pattern is often used both in German and in Esperanto. In Esperanto, the object complement is a noun phrase in the nominative, but by its function it is still the same pattern as in German. In some cases, however, the German direct object can be translated by a prepositional phrase (pattern 3k). Thus German pattern **3e** sentences can be translated into Esperanto pattern **3e** sentences, but it is also possible to translate them into Esperanto pattern 3k sentences.

The exact way of translating a German pattern **3e** sentence depends on the valence of the verbs of both the source language and the target language.

two direct objects are not possible. German pattern 3g sentences have to be translated into Esperanto pattern 3f sentences, where the personal object becomes the indirect object.

German **Esperanto**

3 g)

S → NP VP
VP → Vdt NP_4 NP_4
verb valence 3

S → NP VP
VP → Vdt **NP_4 NP_3**

Pattern 3 g
Er lehrt ihn **Französisch**

Pattern 3 f
Li **instruas** francan **lingvon al** H.

3 h)
(Transitive verb with a direct object and an object of manner)

Pattern 3h sentences contain a transitive verb, a direct object, and an object of manner. The valence of the transitive verb is 3, since it requires a subject, a direct object and an object of manner. This sentence pattern is often used both in German and in Esperanto. German pattern 3h sentences have to be translated into Esperanto pattern 3h sentences.

German **Esperanto**

3 h)
S → NP VP
VP → Vt NP_4 PP_M
verb valence 3

S → NP VP
VP → Vt NP_4 PP_M

Pattern 3 h
Er empfing ihn freundlich

Pattern 3 h
Li **ricevis lin** agrable.

3 i)
(Complex transitive verb with an object of manner with a dependent direct object)

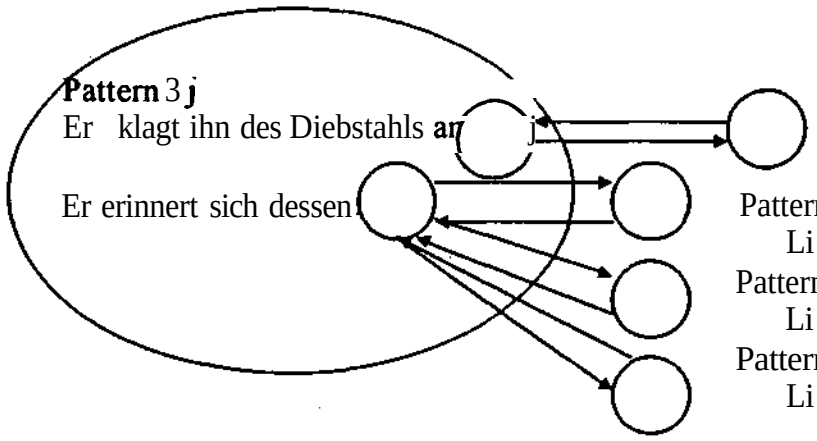
Pattern 3i sentences contain a complex transitive verb and an object of manner with a dependent direct object. Complex transitive verbs always refer to a direct object and an object complement. The valence of double transitive verbs is 2, since they require a subject and an object of manner with a dependent direct object. This sentence pattern is quite often used in **German,** but not in Esperanto, where it is considered as primitive and as a kind of baby talk. Of course, German pattern 3i sentences may be translated into Esperanto pattern 3i sentences, but it is much better style in Esperanto to express the German object of manner and the verb in

German **Esperanto**

3 j)

S → NP VP
VP → Vdt NP_4 NP_2
verb valence 3

S → NP VP
VP → Vdt NP_4 NP_2



Pattern 3 b **VP → Vct NP_4 PP**
Li **kulpas lin** pro **^stelo.**

Pattern **3** a VP → Vt **NP_4**
Li **memoras** tion.
Pattern 6a VP → Vct **NP_4**
Li memoras **pri** tion.
Pattern 2f VP → BE AP **PP_{dep}**
Li estas rememorante pri tion.

3 k)
(Complex transitive verb with a prepositional object as an object **complement)**

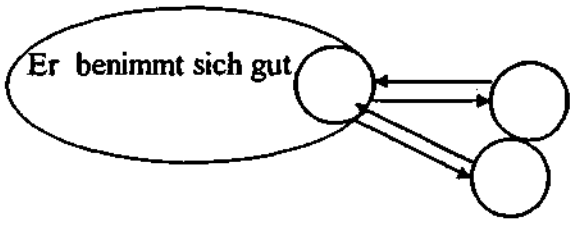
Pattern 3k sentences contain a complex transitive verb, a direct object different from the subject, and a prepositional object as an object complement. Complex transitive verbs always refer to a direct object and an object complement. The valence of complex transitive verbs is 3, since they require a subject, a direct object and an object complement. This sentence pattern is often used both in German and in Esperanto. In Esperanto, the object complement is a noun phrase in the nominative, but by its function it is still the same pattern as in German. German pattern 3k sentences have to be translated into Esperanto pattern 3k sentences in most cases. In some cases, however, it is also possible to translate the prepositional object of a German pattern 3k sentence into a direct object in Esperanto, thus replacing the prepositional object of the German sentence by a direct object (pattern 3e). Whether or not this is possible depends on the valence of the verb in both the source language and the target language.

German **Esperanto**

3 k)
S → NP VP
VP → V NP_4 PP
verb valence 3

pronoun and the object of manner, it is possible to translate a German pattern 3m sentence into a sentence with an intransitive verb (pattern 1). It is considered as particularly good style to translate German pattern 3m sentences into Esperanto pattern 1 sentences.

German	Esperanto
3 m)	
$S \rightarrow NP\ VP$	$S \rightarrow NP\ VP$
$VP \rightarrow Vr\ NP_4\ PP_M$	$VP \rightarrow Vr\ NP_4\ PP_M$
verb valence 3	



Pattern 1 $VP \rightarrow V$
Li **bonkondutas**.
Pattern 10a $VP \rightarrow V\ PP_M$
Li kondutas bone.

3 n)
(Transitive verb with a reflexive pronoun as a direct **object**, an object of manner, and a prepositional **object**)

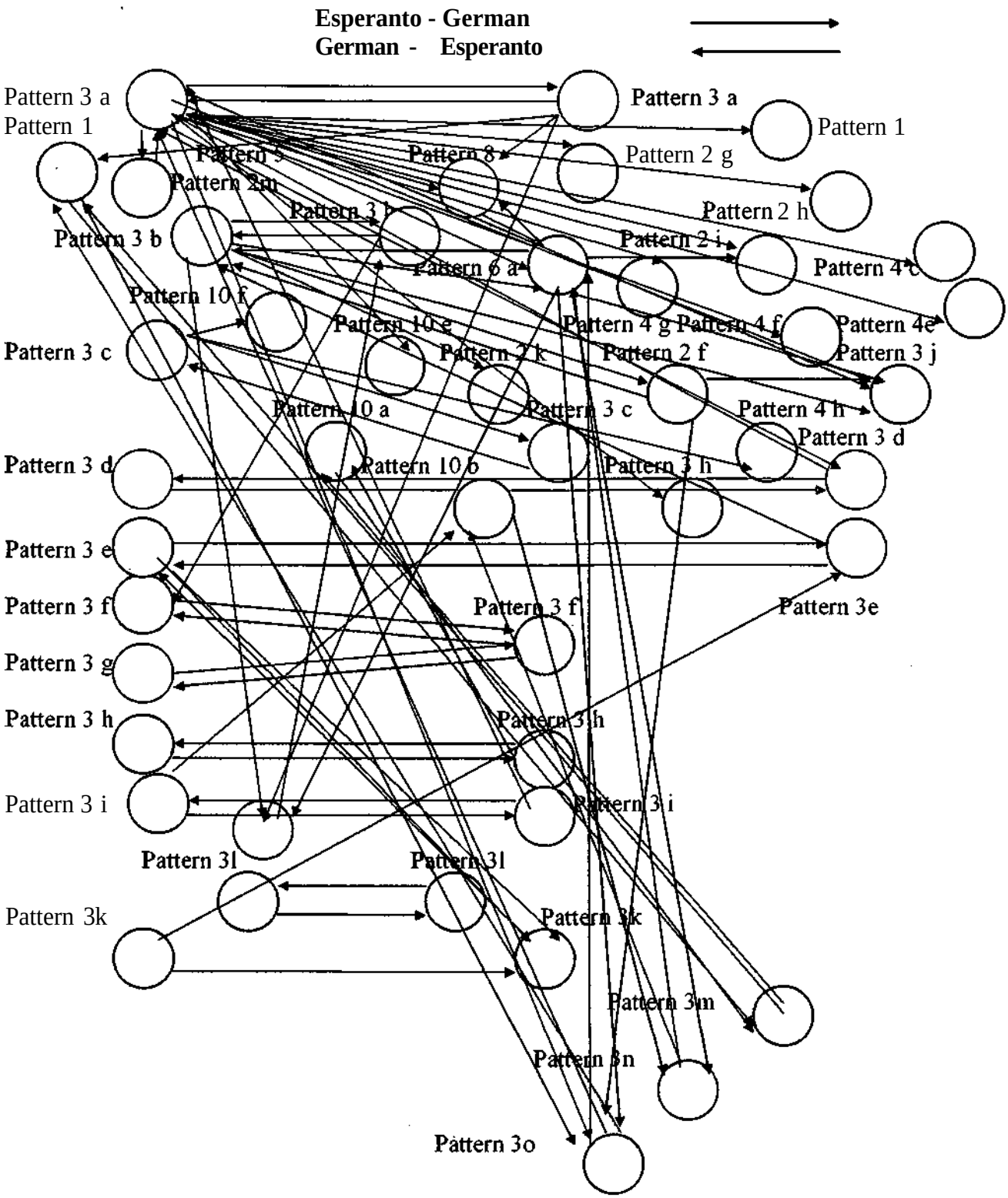
Pattern 3n sentences contain a reflexive verb, a reflexive pronoun, which can be regarded as a direct object identical with the subject, an object of manner, and a prepositional object. The valence of such reflexive verbs is 4, since they require a subject, a reflexive pronoun, an object of manner, and a prepositional object. In **contrast** to **Esperanto**, where reflexive verbs can equally be used as transitive verbs and are thus treated as transitive verbs, there are German verbs which can only be used as reflexive verbs and thus form a category of their own. Sentence pattern 3n is often used in German, but does not exist in Esperanto. Reflexive verbs of this kind have to be translated into single Esperanto verbs, while the object of manner and the prepositional object may remain an object of manner and a prepositional object in both languages. Thus, a sentence with an intransitive verb, an object of manner, and a prepositional object (pattern **10b**) is obtained in Esperanto. If it is possible to **find** a verb that expresses both the German reflexive pronoun and the object of manner, it is possible to translate a German pattern 3n sentence into a sentence with an intransitive verb and a prepositional object (pattern 6a). It is considered as particularly good style to translate German pattern 3n sentences into Esperanto pattern 6a sentences.

German	Esperanto
3 n)	
$S \rightarrow NP\ VP$	$S \rightarrow NP\ VP$
$VP \rightarrow Vr\ NP_4\ PP_M$ PP	$VP \rightarrow Vr\ NP_4\ PP_M PP$

with sentences taking a direct and an indirect object, where the personal object becomes the indirect object. In English, it is also possible to express the personal object as an indirect object or a kind of prepositional phrase, which is not possible in German. In Esperanto, the dative is also expressed as a kind of prepositional phrase, exactly in the same way as in English.

Genitive objects can only be found in German, and even in this language they tend to disappear. In English and Esperanto they are most usually translated by prepositional phrases.

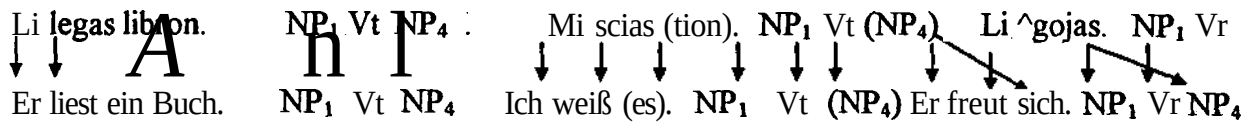
3. Pattern 3

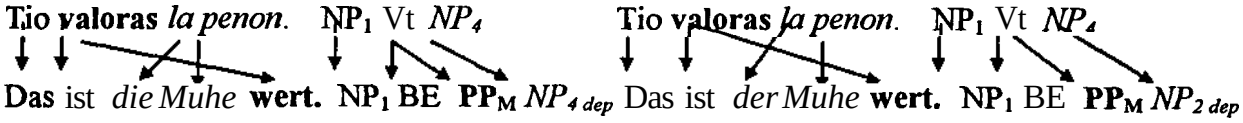

Esperanto - German
German - Esperanto
Pattern 3 a
Pattern 1
Pattern 3 a
Pattern 1
Pattern 2 g
Pattern 2 h
Pattern 3 b
Pattern 2 i
Pattern 4 c
Pattern 10 f
Pattern 4 g
Pattern 4 f
Pattern 4e
Pattern 3 c
Pattern 2 f
Pattern 3 j
Pattern 4 h
Pattern 3 d
Pattern 3 d
Pattern 10 b
Pattern 3 h
Pattern 3 e
Pattern 3 f
Pattern 3 f
Pattern 3e
Pattern 3 g
Pattern 3 h
Pattern 3 i
Pattern 3l
Pattern 3l
Pattern 3k
Pattern 3k
Pattern 3m
Pattern 3n
Pattern 3o

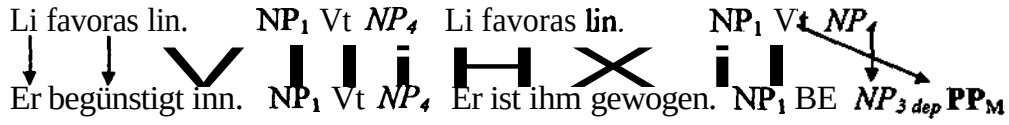
7.1.4.4 Translation

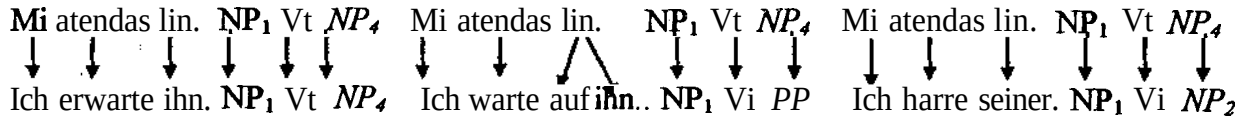
In this section the translation of pattern three sentences is shown. In most cases, sentences of pattern three remain pattern three sentences in the target language, but in some cases, they may become also pattern 1, pattern 6a, pattern 10a, or pattern 10b. If the verb is not a purely reflexive verb in German or English, however, the direct object remains a direct object also in the target language. Thus pattern three sentences are translated into pattern three sentences most of the times.

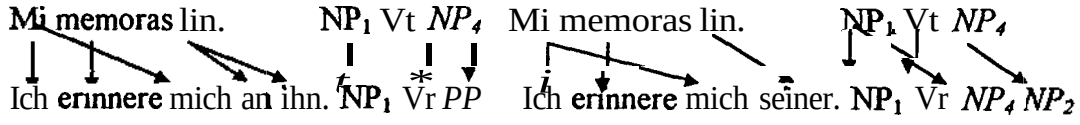
3a NP_1 Vt NP_4

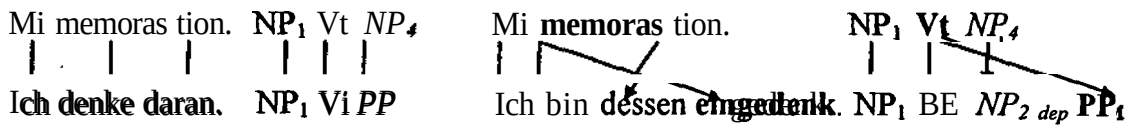


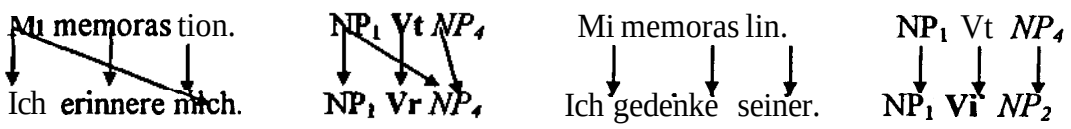


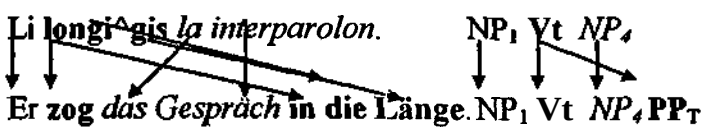


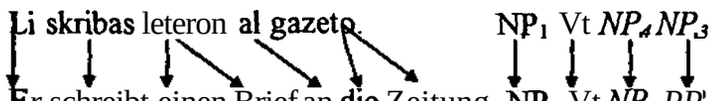


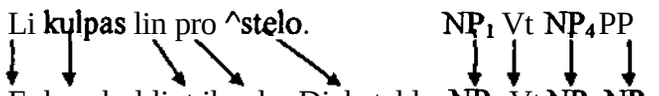


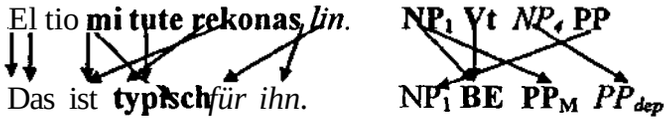


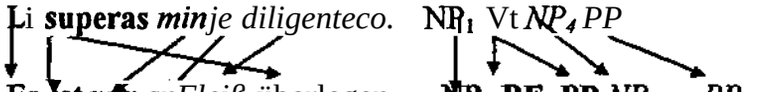


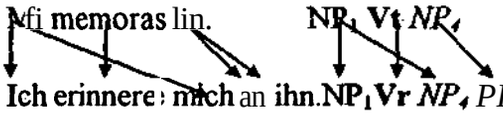


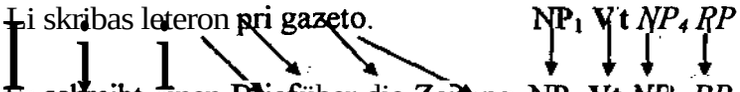


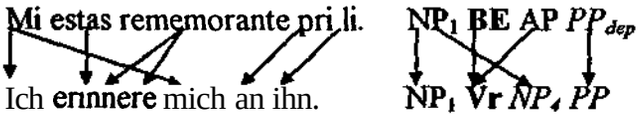




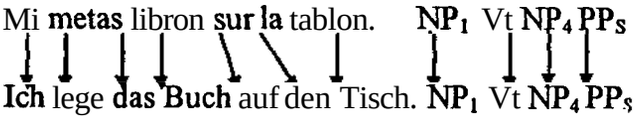


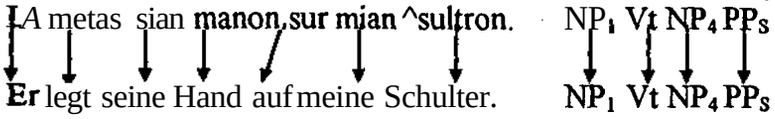


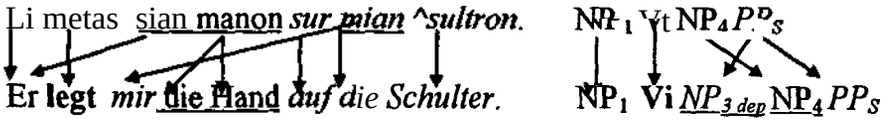




3c NP1 Vt NP4 PPS

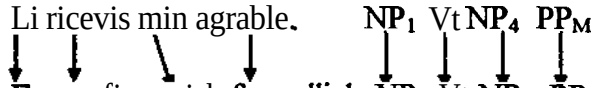






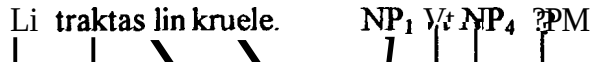
3 h NP_1 Vt NP_4 PP_M

Li ricevis min agrable. NP_1 Vt NP_4 PP_M



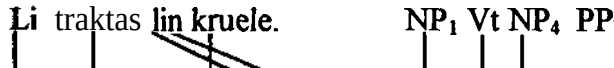
Er empfing mich freundlich. NP_1 Vt NP_4 PP_M

Li traktas lin kruele. NP_1 Vt NP_4 PP_M



Er behandelt ihn grausam. NP_1 Vt NP_4 PP_M

Li traktas lin kruele. NP_1 Vt NP_4 PP_M



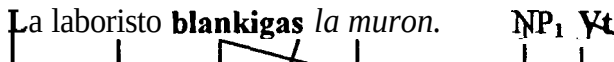
Er handelt grausam an ihm. NP_1 Vi PP PPM

3 i NP_1 Vt $NP_{4\,dep}$ PP_M

La laboristo faras *la muron* blanka. NP_1 Vt $NP_{4\,dep}$ PP_M

Der Arbeiter macht *die Mauer* weiß. NP_1 Vt $NP_{4\,dep}$ PP_M

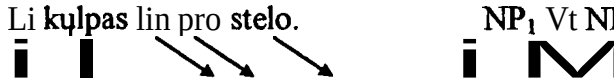
La laboristo blankigas *la muron.* NP_1 Vt NP_4



Der Arbeiter macht *die Mauer* weiß. NP_1 Vt $NP_{4\,dep}$ PP_M

3 j NP_1 Vt NP_4 NP_2

Li kulpas lin pro stelo. NP_1 Vt NP_4 PP

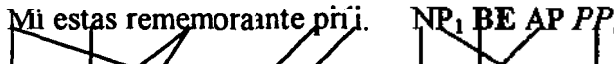


Er beschuldigt ihn des Diebstahls. NP_1 Vt NP_4 NP_2

Mi memoras lin. NP_1 Vt NP_4 Mi memoras pri li. NP_1 Vi *PP*

Ich erinnere mich seiner. NP_1 Vr NP_4 NP_2 Ich erinnere mich seiner. NP_1 Vr NP_4 NP_2

Mi estas rememoranta pri li. NP_1 BE AP PP_{dep}



Ich erinnere mich seiner. NP_1 Vr NP_4 NP_2

3 k NP_1 Vct NP_4 PP

Li elektas lin kiel prezidanton. NP, Vct NP_4 PP

Er wählt ihn zum Präsident. NP_1 Vct NP_4 PP

of such augmented transition networks. Of course, the networks of all sentence patterns have to be stored somewhere in computer memory. In this section, for reasons of simplicity, only the first three patterns are given. Furthermore, only the unmarked word order of these sentence patterns is given. This means that the single components can be swapped against each other for stylistic reasons, or other elements can still be inserted optionally. These are not shown in the following augmented transition networks.

As in other augmented transition networks, nodes depict a given state of a sentence. The arcs indicate possible transitions from this given state to other possible successor states. Components of sentences constitute the linguistic units of these augmented transition networks. The terminal symbols, in this case the complete sentence patterns, are shown by nodes with bold lines.

7.2.1 English

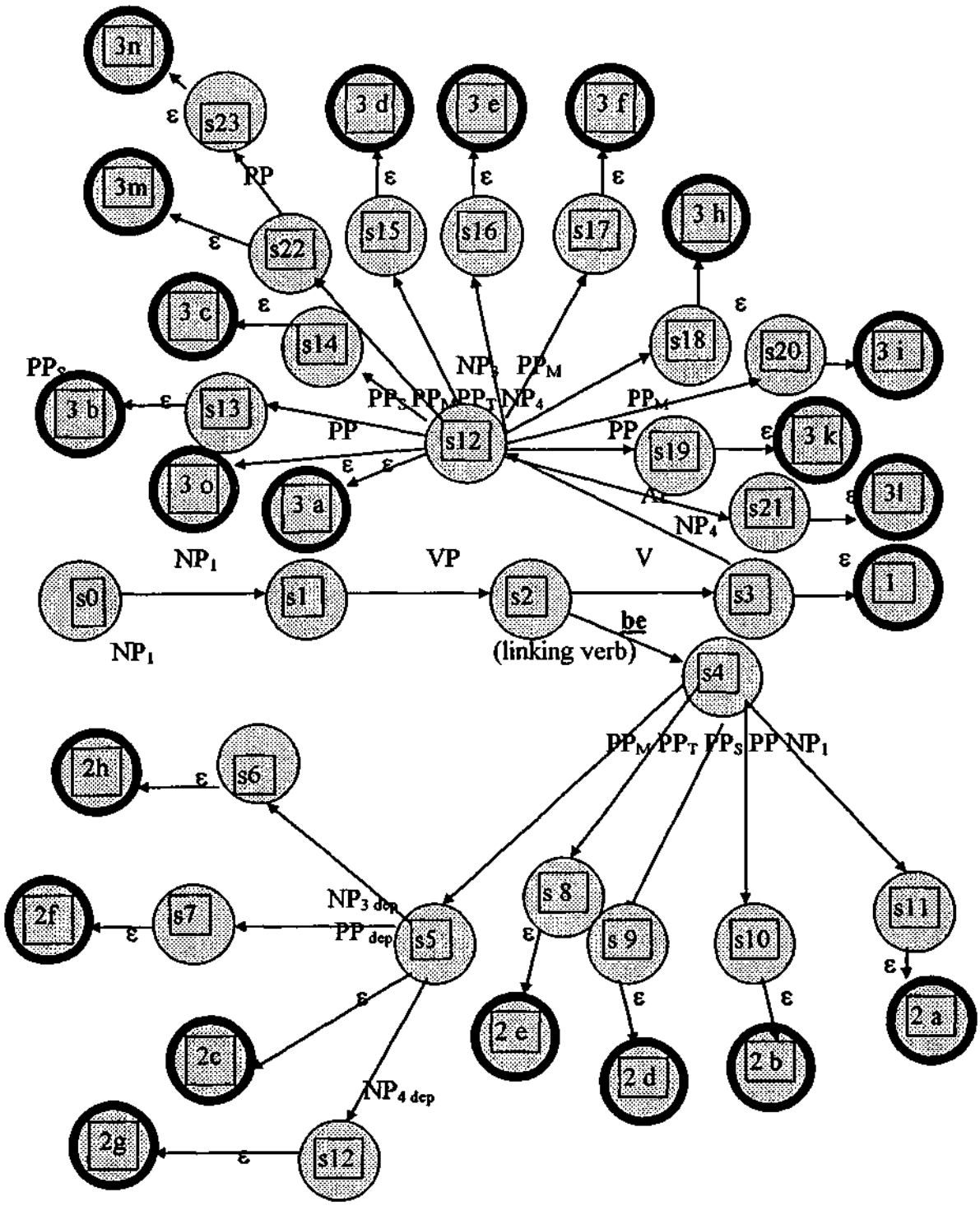
English sentences must have at least one subject and a verb. Thus, an English sentence has to contain a subject, i. e. a noun phrase in the nominative. This noun phrase is usually followed by a verb phrase. This verb phrase decides what sentence pattern a given sentence belongs to.

If it contains only one intransitive verb, this is sentence pattern one. An intransitive verb does not require a direct object. With pattern one sentences, the verb does not require anything else.

With transitive verbs, i. e. verbs that require at least one direct object, pattern three is constituted. Also reflexive verbs fall into this group, as there are many reflexive verbs that can also be used as transitive verbs. In the former case, the direct object is identical with the subject, in the latter case, it is different. Verbs that can be used both ways were classified as transitive verbs. For this reason, they were added to pattern three sentences which are composed by direct object sentences. This means that all pattern three sentences contain a direct object, or a noun phrase in the accusative. If a sentence belongs to pattern three, it must therefore contain a subject or a noun phrase in the nominative, a verb, and a direct object, i. e. a noun phrase in the accusative. As English cases are not marked, this sequence has to be kept strictly, i. e. subject, verb, and object. Thus, the noun phrase and the direct object can be seen by their positions in the sentence.

Depending on what succeeds the subject, the subpatterns of pattern three can be determined. Thus, if the direct object is not succeeded by any element, the sentence falls into pattern 3a, if the direct object is succeeded by an indirect object, it is a sentence of pattern 3f, if the direct

Here is the ATN with the first three English sentence patterns:



7.2.3 **Esperanto**

As already shown, there are no official definitions of Esperanto syntax. The *fundamento* sets up some rules concerning morphology and vocabulary, but does not mention syntax. Sentences were supposed to come „naturally", which means that they are expected to be formed according to the syntax of most Indo-European languages. Since these also differ from each other widely, Esperanto syntax, as far as it is possible to speak of syntactical rules, developed by way of conventions. Although some attempts to formulate syntactic rules with the help of big corpora were made, Esperanto sentence patterns were defined somewhat arbitrarily in this paper. This does not mean that they are not used in that way. Each pattern was tested with speakers of Esperanto, before it found its way into the paper. Nevertheless, these sentence patterns for Esperanto are new, and they were developed along with the English and German sentence patterns in a way to accommodate most of the English and German sentences. In any case, there are less sentence patterns in Esperanto than in German or English, due to the fact that the language has been made up in a „logical" and regular way without those complex syntactical constructions natural languages tend to have.

Esperanto sentences are much simpler than their German and English counterparts. First of all, they tend to be shorter, very often expressing a whole group of verb and noun phrase(s) by a simple verb. Short sentences are considered to be elegant. Thus, patterns zero, one, two, and three can be said to represent more than fifty percent of all Esperanto sentences. Especially patterns one and 3a are used very often in Esperanto.

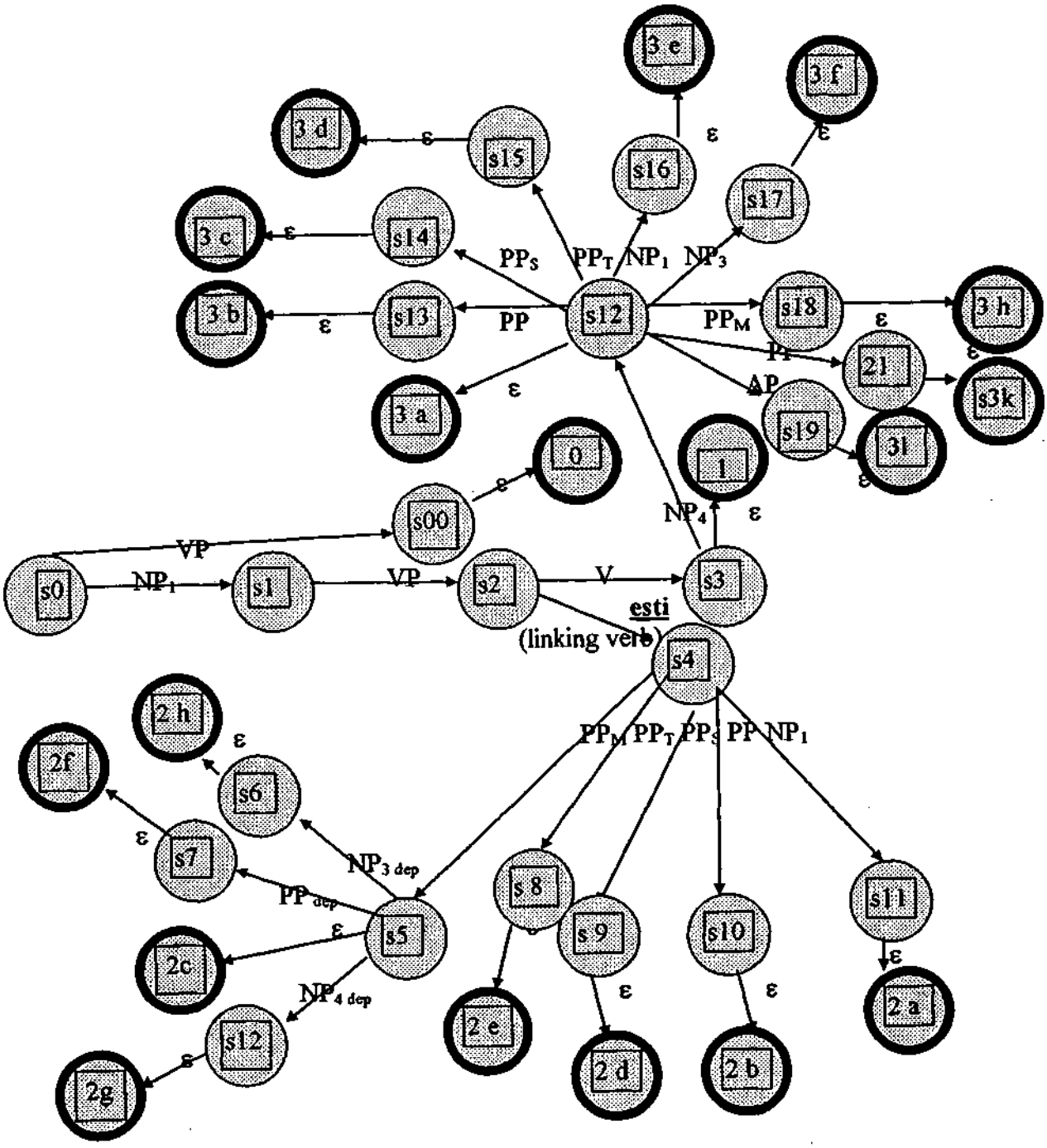
In Esperanto, as in other Romance languages, e. g. Italian, sentences without a subject can be found. Some Esperanto sentences only consist of a single verb. These form pattern 0. In German and English, these sentences are translated by sentences of pattern one with an impersonal subject. Mostly, this kind of sentences is used with verbs referring to the weather.

All the other sentences must have at least one subject, i. e. a noun phrase in the nominative, and a verb. This noun phrase is usually followed by a verb phrase. This verb phrase decides what sentence pattern a given sentence belongs to.

If it contains only one intransitive verb, this is sentence pattern one. An intransitive verb does not require a direct object. With pattern one sentences, the verb does not require anything else. Pattern one is extremely popular in Esperanto, where verbs can be preceded by modifying prefixes where in German and English adverbs would have to be taken. For example, Esperanto *Li bonkondutas.* (pattern 1) would have to be translated by *Er benimmt sich gut.*

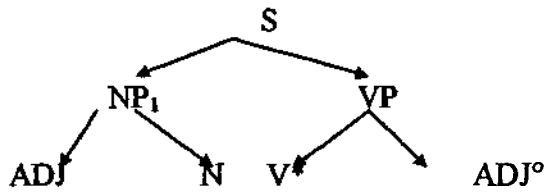
the adjective has to be taken into account. Again, these phrases are simpler in Esperanto than in German or English.

Here is the ATN with the first three Esperanto sentence patterns.



7.3.1.1 The Dictionary for Analysis

The dictionary for analysis is necessary for parsing a given sentence in the source language. It has to contain the words and additional information concerning the possible word category or word categories and additional linguistic information concerning relevant features of an individual word. With the help of this information, the word categories and later the sentence components are found out. Especially for verbs and adjectives or adverbs, among other features their valences are needed in order to establish the sentence pattern a given sentence can fall into. Then the pattern or patterns of a given sentence in the source language is determined, along with the corresponding word categories and words. Thus, the sentence "Mathematical linguistics is interesting." is parsed in this way:



Linking verb* *⇒ Pattern 2

Valence 0 Valence 2* **Valence** 0° °⇒ c

Attribute Singular Singular Proposition

Neuter 3rd person

1st case Present tense simple

Indicative

This means that the given sentence consists of a subject or noun phrase in the nominative containing an adjective used as an attribute and a neuter singular noun in the nominative, and a verb phrase with a third person singular linking verb in the present tense simple indicative and an adjective used as a proposition . Since the noun phrase adjective is used as an attribute, it has to show the same features as the noun, and since the verb phrase adjective is used as a proposition, it has not been declined. The fact that a linking verb with the valence 2 constitutes the main verb of the sentence means that the sentence must be a pattern 2 sentence. The propositional adjective of the verb phrase with the valence 0 in combination with the linking verb having the valence 2 indicates that the sentence is pattern 2c.

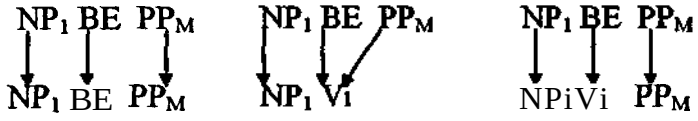
7.3.1.2 The Dictionary for Transfer

The dictionary of transfer contains all the rules of translation. First, it comprises all the sentence patterns of the source language, the sentence patterns of the target language and the rules of allocation of these patterns to each other. Then it also includes all the critical words,

	with adjective as a subject complement	VP→ BE AP AP→ ADJ		verb	AP AP → ADV	NP_1 BE ADJ

The rules of transfer say something like this:

2c) 2c → 2c 2c → 1 2c →10a



With these patterns and the additional information of parsing, it should be possible to translate the sentence „Mathematical linguistics is interesting ." into Esperanto. The possible sentence patterns have been assigned to each other, and now the words have to be looked up in the dictionary from English into Esperanto. First of all the verb of Esperanto has to be looked up. "Is" in Esperanto means „estas" and has the valence 2. Since the English verb is "is" and the Esperanto verb is "estas", the valence of the adjective "interesting" has to be looked up. „Interesting" means "interesa" and has the valence 0, which means that no other sentence component can depend on this adjective. Thus the sentence pattern 2c can be employed for the target language.

Next, the dictionary of transfer says that pattern 1 is equally possible in the target language. Therefore it is necessary to find out if the linking verb and the adjective together can be expressed in an Esperanto verb. Looking up "is interesting" in the dictionary for English to Esperanto yields "interesi^gas". Thus a pattern 1 sentence is equally possible. Since no intransitive verb requiring an object of manner can be found for "is interesting", pattern 10 a is not possible.

7.3.1.3 The Dictionary for Synthesis

The dictionary for synthesis is necessary for filling the slots of a given sentence pattern of the target language. It has to contain the words and additional information concerning the possible word category or word categories and additional linguistic information concerning relevant features of an individual word. With the help of this information, the words are looked up in order to find the correct words and form of the words to fit with the word categories and later the sentence components. Especially for verbs and adjectives or adverbs, among other features

Attribute	Singular	Singular	Proposition
	Neuter	3rd person	
	1st case	Present tense simple	
		Indicative	
Matematika lingvistiko	estas		interesa.

This sentence can be translated from Esperanto into German by a second step of analysis, by a second transfer from Esperanto into German, where the valences of the verb and the adjective are looked up in both languages, and where the possible German sentence **pattern(s)** are established. By a second step of synthesis the German words are looked up and filled in to form the correct German sentence(s). This algorithm works the same way as above and yields one or more correct German sentences.

7.3.1.4 The Meaning of the Dictionary for Translation

As has been shown above, the translation algorithm would not work without a dictionary. Not only the words with specific linguistic information according to their word categories and their most important forms have to be entered, also the sentence patterns and sentence relevant information as well as critical words for diverse linguistic phenomena have to be **stored**. The dictionaries of analysis and synthesis can be interchanged, as the algorithm can work in both directions. They can be seen as monolingual dictionaries for English, German, and Esperanto. The dictionaries for transfer may be regarded as bilingual dictionaries. They contain the words in the source language and their counterparts in the target language, the allocation tables for the sentence patterns in the source language to the sentence patterns in the target language, and various translation rules for diverse linguistic phenomena. All these items have to be stored somewhere, and technically speaking these dictionaries correspond to large databases where all the words, grammatical rules, and sentence patterns are stored. If this is a single database or several databases containing different kinds of information is a matter of secondary interest and depends on technical data of the machines available. Nevertheless, the translation algorithm without dictionaries or a big dictionary subdivided into several different sections simply would not work.

Next the other components are examined and grouped around the verb. At this point it must be examined, if the given sentence has two or more deep structures, this time due to the fact that it may have two or more different verb phrases. In one case, one word could have two or more meanings that would equally make sense in the given sentence. An example for such a sentence would be *"The drilling machine is broken. "*, where this sentence could mean that the drilling machine in question has actually been split, or that the machine is simply defective. In both cases the translation into Esperanto is different. Another example is the case where the components have only one meaning each, but they can be grouped in a different way. An example for such a sentence is *They saw the man with the telescope.*, where it is not clear who the owner of the telescope was, either *they* or *the man,* i. e. if the attribute belongs to the subject or the direct object. Another example can be given with the sentence *They saw the tree.*, where it is not sure whether they cut down the tree or whether they perceived the tree. In this case the verb of the verb phrase has two different meanings, but the same valence, so that both sentences are equally possible with the given components. Both sentences will be translated, stored and presented to the user.

The words are stored in a buffer and stored along with their categories and additional information belonging to these categories. The words are grouped into components and they are grouped in a way to match the sentence pattern. If there is a rest it will be appended. If the components do not match the pattern this means that either another sentence pattern has to be found, or, if this is not possible, the input sentence was defective. In this case it is rejected.

If the pattern can be matched, the verb will be looked up for a corresponding verb in the target language. The different components will be grouped and looked up, as shown in the previous section, and arranged in the buffer of the translated sentence. If there is more than one translation, all will be presented to the user.

Subsequently, the translating algorithm is given in pseudo-code:

```
PROGRAM  Translate;

CONST
    limit = 10;

TYPE

  phrases : ARRAY [0..limit] OF  dictionary.entry;

  vphrase = RECORD
```

```
sourcepattern, targetpattern, result :wordpattern;
pp :pphrase;
ap :aphrase;
np np1, np2, np3, np4 : nphrase;
vp, comp, complement :vphrase;
v, verbum :verb;
possibleverbphrases : vrbphrase;
adj, adjec :adjective;
possibleadjectivephrases : aps;
i, vns, vnt, ans, ant, sentencesprocessed, sentnum, entries, adjentries :WORD;
result : wordpattern;
results :patterns;


BEGIN

sentnum:=possiblesentence(sentence);
sentencerecord:=parse(sentence);
FOR i:=1 TO sentnum DO
  enter(sentencerecord, possiblesentences[i]);

    {if a sentence has two or more deep structures, as for example
     „ They are flying planes." }

sentenceprocessed:=0;
{All sentence strings have to end with '.' and then '0'}
{If a string or an array is empty they have to be filled with '0'}
{All empty positions contain a '0'. Blank is not empty.'}
{Position '0' of a string or array contains its length.}

REPEAT
  IF (possiblesentences[sentencesprocessed]='0') THEN
    WriteLn('No translation possible because of erroneous input.')
  ELSE
    BEGIN
      load (possiblesentences[sentencesprocessed], sentence);
      INC(sentencesprocessed);
      verbum:=lookup(sentence.verb, source);
      vns:=valence(verbum);
      v :=lookup(sentence.verb, target);
      vnt:=valence(v);
      vp:= lookup(sentence.verb.verbphrase, target);
      sourcepattern:=pattern(sentence, source);

      IF (sourcepattern[1] = '0') THEN
        BEGIN
          targetpattern:='1';
          result:='1';
          results[1]:='1';
          np1:= findword (Perspron (pers3, sg, neuter, case1, target);
```

```
    FOR i:=l TO entries DO
      BEGIN
        translatedsentence:=build(np1, vp)
        result:= {'3' ormore}
          IF rest THEN
              append(rest, translatedsentence);
      enter(targetpattern, translatedsentence, possibletranslateds [i]);
      enter(targetpattern, possibletranslateds[i], possibletranslations[sentencesprocessed]);
      result:=targetpattern;
      enter(targetpattern, sentence, results[i]);
  END;

UNTIL (sentencesprocessed > sentnum);

END.
```

7.5 Some *Examples for Translation*

Subsequently, this algorithm will be shown by means of some - possibly ambiguous - German sentences that have to be translated into Esperanto.

7.5.1 An Ambiguous Sentence with (a) Transitive Verb(s)

For the first example, a sentence with one surface structure, but two deep structures will be taken: *Reiche Studenten meinen Wein.* The sentence has already been parsed and yields the following structures:

sentencerecord[1] and sentencerecord[2]

Reiche Studenten meinen Wein. *(Du)* *Reiche Studenten meinen Wein.*

ADJ N V N (PersPron) V *N DET N*

NP_1 VP (NP_1) V NP_3 NP_4

(NP_1) VP

Hence, each of these source language sentence is stored in a **sentencerecord,** and both sentence records in turn are entered in the structure **possiblesentences,** which now contains these two sentencerecords. Since there are no other lexical ambiguities, the sentencerecords contain one **sentence each,** and the number of possible sentences **(sentnum)** equals two.

The sentence pattern(s) of the source language has to be determined and stored in the variable word pattern. With the first possible sentence, this word pattern equals **'3a',** since this sentence

8. *parolas pri vito.*

Next, the noun phrase in the nominative is added, in this case *Ri^caj studentoj,* and each sentence is entered in the **datastructure** translatedsentence. Thus, the possible Esperanto translations of the first possible German sentence are:

1. *Ri^caj studentoj volas vinon.*
2. *Ri^caj studentoj volas viton.*
3. *Ri^caj studentoj pensas pri vino.*
4. *Ri^caj studentoj pensas pri vito.*
5. *Ri^caj studentoj volas diri vinon.*
6. *Ri^caj studentoj volas diri viton.*
7. *Ri^caj studentoj parolas pri vino.*
8. *Ri^caj studentoj parolas pri vito.*

All these sentences are stored in the data structure translatedsentence, and this data structure in turn is stored at the first position of the data structure **possibletranslations**.

Next, the second possible German sentence has to be considered. In this case, *Reiche* is the main verb in the imperative in the singular. The virtual noun phrase in the nominative here is *Du.* It is virtual because it is taken as the noun phrase in the nominative for the program, but it is never printed out. This verb is a double transitive verb requiring a direct and an indirect object, the indirect object in the dative. This corresponds to pattern 3f. *Studenten* constitutes the indirect object in the dative, and *meinen Wein* the direct object. The latter noun phrase consists of a possessive pronoun as a determiner and a noun in the singular. The indirect object consists of a noun in the plural. The possible translations *of reichen* as a transitive verb are *doni* **and** *prezenti*. Both Esperanto verbs require a direct and an indirect object, the latter in the dative, as in German. Thus the same word pattern can be taken. *Studenten* has to be translated as *al studentoj,* and *meinen Wein* can be translated as *mian vinon,* if the beverage is meant, or *vian viton,* if the plant is referred to. The algorithm yields the following possible translations stored in possibleverbphrases: translatedsentence:

1. *donu al studentoj mian vinon.*

Furthermore, it is also possible to translate *ist interessant* as an intransitive verb with the valence 1, i. e. with the Esperanto ***interesi^gas.*** This often happens in Esperanto. Thus, ***interesi^gas*** becomes the second possible verb phrase. ***Interesi^gas*** only requires a noun phrase in the nominative, therefore it has the valence 1. With this verb phrase, a pattern 1 sentence is formed. Both verb phrases are stored in **possibleverbphrases**:

1. *estas interesa.*

2. ***interesi^gas.***

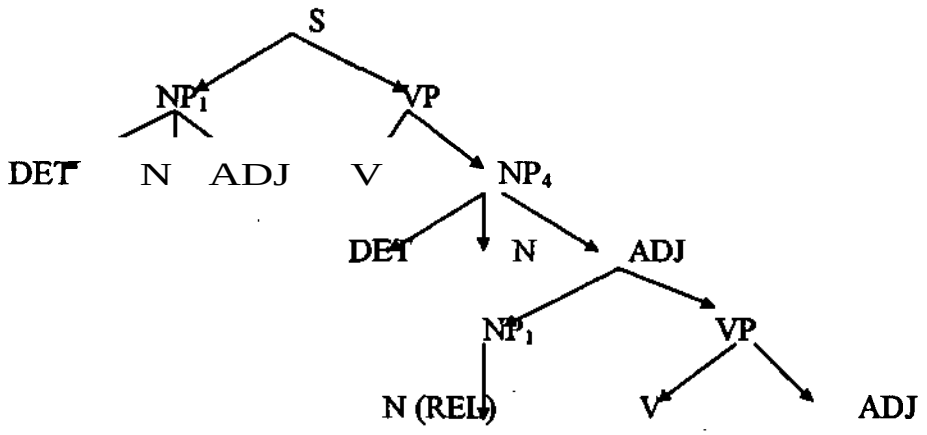
The noun phrase in the nominative is added, and both sentences are stored in the data structure translatedsentence:

3. ***Matematika lingvistiko*** *estas interesa.*

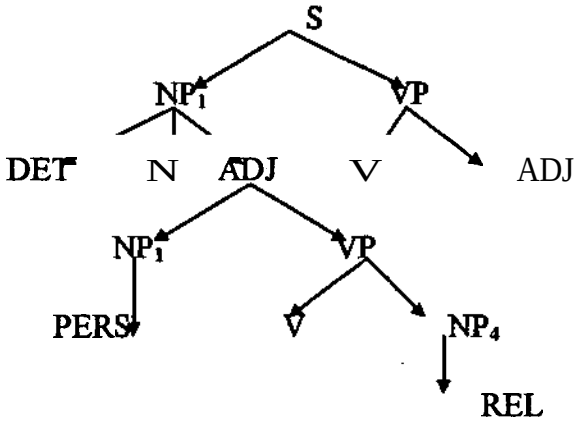
4. *Matematika lingvistiko* ***interesi^gas.***

7.5.3 Verb with Impersonal Subject

If the German sentence *Es* ***regnet.*** has to be translated into Esperanto, first the sentence is parsed. On parsing, an impersonal subject and an intransitive verb with the valence 1 are found. The sentence is a pattern 1 sentence, therefore, the source pattern (sourcepattern) is '**1**' in German. These are stored into the data structure possiblesentences. The sentence is unambiguous, which means that the verb and the noun phrase in the nominative can be looked up in the target language *regnet* means ***Pluvas*** in Esperanto, and this verb has the valence 0. Therefore, the pattern of the target sentence (targetpattern) is '**0**'. This means that this verb does not require a subject. German pattern 1 verbs can be translated by pattern 0 sentences. For this **reason,** the German impersonal subject is not translated in Esperanto. Translatedsentence therefore contains *Pluvas.*



The sentence still consists of a noun phrase in the nominative, a verb, and a direct object. The direct object in turn consists of a determiner, the „adjective", which is a relative clause in this case, and the noun. With the relative pronoun and the additional verb a relative sentence can be recognised by the program. The adjective is marked as a subordinate clause, where the first element, the relative pronoun, if there is one, is stored as first element for the sentence buffer of the subordinate clause. (If there is no relative pronoun, which may happen in English sentences, this position remains empty.) This relative sentence is first treated as a sentence of its own, in this case a sentence like "The book is interesting.", a perfect pattern 2c sentence, which is parsed and translated and stored as ADJ in the main clause. Of course, the relative sentence may also refer to other parts of the sentence. Consider the pattern 2c sentence "The book that she is reading is interesting." (or "The book she is reading is interesting.")



Here, the sentence consists of a subject or a noun phrase in the nominative, a linking verb and an "adjective", which is a relative clause here. The sentence is parsed and the subordinate clause is treated like a sentence component, in this case an adjective, first, but it is marked as a subordinate clause. The first element is stored in the position of the adjective. (It stays empty,

8.2 Advantages and Disadvantages of Sentence Patterns for Machine Translation

8.2.1 Advantages

The translation system works with sentence patterns. The sentence patterns give the structure of possible sentences in a given language. Their components can be regarded as kinds of slots that have to be filled with appropriate words and forms of words. This technique has several advantages and disadvantages that have to be taken into consideration. There are three important advantages:

- The algorithm can be implemented easily.
- The algorithm can be expanded easily.
- It is easy to add further information.

8.2.1.1 Implementing the Algorithm

As has been shown in the previous chapter, the algorithm needs a dictionary and a list of possible sentence patterns of the source language, the intermediate language, and the target language. In general, the number of sentence patterns has to be restricted, since it is not possible to list really all possible sentence patterns of a given language.

In this paper the number of sentence patterns was restricted to main clauses. More complex clauses were not taken into account. Likewise, only sentence patterns that may occur in technical texts like users' instructions, users' manuals, textbooks, etc. were considered. Sentence patterns that may be found in poems or literary texts were omitted altogether.

The sentences are parsed by means of the dictionary of words with additional information and the dictionary of sentence patterns. At this level, it is not necessary to consider additional information to the words from the start, as merely the sentence patterns themselves are taken into account. This means that if the structure is correct, several different sentences can be processed without having to look up the single words for translation right at the beginning. This way much time can be saved. First the word categories are determined, then they are assembled into syntagms, and at last, the corresponding sentence patterns are looked up. At the same time, the sentence is verified, since only well-formed sentences can be processed properly. In the version of the algorithm shown above ill-formed sentences are simply rejected.

When the sentence pattern has been determined, it is possible to look it up in the dictionary of sentence patterns in order to determine which sentence pattern(s) in the target language may

items in a database. Again, the algorithm itself is in no way affected by increasing the number of entries of one or more of the dictionaries.

8.2.2 Disadvantages

Unfortunately, there are not only advantages to this method. Sentence patterns may cause serious problems concerning their complexity, possible ambiguities, and the sheer number of possible sentences of a given language. Furthermore, the word categories themselves may give rise to important problems of definition. These are the main problems that may arise by using this technique:

- The sentences of a given language may be complex
- The sentences may be ambiguous.
- The word categories may cause linguistical problems.
- There is no way of determining all possible sentence patterns of a given language.
- It is not possible even to estimate the amount of time and resources that would be required for implementing this method.

This last disadvantage is the main reason why no real implementation of Intrling exists. Even though restrictions were made concerning the kinds of texts and sentence patterns, it is still not possible to find all possible sentence patterns and combinations of sentence patterns that could be generated recursively from the existing patterns within a reasonable period of time.

8.2.2.1 Complexity

The sentences of a given language may be complex. The complexity of language constitutes one of the main problems of language processing in general, not only of machine translation. A main clause, for example, may have several nested subordinate clauses and/or appositions, so that the sentence may consist of several subordinate clauses with a split main clause. Although it is possible to process such complex clauses by the same method as simple main clauses, as has been demonstrated above, restrictions have to be made. For technical reasons, it is not possible to process sentences to an indefinite depth.

8.2.2.2 Ambiguity

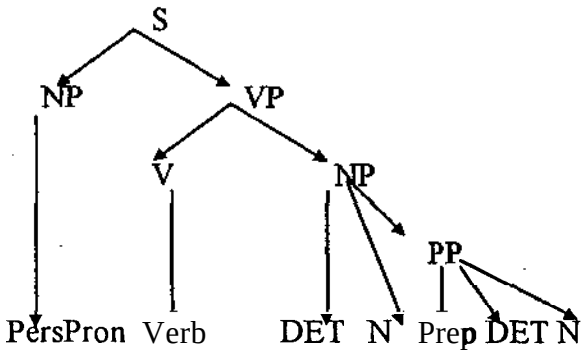
Again, the ambiguity of given sentences causes one of the main problems in a natural language. Ambiguities constitute the main problem of computational linguistics in general and machine

8.2.2.2.2 Semantical Ambiguities

With natural languages, it is possible that a given word may have one or more different meanings. With the example above, the German word *Floh* may designate the flea, and, if the word is the first in the sentence, as for example with questions, it may be the past tense form of *flee,* i. e. fled. Another example would be the English word *saw* as the past tense form of *see,* and the noun *saw,* which refers to a cutting instrument. Thus the sentence *They saw the tree.* could mean that the tree was perceived or that the tree was cut down. Again, these homographs may be resolved partly by transition matrices, or, as in the example, by the context, or by giving both sentences and asking the user which of them is valid. In some cases, not even a human translator would find the correct solution without the context or without asking additional questions, therefore it is legitimate if a program does the same thing. (Hrandek [2000b])

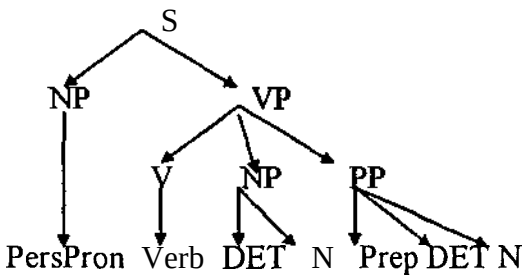
8.2.2.2.3 Syntactical Ambiguities

In natural languages it may also happen that one sentence may have two interpretations, as for example with the sentence *They saw the man with the telescope.* and its German counterpart, *Sie sahen den Mann mit dem Fernrohr.* Although in this particular example, these ambiguities correspond to each other, this need not always be the case. In this example, either the man with the telescope could have been seen, thus



They saw the man with the telescope.

or the man could have been seen by means of a telescope, thus



They saw the man with the telescope.

With other than Indo-European languages, however, this need not be the case, and languages as for example agglutinating languages, like Inuit, or integrating languages like certain languages of the Red Indians, may need completely different categories and thus different kinds of sentence patterns. In this case, also the German, English, and Esperanto sentence patterns may have to be reformulated in order to accommodate the word categories and sentence patterns of these exotic languages. The sentence patterns might have to be expanded in some way or other, not stated completely anew.

8.2.2.4 The Number of Sentence Patterns

The translating system above is supposed to work for technical texts as users' manuals, users' instructions, or textbooks for teaching science, not for literary or otherwise experimental texts. With this restriction, it is possible to include a large number of sentence patterns, but by no means all of them. Indeed, it is practically impossible to list all conceivable sentence patterns, even if they could be accommodated by a large amount of storage space. There are several reasons for this fact:

1. Especially with literary texts, sentence patterns could be developed that never existed before. But this is not only true for literary texts, but for any kind of advertising texts which live on ambiguities and completely new forms and structures. Since the sentence patterns are most probably denumerable, it will never be possible to list all of them.

2. The way of speaking also depends on communities of speakers and peer groups. It is possible, for example, that a given pattern is in use with young people, but not with others who would consider this pattern as ill-formed. Likewise, such patterns may depend on the region, on professional groups, and the like, so that not even a native speaker knows all of them. Therefore, even if large dictionaries were used, only part of the patterns could be listed.

3. Language is something dynamic, and a given pattern may have died out or may be on the verge of dying out. Thus it may not be possible to decide whether or not a given pattern is still a valid pattern. Furthermore, this highly depends on the person or persons who establish the list of sentence patterns, and there need not necessarily be a consensus with all groups. Thus restrictions have to be made in any case, and with restrictions, this method works very well.

although this language does not belong to the Indo-European languages. (Langenscheidt [1999]). The task may be difficult, but it can be accomplished.

It is not at all understood, however, that any language can be described in this way. Some languages totally different from Indo-European languages may not possibly be explained in this way, for example because they have no sentences as we know them. This might be the case for some agglutinating languages for example, where Indo-European adverbs of manner, place, and time may be translated as verb forms or prefixes or suffixes. It is also conceivable that even for certain Indo-European languages some other systems of word categories than the traditional Greek system might define them in a better way. Eggers, for instance, created his own system of word categories for processing the German language by a computer in 1969. (Hrandek [1999b])

Another open question is whether or not it is possible to find word categories valid for any given language. At present, this question has not been answered exhaustively yet.

8.3.2 Syntax

Basically it is not possible to record all possible sentence patterns of a language. Of course, this is also true with vocabulary, but in this case, investigations have shown that, for Indo-European languages at least, the thousand most frequently used words make up 80% of the vocabulary of a language. (Hrandek [1999/2000]) Since with Intrling, mostly technical texts are to be translated, it may be enough to list these thousand most frequent words together with the most important technical terms of the respective technical field.

There have been investigations about the frequency of words, and frequency dictionary have been made up for most important Indo-European languages. With sentence patterns, however, there are no known lists of for instance the hundred most common sentence patterns. Possibly the ones listed in the Duden grammar or the Advanced Learners' Oxford dictionary will do for such translation systems, but it is not at all clear whether or not they are the most common ones. Even if they are, the question remains whether this is true in general, or if this is only true for certain kinds of texts.

Although the use of sentence patterns has simplified translation in a considerable way with Intrling, the question remains whether or not this method would make sense in other languages. Even if systems translating other than Indo-European languages may use interlinguas (CICC [1994]), they may not work with sentence patterns. Especially with

European languages, the interlingua still must look widely different from the interlingua of the Asian system.

It would be interesting to know how exactly an author's nationality and mother tongue affect his or her interlingua. Although this constitutes a question of psychology of language, it should be possible to compare the features of the author's mother tongue with the features of his or her interlingua and find some relevant mathematical features to compare them against each other. Even if the interlingua can be derived from an existing auxiliary language, the impact of an author's nationality and mother tongue may still be seen by the way it has been modified. This also leads to the question whether or not it is possible to construct something like an ideal interlingua. The ideal interlingua works completely independently of all languages that may have to be processed in the machine translation system. This would require language independent word categories, and from these language independent word categories, language independent sentence patterns would have to be formed. There is no evidence that it is possible to find such language independent word categories to begin with.

At present, word categories, sentence patterns, and consequently interlinguas depend on the source language (s) and on the target language(s). To date, there is nothing like a universal interlingua. It is doubtful, however, if such an ideal interlingua really exists or can ever be constructed. Most probably, it is not possible to construct one interlingua for all languages in the world. This assumption, however, has not been proven either. Thus this question belongs to the open problems. (Hrandek [1997b])

8.3.4 Semantics and Knowledge of the World

In this context, two essential questions arise: How far is translation between speakers of two or more cultures with completely different backgrounds is possible, and in what way can knowledge of the world stored in electronic devices. The first question concerns linguistics, the second question deals with computer science.

8.3.4.1 Storing Meaning and Knowledge of the World Electronically

So far, no satisfactory way has been found to store knowledge of the world. For this reason, the restriction was made that only technical texts or technical manuals would be translated by Intrling. To date, it is not really possible to translate literary texts or jokes, which live on inherent ambiguities and special knowledge of the world. There have been attempts to describe the world formally, but so far the huge amount of relations necessary to depict for example a single semantic field would still exceed all storage space available. With homonyms, the task is

1. Is it possible to talk about languages using **n-ary** logic in terms of a natural language using binary logic? Since each natural language uses the same language as its metalanguage, it is not clear either how far it is possible to talk about languages using n-ary logic in terms of a natural language using binary logic. In this case, this latter language cannot be the meta-language of the former, and therefore the correct meaning cannot be expressed in the other language.

2. How far it is possible to translate from such a language into a language based on binary logic, or how far it is possible to translate from a binary logic language into an n-ary logic language? Can these languages mapped to each other in a meaningful way?

3. If translation is possible and translation systems between languages of this kind are to be built, the question arises what kind of interlingua has to be used with them. Is it possible to construct an interlingua which serves the ends of both languages, or is it necessary to find a compromise between them.

4. Furthermore mathematical logic does not necessarily correspond to the logic of language. In a previous chapter, the logic of language was described as if it applied to all existing languages. In fact, the logic of Indo-European languages was described. It is not certain if the logic of all languages works the same way as the logic of **Indo-European** languages. Indeed, there is evidence that some languages at least obey laws of logic of their own. Thus, the logic of language seems to depend on its specific language, and each language has to be analysed separately. In this case, the question arises whether it is possible to render the logic of the source language in the target language, and, if it is, what impact this would have on translation. Of course, this also leads to questions concerning the **interlingua,** in what way it would have to accommodate the logic of the source language and the logic of the target language. In any case, logic deals with only one aspect of language, i. e. the formal and rational aspect. Certain phenomena of language, as for example creative and literary, especially lyric texts, could not be analysed by mathematical logic.

The interlingua of Intrling is a simplified kind of Esperanto. It would also have been possible to choose a logical interlingua defined for the purpose of translation. The big disadvantage of logical interlinguas is, however, that it is not always possible to express natural language sentences by logical formulas. For example, it is not possible to render the exact meaning of consecutive clauses by a logical formula. By transforming natural language sentences into logical formulas, much information would be lost. Such problems will never occur with Esperanto, since it resembles very much a natural language.

Furthermore, it is not always easy to translate natural language sentences into logical formulas, even if the exact meaning can be kept up. Very often, these logical formulas are much longer and more complex than the original natural language sentence and take much storage space. Processing such long sentences may slow down the system considerably. With Esperanto, there is no danger of getting such long and complex kinds of sentences, at least not more complex than the original source language sentence.

In any case, syntax-based interlinguas resembling natural languages are easier to work with. Their grammars can be stored in phrase structure grammars and thus be processed efficiently. Many parsing algorithms work with phrase structure grammars, and with their help, it is possible to determine the sentence pattern(s) a given sentence may belong to. The sentences can be parsed relatively easily, and there are enough parsers working effectively. Also these parsed sentences can be compared to the existing sentence patterns and thus be verified.

Although in this paper, only simple main clauses were treated, it is possible to generate and process more complex sentences with main clauses and subordinate clauses by treating the subordinate clauses as components of otherwise simple main clauses, and by the use of iterations or recursion. In any case, these sentence patterns can be found and processed with the help of parsers, tables of possible sentence patterns, and dictionaries.

Parsers can work on different linguistic levels, for example with words, with syntagms, or with word categories. They are equally useful at each level. Parsing algorithms can be implemented quickly and easily and work in a predictable way. A lot of different parsing algorithms exist.

With the algorithm of Intrling, the main task is to gather linguistic information and to store it in dictionaries. Likewise, this information has to be maintained and updated, as languages and their sentence patterns change over time. The algorithm itself can be programmed

[1992]) (Mayer H. [1992]) (Mayer H. [1993]) as well as with the help of Mrs. Helga Farukuoye.

With a given input sentence, the valence of the main verb determines the sentence pattern(s) a sentence may belong to. The term valence is used in the way defined by Tesnière. This means that a verb requires a certain number of obligatory components, and if one or more of these has been omitted, the sentence is not correct. Thus the number and positions of the components of a natural language sentence mostly depends on its main verb.

Once this sentence pattern has been found, the verb is looked up in the bilingual dictionary the corresponding Esperanto verb(s) is (are) selected and their valences determined. It is possible that one sentence may be translated in several different ways. In a next step, the components of the source language sentence are looked up in turn, translated and inserted into their respective positions with the Esperanto main verb. This procedure yields one or more sentences, and all of them are presented to the user.

With sentences containing a linking verb as the main verb, the valence(s) of their object complements may have to be considered as well, before they can be looked up in the bilingual dictionary and then be translated.

If there are more components than necessary, they will be added according to the grammatical rules stored in the phrase structure grammar of the target language. With English, German, and Esperanto, they will be appended in many cases, but this need not always be the case. With other languages, they may be treated in a completely different manner depending on the grammars of these languages.

The sentence patterns as well as most grammatical rules are stored in phrase structure grammars and in augmented transition networks. With augmented transition networks, it is possible to verify sentences while they are processed at analysis, and to determine the different components, their word categories, and the possible sentence pattern(s) of a given source language sentence. In contrast, phrase structure grammars are more suitable for storing grammatical rules, for storing sentence patterns, and for generating sentences at synthesis. Both are necessary for the translation algorithm.

This means that the algorithm heavily relies on syntax, but less on semantics and even less on pragmatic issues. The reason for this is that there are many efficient parsing algorithms, which work on syntax, but there are no really practicable semantic algorithms. Semantic fields

worked with semantics-based algorithms, it would work with semantic fields and semantic markers, not with meaning as we know it.

As a matter of fact, Intrling works with syntax-based algorithms, using sentence patterns, augmented transition networks, and phrase structure grammars with the parsing algorithms they enable. There is no processing or even understanding of meaning, however, nor any stored knowledge of the world. Translation is performed by purely syntactical algorithms, together with the phrase structure grammars of the given languages. Within the restrictions cited above, the algorithm will work, with other kinds of texts, as for example literary texts or lyrics, it will not.

Translation takes place with the help of Esperanto. Esperanto has been used as an interlingua with machine translation systems elsewhere, e. g. with Witkam's Distributed Language Translation (DLT) system (Witkam [1983]). With this system, a rigid word order was defined for Esperanto as well as for every language to be translated, regardless whether or not strict word order had to be used. In Esperanto, for example, there is no such thing as a strictly defined word order.

Translation systems prescribing a rigid word order the way it has to be observed with English sentences may perform very well with certain Indo-European languages, as for example English or French, where such a strict word order prevails. With other, especially other than Indo-European, languages, however, this kind of interlingua may become impracticable.

For this reason, Intrling works with sentence patterns. This use of sentence patterns is definitely new. Nowhere else, machine translation systems employ sentence patterns in the sense as they are applied with Intrling. Likewise, the combination of Esperanto as an interlingua and the use of sentence patterns does not exist in any other machine translation system. It is unique with Intrling.

Sentence patterns cannot even be found in Esperanto grammars, in the first place, since they have not been considered necessary by Esperantists. In their opinion, Esperanto sentences come quite naturally, so there is no need to explain them.

This may be true for native speakers of Indo-European languages, but certainly not for speakers of other than Indo-European languages. Thus Esperanto sentence patterns had to be determined from scratch, as sentence patterns are not even mentioned in the *fundamento*.The sentence patterns depend on the valence(s) of the main verb(s) of the sentence.

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In the following section the most important keywords are listed along with the **number(s)** of pages where they occur. If more than one number is **given,** the word can be found on every single page.

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E\E	9	1	2	2b	2c	2d	2e	2f	2g	2h	2i	2j	2k	2l	2 B	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	1	1	0	0	0	0	0	1	0	0	-	-	-	-	-	1	0	0	0	0	0	-	0	0	-
2a	0	0	1	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
2b	0	0	0	1	0	0	0	1	0	0	-	-	-	-	-	0	1	0	0	0	0	-	0	0	-
2c	0	1	0	0	1	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
2d	0	0	0	0	0	1	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
2e	0	0	0	0	0	0	1	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
2f	0	1	0	0	1	0	0	1	0	1	-	-	-	-	-	1	1	0	0	0	0	-	0	0	-
2g	0	0	0	0	0	0	0	0	1	0	-	-	-	-	-	1	0	0	0	0	0	-	0	0	-
2h	0	0	0	0	0	0	0	1	0	1	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
2i	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2j	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3a	0	0	0	1	0	0	0	1	0	1	-	-	-	-	-	1	0	0	0	0	0	-	0	0	-
3b	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	1	0	0	0	0	-	0	0	-
3c	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	1	0	0	1	-	0	0	-
3d	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	1	0	0	-	0	0	-
3e	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	1	0	-	0	0	-
3f	0	0	0	0	0	0	0	0	0	1	-	-	-	-	-	0	0	0	0	0	1	-	0	0	-
3g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3h	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	1	0	-
3i	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	1	0	0	0	0	0	-	0	1	-
3j	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4a	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	1	0	-	0	0	-
4b	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
4m	0	1	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
4n	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
4o	0	1	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
4p	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	1	0	0	0	0	0	-	0	0	-
4w	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
fr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4d	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4e	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4h	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6a	0	0	0	1	0	0	0	0	0	0	-	-	-	-	-	1	0	0	0	0	0	-	0	0	-
6b	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
7	0	0	0	0	0	0	1	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
8	0	1	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
9	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
10a	0	1	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
10b	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
10c	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
10d	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-
10e	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	1	0	1	0	0	0	-	0	0	-
10f	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	1	0	0	0	-	0	0	-

b) Esperanto to English

Esperanto syntax can be adapted to English syntax very easily. Indeed, with the exception of Pattern 0 it can be said to be nearly identical. Some unusual sentence patterns that were introduced for translating German sentences from Esperanto into English were also introduced, but they are not often used.

With the matrix for translating Esperanto to English, there are many diagonal entries. This shows that most of the Esperanto sentence patterns can be mapped to their corresponding patterns in English, which proves that the syntax of these two languages is similar in a high degree. Again, the entries of 1 are distributed relatively evenly, although there is a slight preference of the patterns 1 and 3a.

E\E	3k	31	3m	3n	3o	4a	4b	4c	4d	4e	4f	4g	4h	5	6a	6b	7	8	9	10a	10b	10c	10d	10e	10f
0	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
1	0	0	1	0	1	0	0	-	0	0	-	-	-	-	0	0	0	1	0	1	0	0	0	0	0
2a	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
2b	0	0	0	0	0	0	0	-	0	0	-	-	-	-	1	0	0	0	0	0	0	0	0	0	0
2c	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
2d	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
2e	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	1	0	0	0	0	0	0	0	0
2f	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
2g	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
2h	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	**0**	0	0	0
2i	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2j	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2k	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3a	0	0	0	0	0	1	0	-	0	0	-	-	-	-	1	0	0	0	0	0	0	0	0	1	0
3b	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
3c	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	1
3d	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
3e	1	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
3f	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
3g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3h	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
3i	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
3j	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3k	1	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
3l	0	1	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
3m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3o	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4a	0	0	0	0	0	1	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
4b	0	0	0	0	0	0	1	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
4c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4d	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
4e	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0
4f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4h	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6a	0	0	0	1	0	0	0	-	0	0	-	-	-	-	1	0	0	0	0	0	0	0	0	0	0
6b	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	1	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	1	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	1	0	0	0	1	0	0	0
9	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	1	0	0	0	0	0	0
10a	0	0	1	0	1	0	0	-	0	0	-	-	-	-	0	0	0	0	0	1	0	0	0	0	0
10b	0	0	0	1	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	1	0	0	0	0
10c	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	1	0	0	0
10d	0	0	0	0	0	0	0	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0	1	0	0
10e	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
10f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	T	A	B	L	E			E	S	p	E	R	A	N	T	O			G	E	R	M	A	N	
E\G	0	1	2a	2b	2c	2d	2e	2f	2g	2h	2i	2j	2k	21	2 m	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2a	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2b	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2c	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2d	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2e	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2f	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1
2g	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2h	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2i	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2j	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3a	0	1	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	0	1	0	0	0	0	1	1
3b	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
3c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
3d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
3e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
3f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
3g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
3i	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
3j	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3k	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3m	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3o	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4a	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
4b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4h	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6a	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1
6b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0
10c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10e	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

d) German to Esperanto

German contains most sentence patterns. Apart from pattern 0, which consists of only one verb, all the sentence patterns under consideration can be found in German sentences. Their word order is said to be free, which means that their elements can be combined in several possible ways. Although this is also true for Esperanto, German sentences differ more from Esperanto sentences than English sentences do. German sentences cannot be mapped to Esperanto so easily. The 1's in the entries of the matrix are very sparse, which means that there are not many sentence patterns available for a given sentence pattern on translation. In some cases there are several equivalent possibilities of translating from one sentence pattern into another, but in most cases there are not.

G\E	3k	3l	3m	3n	3o	4a	4b	4c	4d	4e	4f	4g	4h	5	6a	6b	7	8	9	10	10	10	10	10	10
																				a	b	c	d	e	f
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2f	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2h	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2i	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2j	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2k	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3a	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
3c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3e	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3i	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3j	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
3k	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3l	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
3n	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
3o	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
4a	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
4b	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4c	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
4d	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4e	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4f	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4g	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
6a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
6b	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
10a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
10b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10c	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0
10d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
10e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
10f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1. THE ENGLISH SENTENCE PATTERNS

	Type	Structure of VP	+	Examples
1)	Intransitive verb without objects	Vi	-	It is raining.
2 a)	Linking verb with identifying nominative as a subject phrase	BE + NP_1	a) NP_1	He is a student.
2 b)	Linking verb with identifying prepositional phrase as a subject phrase	BE + PP	b) PP	The book is about students.
2 c)	Linking verb with adjective as a subject phrase	BE + AP	c) AP AP →ADJ	The rose is beautiful.
2 d)	Linking verb with adverb of place as a subject phrase	BE + PP_S	d) PP_S	The book is on the table.
2 e)	Linking verb with adverb of time as a subject phrase	BE + PP_T	e) PP_T	The meeting will be tomorrow.
2 f)	Linking verb with adjective and dependent prepositional object as a subject phrase	BE + AP + PP_{dep}	O AP→ ADJ + PPdep	He is free of his sorrows. This is typical of him.
2 g)	Linking verb with adjective and dependent direct object as a subject phrase	BE + AP + $NP_{4\ dep}$	g) AP→ ADJ + NP_{4dep}	The fence is two meters long.
2 h)	Linking verb with adjective and dependent indirect object in the dative as a subject phrase	BE + AP + $NP_{3\ dep}$	h) AP→ ADJ + NP_{3dep}	The tool is useful to me. He is similar to him.
3 a)	Transitive verb with direct object	Vt + dO	a) -	He is reading a book.
3 b)	Transitive verb with direct object and prepositional object as an adjunct	Vt + dO + PP	b) PP	I write a letter about my friend.
3 c)	Transitive verb with direct object and spatial object as an adjunct	Vt + dO + PP_S	c) PP_S	I put the book on a desk. I show him into the room. They took us home.

4 b)	Intransitive verb with an indirect object and a prepositional object as adjuncts	Vi + iO+ PP	b) PP	He talks to me about the book. They tell us about the last events.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	a)-	He talks about the book.
6 b)	Intransitive verb with two prepositional objects as adjuncts	Vi + PP + PP	b) PP	They discuss with us about the book.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T		He will come tomorrow.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	-	The children have come home.
9)	Intransitive verb with an object of causality as an adjunct	Vi + PP_C	-	He did it for friendship's sake.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	a)-	He behaves well. He goes by train. He came quickly.
10 b)	Intransitive verb with an object of manner and a prepositional object as adjuncts	Vi+ PP_M + PP	b) PP	He came with us gladly.
10 c)	Intransitive verb with an object of manner and a spatial object as adjuncts	Vi+ PP_M + PP_S	c) PP_S	He goes to London by train. They went to school by bus.
10 d)	Transitive verb with a direct object and an object of manner with a dependent direct object as an adjunct	Vt + dO + PP_M + NP_{4dep}	d) dO + PP_M + NP_{4dep}	He throws the ball two meters up.
10 e)	Intransitive verb with a spatial object and a dependent direct object as an adjunct	Vi + PP_S + $NP_{4\ dep}$	e) PP_S + $NP_{4\ dep}$	He goes down the stairs.

2. THE ESPERANTO SENTENCE PATTERNS

no	Type	Structure of VP	+	Examples
0)	Intransitive verb without subjects and objects	-	~	Pluvas.
1)	Intransitive verb without objects	Vi		La mano de la infano sangas.
2 a)	Linking verb without objects and identifying nominative as a subject complement	BE + NP_1	a) NP_1	Li estas studento.
2 b)	Linking verb with identifying prepositional phrase as a subject complement	BE + PP	b) PP	La libro estas pri studentoj.
2 c)	Linking verb with adjective as a subject complement	BE + AP	c) AP AP AP →ADJ	Mia mono estas for. Mia mono estas perdita. La rozo estas bela.
2 d)	Linking verb with adverb of place as a subject complement	BE + PP_S	d) PP_S	La libro estas sur la tablo.
2 e)	Linking verb with adverb of time as a subject complement	BE + PP_T	e) PP_T	La renkonto estos morgaŭ.
20	Linking verb with adjective phrase with a dependent prepositional object as a subject complement '	BE + AP	f) AP→ADJ PP_{dep}	Li estas libera de ciuj zorgoj. Mi estas scivola pri tia raporto.
2 g)	Linking verb with adjective and dependent direct object as a subject complement	BE + AP	g) AP →ADJ + $NP_{4\ dep}$	La fendo estas dudek metrojn longa.
2 h)	Linking verb with adjective and dependent indirect object as a subject complement	BE + AP	h) AP →PP_M + $NP_{3\ dep}$	Tio estas serva al mi. La laborilo estas utila al mi. Li estas simila al li. Mi estas fremda al tiu viro. Li estas bonintenca al li. Li estas kapabla al tiu krimo.
3 a)	Transitive verb with direct object	Vt + dO	a) -	Li legas libron. Mi atendas lin. La patrino varmigas la supon. Li karesas mian vangon. Mi memoras lin.
3 b)	Transitive verb with direct object and prepositional object as an adjunct	Vt + dO + PP	b) PP	Li superas min je diligenteco. Li superas min por diligenteco. Mi skribas leteron pri mia amiko.

4 e)	Transitive verb with a direct object and a dative of pertinence as an object complement	Vt + dO + $NP_{3\ dep}$	e) NP_4 +$NP_{3\ dep}$	Li **karesas** la vangon **al** mi.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	a) -	Mi **skribas** pri la gazeto. Li koleras **kontraŭ** li.
6 b)	Intransitive verb with two prepositional objects as adjuncts	Vi + PP + PP	b) PP	Mi **diskutas kun** li pri la **libro**.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	-	Li venos **morgaŭ**. Li venos somere. **Dum** la festo regis gajeco.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	-	Li **logas** en **Berlino**. Li iras supren. Li logas Berline. Sur la festherbejo regis gajeco. Li **skias valen**. Li taksias hotelen.
9)	Intransitive verb with an object of causality as an adjunct	Vi + PPc	-	Li **venis** pro **amikeco**.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	a)-	Li **parolas** bone. Li kondutas bone. Li **fartas malbone**.
10 b)	Intransitive verb with an object of manner and a prepositional object as adjuncts	Vi+ PP_M + PP	b) PP	Li kondutas **amikece vidalvide** de li. Koncerne lin mi kondutas amikece
10 c)	Intransitive verb with an object of manner and a spatial object as adjuncts	Vi + PP + PP_S	c) PP_S	Li veturas al hotelo taksie. Li veturas hotelen per **taksio**
10 d)	Transitive verb with a direct object and an object of manner with a dependent direct object as an adjunct	Vt + dO + PP_S + NP_{4dep}	d) NP_4+ $NP_{4\ dep}$	Li ^jetas pilkon unu **metron** alten. Li ^jetas pilkon unu metron **malproksimen**.

2 j)	Linking verb with adjective and dependent indirect object in the dative and dependent indirect object in the genitive as subject complement	BE+ AP	j) AP→ADJ + $NP_{3\ dep}$+ $NP_{2\ dep}$	Ich bin mir dessen bewußt.
2 k)	Linking verb with an adjective with a dependent indirect object and a dependent prepositional object as subject complement	BE + AP	k) AP →ADJ + $NP_{3\ dep}$ + PP_{dep}	Er ist mir an Fleiß überlegen.
2 l)	Linking verb with spatial object and dependent prepositional object as subject complement	BE + PP_{dep} + PPs	O PP_{dep} + PP_S	Er ist in Wien wohnhaft.
2 m)	Linking verb with object in the second case as subject complement	BE + NP_2	m) NP_2	Er ist dieser Meinung. Er ist des Teufels.
3 a)	Transitive verb with direct object	Vt + dO +	a)-	Er liest ein Buch.
3 b)	Transitive verb with direct object and a prepositional object as an adjunct	Vt + dO + PP	b) PP	Ich schreibe einen Brief über meinen Freund.
3 c)	Transitive verb with direct object with a spatial object as an adjunct	Vt + dO + PP_S	c) PP_S	Ich lege das Buch auf den Tisch.
3 d)	Transitive verb with direct object with a temporal object as an adjunct	Vt + dO + PP_T	d) PP_T	Ich verschob das Treffen auf morgen.
3e)	Complex transitive verb with direct object and identifying accusative as an object complement	Vct + dO + NP_4	e) NP_4	Er nannte ihn einen Lügner.
3 f)	Double transitive verb with a direct object and an indirect object (dative)	Vdt + dO + iO	f) iO	Ich gebe ihm das Buch.
3 g)	Double transitive verb with two direct objects	Vdt + dO + dO	g) dO	Ich lehre ihn die französische Sprache.
3 h)	Transitive verb with direct object and object of	Vt + dO + PP_M	h) PP_M	Er empfing mich freundlich.

	with a direct object with a dative of pertinence as object complement and an object of manner as an adjunct	PP_M + NP_3 dep	dO + PP_M + $NP_{3\ dep}$	Nase gerade.
4 g)	Intransitive verb with an object of space with a dative of pertinence as an adjunct	Vi + PP_S + $NP_{3\ dep}$	g) PPs + NP_{3dep}	Er klopft mir auf die Schulter.
4 h)	Double transitive verb with a direct object with a dative of pertinence as an object complement, and an object of space as an adjunct	Vdt + dO+ PP_S + $NP_{3\ dep}$	h) dO+ PP_S+ $NP_{3\ dep}$	Er legt mir die Hand auf die Schulter.
5)	Intransitive verb with genitive object	Vi + NP_2	-	Ich harre seiner. Wir gedenken der Toten.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	a) -	Ich schreibe über die Zeitung.
6 b)	Intransitive verb with two prepositional objects as two adjuncts	Vi + PP + PP	b) PP	Ich diskutiere mit ihm über das Buch.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	-	Er kommt morgen.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	"	Er wohnt in Berlin.
9)	Intransitive verb with an object of causality as an adjunct	Vi + PP_C	-	Er kam aus Freundschaft.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	a)-	Das Kleid paßt gut.
10 b)	Intransitive verb with an object of manner and a prepositional object as two adjuncts	Vi+ PP_M + PP	b) PP	Er kam gerne mit uns.
10 c)	Intransitive verb with an object of manner and a spatial object as two adjuncts	Vi+ PP_M + PPs	c) PP_S	Auf der Festwiese ging es lustig zu.

C. *THE TRANSLATION TABLES*

1. ESPERANTO TO ENGLISH

			Esperanto	to	English
no	Type	Structure of W	Examples in Esperanto	no	Examples in English
0)	Intransitive verb without subject and objects	Vi	Pluvas.	1)	It is raining.
1)	Intransitive verb without objects or adjuncts	Vi	Li venas.	1)	He is coming.
1)	Intransitive verb without objects or adjuncts	Vi	Li ^gojas. Mi bedauras. La rozo belas. Li bonfartas.	2 c)	He is happy. I am sorry. The rose is beautiful. He is well.
1)	Intransitive verb without objects or adjuncts	Vi	Li bonkondutas.	3 m)	He behaves himself well.
1)	Intransitive verb without objects or adjuncts	Vi	Li bonkondutas.	3 o)	He behaves himself.
1)	Intransitive verb without objects or adjuncts	Vi	Li bonkondutas.	10 a)	He behaves well.
1)	Intransitive verb without objects or adjuncts	Vi	Li supreniras.	8)	He goes up. He goes upstairs.
2 a)	Linking verb with identifying nominative as a subject complement	BE + NP_1	Li estas studento.	2 a)	He is a student.
2 b)	Linking verb with identifying prepositional phrase	BE + PP_1	La libro estas pri studentoj. Mi estas en lia servo. Mi estas je lia servo.	2 b)	The book is about students. I am at his service.
2 b)	Linking verb with identifying prepositional phrase	BE + PP_1	Mi estas en lia servo.	3 a)	I serve him
2 b)	Linking verb with	BE + PP_1	Mi estas en lia servo.	6 a)	I work for him

	object as an adjunct				
2 h)	Linking verb with adjective and dependent indirect object as an adjunct	BE + AP + $NP_{3\ dep}$	Tio estas serva al mi. La laborilo estas **utila** al mi. Li estas simila al **li**.. Mi estas fremda al tiu viro. Li estas bonintenca al **li**.	**2 h)**	This is useful to me. The tool is useful to me. This tool is of use to me. He is similar to him. I am unknown to this man. This man is a stranger to me. He is friendly to him.
2 h)	Linking verb with adjective and dependent indirect object as an adjunct	BE + AP + $NP_{3\ dep}$	Li estas kapabla al tiu **krimo**. Li estas bonintenca al li.	**2 f)**	He is capable of this crime. He is friendly towards him.
2 h)	Linking verb with adjective and dependent indirect object as an adjunct	BE + AP + $NP_{3\ dep}$	Tio estas serva al mi. La laborilo estas utila al mi. Li estas simila al mi.	3 a)	This serves me. The tool serves me. He resembles me.
3 a)	Verb with direct object	Vt + dO	Li **legas** libron. Mi **memoras lin**.	3 **a)**	He is reading a book. I remember him.
3 a)	Transitive verb with direct object	Vt + dO	Mi scias tion. Mi memoras tion.	1)	I know. I remember.
3 a)	Transitive verb with direct object	Vt + dO	Tio valoras la penon.	**2 g)**	This is worth the trouble.
3 a)	Transitive verb with direct object	Vt + dO	Mi **^satas** muzicon.	4 a)	The music appeals to me.
3 a)	Transitive verb with direct object	Vt + dO	Mi atendis lin.	6 a)	I was waiting for him.
3 a)	Transitive verb with direct object	Vt + dO	La **laboristo blankigas** la muron.	**3 i)**	The worker paints the wall white.
3 a)	Transitive verb with direct object	Vt + dO	Li **malsupreniras** la stuparon.	10 e)	He goes down the stairs.
3 a)	Transitive verb with direct **object**	Vt + dO	Mi bedauras lin.	**2 f)**	I am sorry for him.
3 b)	Transitive verb with direct object and a prepositional object as an adjunct	Vt + dO + PP	Mi skribas leteron pri mia **amiko**. Li kulpas lin pro **^stelo**.	**3 b)**	I write a letter about my friend. He accuses him of stealing.

	(dative)				
3 h)	Transitive verb with direct object and object of manner	Vt + dO + PP_M	Li ricevis **lin** agrable.	3 h)	He received him kindly.
3 i)	Complex transitive verb with an adjective with a dependent direct object as an object complement	Vct + AP AP →ADJ + dO_{dep}	La laboristo faras la muron **blanka**.	3 i)	The worker paints the wall white.
3 k)	Complex transitive verb with direct object and identifying noun phrase as an object complement	Vct + dO+ PP	Hi elektis lin kiel **prezidanton**. Li konsideras lin kiel **amikon**.	3 k)	They elected him as president. He considers him as a friend.
3 k)	Complex transitive verb with direct object and identifying prepositional phrase as an object complement	Vct + dO+ PP	**Ili** elektis lin kiel prezidanton. Li konsideras lin kiel amikon.	3 e)	They elected him president. He considers him a friend.
3 l)	Complex transitive verb with direct object and an adjective phrase as an object complement	Vct + dO+ AP	**Ili** konsideras lin kiel inteligentan.	3 l)	They consider him as intelligent.
4 a)	Intransitive verb with an indirect object as an adjunct	Vi + iO	La muziko **pla^cas al** mi.	4 a)	The music appeals to me.
4 a)	Intransitive verb with an indirect object as an adjunct	Vi + iO	Li similas al **li**. La **laborilo servas** al mi. Tio servas al mi.	2h)	He is similar to him. The tool is useful to me. This is helpful to me.
4 a)	Intransitive verb with an indirect object as an adjunct	Vi + iO	Li kapablas al tiu **krimo**.	**2 f)**	He is capable of this crime.
4 a)	Intransitive verb with an indirect	Vi + iO	Li similas al li. La laborilo servas al mi.	3 a)	He resembles him. The tool serves me.

	object as an adjunct				
6 b)	Intransitive verb with two prepositional objects as adjuncts	Vi + PP + PP	Mi **diskutas kun** li pri la **libro**.	6 b)	I discuss with him about the book.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	Li venos **morgaŭ**. Li venos somere.	7)	He is coming tomorrow. He will come in summer.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	La renkonto estos **morgaŭ**.	2 e)	The meeting will be tomorrow.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	**Dum** la festo regis gajeco.	10 c)	At the party things were going on lively.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	Li **logas** en **Berlino**. Li logas Berline. Li iras supren.	8)	He lives in Berlin. He goes up. He goes upstairs.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	Sur la festherbejo regis gajeco. Li taksias **hotelen**. Li **skias valen**.	10 c)	At the meeting ground things were going on lively. He goes to the hotel by taxi. He goes down into the valley.
9)	Intransitive verb with an object of causality as an adjunct	Vi + PP_C	Li **venis** pro **amikeco**.	9)	He came for friendship's sake.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Li **parolas** bone. Li kondutas bone.	10 a)	He speaks well. He behaves well.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Li kondutas bone.	3 m)	He behaves himself well.
10 a)	Intransitive verb with an object of manner as an	Vi + PP_M	Li kondutas bone.	3 o)	He behaves himself.

2. ESPERANTO TO GERMAN

			Esperanto	to	German
no	Type	Structure of VP	Examples in Esperanto	no	Examples in German
0	Intransitive verb without subject and object or adjunct	Vi	Pluvas.	1)	Es regnet.
1)	Intransitive verb without objects and adjuncts	Vi	Li venas.	1)	Er kommt:
1)	Intransitive verb without objects and adjuncts	Vi	Li scias.	3 a)	Er weiß es.
1)	Intransitive verb without objects and adjuncts	Vi	La mano de la infano sangas.	4 d)	Dem Kind blutet die Hand.
1)	Reflexive verb without objects and adjuncts	Vi	Li ^gojas.	3 o)	Er freut sich.
1)	Intransitive verb without objects and adjuncts	Vi	Mi bedauras.	4 c)	Es tut mir leid.
1)	Intransitive verb without objects and adjuncts	Vi	La rozo belas.	2 c)	Die Rose ist schön.
1)	Intransitive verb without objects and adjuncts	Vr	Li bonkondutas.	3 m)	Er benimmt sich gut.
1)	Intransitive verb without objects and adjuncts	Vi	Li supreniras.	8)	Er geht hinauf.
1)	Intransitive verb without objects and adjuncts	Vi	Tio konvenas.	10 a)	Das paßt gut.
2 a)	Linking verb with an identifying nominative as a subject complement	BE + NP_1	Li estas studento.	2a)	Er ist ein Student.
2 b)	Linking verb with an identifying	BE + PP	La libro estas pri	2 b)	Das Buch ist über

	dependent prepositional object as a subject complement	PP_{dep}	estas tipo por li. Mi estas scivola pri tia raporto.		bezeichnend für ihn. Ich bin auf deinen Bericht gespannt. Das ist typisch für ihn.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PP_{dep}	Li estas libera de ciuj zorgoj.	2 g)	Er ist seine Sorgen los.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PPdep	Mi estas rememorante pri tio. Li estas libera de ciuj zorgoj.	2 i)	Ich bin dessen eingedenk. Er ist seiner Sorgen ledig.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PP_{dep}	Mi estas rememorante pri tio.	3 b)	Ich erinnere mich daran.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PP_{dep}	Mi estas rememorante pri tio.	3 o)	Ich erinnere mich.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PP_{dep}	Tio estas tipo por li.	4 c)	Das sieht ihm ähnlich.
20	Linking verb with an adjective with a dependent prepositional object as a subject complement	BE + AP + PP_{dep}	Mi estas rememorante pri tio.	6 a)	Ich denke daran.
20	Linking verb with an adjective with a dependent prepositional	BE + AP + PPdep	Mi estas rememorante pri tio.	3 j)	Ich erinnere mich dessen.

3 a)	Transitive verb with direct object	Vt + dO	Mi scias tion.	1)	Ich weiß.
3 a)	Transitiveverb with direct object	Vt + dO	Tio valoras la penon.	2 g)	Das ist die Mühe wert.
3 a)	Transitive verb with direct object	Vt + dO	Mi memoras lin.	3 b)	Ich erinnere mich an ihn.
3 a)	Transitive verb with direct object	Vt + dO	Mi atendis lin.	6 a)	Ich wartete auf ihn.
3 a)	Transitive verb with direct object	Vt + dO	Mi memoras lin. Mi atendas lin.	5)	Ich gedenke seiner. Ich harre seiner.
3 a)	Transitive verb with direct object	Vt + dO	Mi memoras lin.	3 j)	Ich erinnere mich seiner.
3 a)	Transitive verb with direct object	Vt + dO	Mi memoras tion. Tio valoras la penon.	2 i)	Ich bin dessen eingedenk. Das ist der Mühe wert.
3 a)	Transitive verb with direct object	Vt + dO	Mi memoras tion.	3 o)	Ich erinnere mich.
3 a)	Transitive verb with direct object	Vt + dO	Li longi^gis la interparolon.	3 d)	Er zog das Gespräch in die Länge.
3 a)	Transitive verb with direct object	Vt + dO	La laboristo blankigas la muron. La patrino varmigas la supon.	3 i)	Der Arbeiter macht die Mauer weiß Die Mutter macht die Suppe warm.
3 a)	Transitive verb with direct object	Vt + dO	Li karesas mian vangon.	4 e)	Er streichelt mir die Wange.
3 a)	Transitive verb with direct object	Vt + dO	La kuracisto rektigas mian nazon.	4 f)	Der Arzt richtet mir die Nase gerade.
3 a)	Transitive verb with direct object	Vt + dO	Li batelas mian ^sultron.	4 g)	Er klopft mir auf die Schulter.
3 a)	Transitive verb with direct object	Vt + dO	Li batelas mian ^sultron.	8)	Er klopft auf meine Schulter.
3 a)	Transitive verb with direct object	Vt + dO	Li malsupreniras la stuparon.	10 e)	Er geht die Stiege hinunter.
3 a)	Transitive verb with direct object	Vt + dO	Mi bedauras lin.	4 c)	Er tut mir leid.
3 a)	Transitive verb with direct object	Vt + dO	Li favoras lin.	2 h)	Er ist ihm hold.

	identifying **nominative** as an object phrase				
3 e)	Complex transitive verb with direct object and identifying nominative as an object phrase	**Vct + dO + NP_1**	**Ili** elektis **lin prezidanto**.	3 k)	Sie wählten ihn zum Präsident. Sie wählten ihn als Präsident.
30	Double transitive verb with a direct object and an indirect object (dative)	Vdt + dO + iO	Mi donas la libron **al li**.	30	Ich gebe ihm das Buch.
30	Double transitive verb with a direct object and an indirect object (dative)	Vdt + dO + iO	Mi **instruas** francan **lingvon al li**.	3 g)	Ich lehre ihn die französische Sprache.
3 h)	Transitive verb with a direct object and an object of manner as an adjunct	Vt + dO + **PP_M**	Li ricevis min **agrable**. Li **traktas** lin **kruele**.	3 h)	Er empfing mich freundlich. Er behandelt ihn grausam.
3 h)	Transitive verb with direct object and object of manner as an adjunct	Vt + dO + **PP_M**	Li traktas lin kruele.	10 b)	Er handelt grausam an ihm.
3 i)	Complex transitive verb with an object of manner with a dependent direct object as an object complement	Vt + **PP_M** + **NP_{4dep}**	La laboristo faras la **muron** blanka.	3 i)	Der Arbeiter macht die Mauer **weiß**.
3k)	Complex transitive verb with direct object and identifying prepositional phrase as an object complement	**Vct + dO+ PP**	**Ili** elektis lin kiel prezidanton. Li konsideras lin kiel **amikon**.	3 k)	Sie wählten ihn zum Präsident. Sie halten ihn **für** einen Freund.
3k)	Complex transitive verb with direct object and	**Vct + dO+ PP**	**Ili** nomas lin kiel amikon.	3 k)	Sie nennen ihn einen Freund.

	pertinence as a subject complement				
4 e)	Complex transitive verb with a direct object with a dative of pertinence as an object complement	Vct+ dO + NP_3 dep	Li karesas la vangon al mi.	4 e)	Er streichelt mir die Wange.
4 e)	Complex transitive verb with a direct object with a dative of pertinence as an object complement	Vct+ dO + NP_3 dep	La kuracisto rektigas la nason al mi.	4 f)	Der Arzt richtet mir die Nase gerade.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Mi skribas pri la gazeto.	6 a)	Ich schreibe über die Zeitung.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Li koleras kontraŭ li.	2 h)	Er ist ihm gram.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Mi memoras pri li.	3 b)	Ich erinnere mich an ihn.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Mi bonkondutas vidalvide de li.	3 n)	Ich benehme mich gut ihm gegenüber.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Mi memoras pri li.	3 o)	Ich erinnere mich.
6 a)	Intransitive verb with a prepositional object as an	Vi + PP	Mi memoras pri li.	3 j)	Ich erinnere mich seiner.

	adjunct				
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Li parolas bone.	10 a)	Er spricht gut.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Li kondutas bone.	3 m)	Er benimmt sich gut.
10 a)	Intransitive verb with an object of manner as an adjunct		Li fartas malbone.	4 c)	Es geht ihm schlecht.
10 b)	Intransitive verb with an object of manner and a prepositional object as adjuncts	Vi+ PP_M + PP	Li parolas bone pri la gazeto.	10 b)	Er spricht gut über die Zeitung.
10 b)	Intransitive verb with an object of manner and a prepositional object as adjuncts	Vi+ PP_M + PP	Li kondutas amikece vidalvide de li. Koncerne lin li kondutas amikece.	3 n)	Er verhält sich freundschaftlich ihm gegenüber.
10 c)	Intransitive verb with an object of manner and a spatial object as adjuncts	Vi+ PP_M + PPs	Li veturas al hotelo taksie. Li veturas hotelen per taksio.	10 c)	Er fährt mit dem Taxi ins Hotel. Er fährt mit dem Taxi zum Hotel.
10 d)	Complex transitive verb with a direct object and an object of manner with a dependent direct object as an object complement	Vct + PP_S + dO + dOdep	Li ^jetas pilkon unu metron alten. Li ^jetas pilkon unu metron malproksimen.	10 d)	Er wirft den Ball einen Meter hoch. Er wirft den Ball einen Meter weit.

2 f)	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + PP_{dep}	Ich bin bei ihm angestellt.	2 b)	Mi estas en Ha servo.
2 f)	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + PPdep	Er ist zu diesem Verbrechen fähig.	2h)	Li estas kapabla **al** tiu **krimo**.
20	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + PPdep	Das ist bezeichnend **für** ihn. Das ist typisch für ihn.	3 b)	El tio **mi** tute rekonas **lin**.
2 f)	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + PP_{dep}	Er ist zu diesem Verbrechen fähig.	4 a)	Li kapablas al tiu krimo.
2 g)	Linking verb with adjective and dependent direct object as a subject complement	BE + AP + $NP_{4\ dep}$	Der Spalt ist zwanzig Meter lang.	2g)	La fendo estas dudek **metrojn longa**.
2 g)	Linking verb with adjective and dependent direct object as a subject complement	BE + AP + $NP_{4\ dep}$	Er ist seine Sorgen los.	2 f)	Li estas libera de ciuj zorgoj.
2 g)	Linking verb with adjective and dependent direct object as a **subject** complement	BE + AP + $NP_{4\ dep}$	Ich bin mein Geld los.	2 c)	**Mia** mono estas perdita. **Mia** mono estas for.
2 g)	Linking verb with adjective and dependent direct	BE + AP + $NP_{4\ dep}$	Das ist die Mühe wert.	3 a)	Tio valoras **la** penon.

	complement				
2 i)	Linking verb with adjective and dependent indirect object in the genitive as a subject complement	BE + AP + $NP_{2\ dep}$	Das ist der Mühe wert. Ich bin dessen eingedenk. Ich bin dessen gewärtig.	3 a)	Tio valoras la penon. Mi memoras tion. Mi atendas tion. Mi ekvidas tion.
2 i)	Linking verb with adjective and dependent indirect object in the genitive as a subject complement	BE + AP + $NP_{2\ dep}$	Ich bin dessen eingedenk.	6 a)	Mi memoras pri tion.
2 j)	Linking verb with adjective and dependent indirect object in the dative and dependent indirect object in the genitive as a subject complement	BE + AP + $NP_{3\ dep}$ + $NP_{2\ dep}$	Ich wurde mir dessen bewußt.	6 a)	Mi konscii^gis pri tion.
2 k)	Linking verb with adjective and a dependent indirect object and a dependent prepositional object as a subject complement	BE + AP + $NP_{3\ dep}$ + PP_{dep}	Er ist mir an Fleiß überlegen.	3 b)	Li superas min je diligenteco. Li superas min por diligenteco.
2 l)	Linking verb with spatial object and dependent prepositional object as a subject complement	BE + PPs + PP_{dep}	Er ist in Wien wohnhaft.	8)	Li logas en Vieno. Li logas Viene.
2m)	Linking verb with object in the second case as a subject complement	BE + NP_2	Er ist anderer Meinung. Er ist des Teufels.	3 a)	Li havas alian opinion. Diablo lin pelas.
3 a)	Transitive verb with direct object	Vt + dO	Ich lese ein Buch.	3 a)	Mi legas libron.
3 a)	Transitive verb with direct object	Vt + dO	Ich weiß es.	1)	Mi scias.
3 a)	Transitive verb with	Vt + dO	Ich mag die Musik.	4 a)	La muzico ^satas al mi.

30	Double transitive verb with a direct object and an indirect object (dative)	Vdt + dO + iO	Ich gebe ihm das Buch.	3 f)	Mi donas la libron al li.
3 g)	Double transitive verb with two direct objects	Vdt + dO + dO	Ich lehre ihn die französische Sprache.	3 f)	Mi instruas francan lingvon al li.
3 h)	Transitive verb with direct object and object of manner as an adjunct	Vt + dO + PP_M	Er empfing ihn freundlich.	3 h)	Li ricevis lin agrable.
3 i)	Complex transitive verb with an object of manner and a dependent direct object as an adjunct	Vct + PP_M + NP_4 dep	Der Arbeiter macht die Mauer weiß.	3 i)	La laboristo faras la muron blanka.
3 i)	Complex transitive verb with an object of manner and a dependent direct object as an adjunct	Vct + PP_M + NP_4 dep	Die Mutter macht die Suppe warm. Der Arbeiter macht die Mauer weiß.	3 a)	La patrino varmigas la supon. La laboristo blankigas la muron. La laboristo blankpentras la muron.
3 j)	Double transitive verb with a direct object and a genitive object	Vdt + dO+ NP_2	Ich erinnere mich seiner.	2 f)	Mi estas rememorante pri li.
3 j)	Double transitive verb with a direct object and a genitive object	Vdt + dO+ NP_2	Ich erinnere mich seiner.	3 a)	Mi memoras lin.
3 j)	Double transitive verb with a direct object and a genitive object	Vdt + dO+ NP_2	Er klagt ihn des Diebstahls an.	3 b)	Li kulpas lin pro ^stelo.
3 j)	Double transitive verb with a direct object and a genitive object	Vdt + dO+ NP_2	Ich erinnere mich seiner.	6 a)	Mi memoras pri li.
3 k)	Complex transitive verb with direct object and identifying accusative	Vct + dO + NP_4	Sie wählten ihn als Präsident. Sie wählten ihn zum Präsidenten.	3 k)	Ili elektis lin prezidanton.

	object				
4 b)	Intransitive verb with an indirect object and a prepositional object as an adjunct	Vi + iO+ PP	Er spricht mit mir über das Buch.	4 b)	Li parolas **al** mi pri la **libro**.
4 b)	Intransitive verb with an indirect object and a prepositional object as an adjunct	Vi + iO+ PP	Ich stehe ihm zu Diensten. Ich stehe ihm zur Verfugung.	2 b)	Mi estas en lia servo. Mi estas je lia servo.
4 c)	Intransitive verb with an indirect object and an object of manner as an adjunct	Vi + iO + PP_M	Es tut mir leid. Es geht ihm gut.	1)	Mi bedauras. Li **bonfartas**.
4 c)	Intransitive verb with an indirect object and an object of manner as an adjunct	Vi + iO + PP_M	Das sieht ihm ähnlich.	2 f)	Tio estas tipo por **li**.
4 c)	Intransitive verb with an indirect object and an object of manner as an adjunct	Vi + iO + PPM	Er tut mir leid.	3 a)	Mi bedauras **lin**.
4 c)	Intransitive verb with an indirect object and an object of manner as an adjunct	Vi + iO + PP_M	Er sieht ihm ähnlich.	4 a)	Li **similas** al li.
4 c)	Intransitive verb with an indirect object and an object of manner as an adjunct	Vi + iO + PP_M	Es geht ihm gut.	10 a)	Li **fartas** bone.
4 d)	Intransitive verb with a dative of pertinence as a subject complement	Vi + NP_3 dep	Dem Kind blutet die Hand.	4 d)	**Al** la **infano** la **mano** sangas.
4 d)	Intransitive verb with a dative of pertinence as a subject complement	Vi + NP_3 dep	Dem Kind blutet die Hand.	1)	La mano de **la** infano sangas.

5)	Intransitive verb with genitive object	Vi + NP_2	Ich gedenke seiner.	2 f)	Mi estas rememorante **pri li**.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Ich schreibe über die Zeitung.	6 a)	Mi **skribas** pri **la** gazeto.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Ich stehe in seinem Dienst.	2 b)	Mi estas en lia **servo**.Mi estas je lia servo.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Ich warte auf ihn.	3 a)	Mi atendas **lin**.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	Ich denke an ihn.	2 f)	Mi estas rememorante pri **li**..
6 b)	Intransitive verb with two prepositional objects as adjuncts	Vi + PP+ PP	Ich diskutiere mit ihm über das Buch.	6 b)	Mi **diskutas kun** li pri la **libro**.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	Ich komme morgen. Ich komme im Sommer.	7)	Mi venös **morgaŭ**. Mi venös somere.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	Das Treffen findet morgen statt.	2 e)	La renkonto estos **morgaŭ**.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	Er wohnt in Berlin. Er geht hinauf. Er fährt ins Tal.	8)	Li **logas** en Berlino. Li **logas** Berline. Li iras supren. Li **skias valen**.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	Er geht hinauf.	1)	Li **supreniras**.
9)	Intransitive verb with an object of causality as an adjunct	Vi + PP_C	Das Verbrechen geschah aus Eifersucht. Er kam aus Freundschaft.	9)	La **krimo** okazis pro **^jaluzo**. Li **venis** pro **amikeco**.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Er spricht gut.	10 a)	Li parolas bone.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	Das paßt gut.	1)	Tio konvenas.
10	Intransitive verb with an object of	Vi + PP_M	Er handelt grausam	3 h)	Li **traktas** lin **kruele**.

4. ENGLISH TO ESPERANTO

			English	to	Esperanto
no	Type	Structure of W	Examples in English	no	Examples in Esperanto
1)	Intransitive verb without objects or adjuncts	Vi	He is sleeping. He comes.	1)	Li venas. Li donnas.
1)	Intransitive verb without objects or adjuncts	Vi	It is raining.	0)	Pluvas.
1)	Intransitive verb without objects or adjuncts	Vi	I know. I remember.	3 a)	Mi scias tion. Mi memoras tion.
1)	Intransitive verb without objects or adjuncts	Vi	I remember.	2 f)	Mi estas rememorante pri tion.
1)	Intransitive verb without objects or adjuncts	Vi	I remember.	6 a)	Mi memoras pri tion.
1)	Intransitive verb without objects or adjuncts	Vi	The child's hand is bleeding.	4 d)	Al la infano la mano sangas.
2 a)	Linking verb with identifying nominative as a subject complement	BE + NP_1	He is a student.	2a)	Li estas studento.
2 b)	Linking verb with identifying prepositional phrase as a subject complement	BE + PP	The book is about students. I am at his service.	2 b)	La libro estas pri studentoj. Mi estas en lia servo.
2 b)	Linking verb with identifying prepositional phrase as a subject complement	BE + PP	This is like him.	2 f)	Tio estas tipo por li.
2 b)	Linking verb with identifying prepositional phrase as a subject complement	BE + PP	This is like him.	3 b)	El tio mi tute rekonas lin.
2 c)	Linking verb with	BE + AP	The rose is beautiful.	2 c)	La rozo estas bela.

	prepositional object as a subject complement				
2 f)	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP+ PPdep	He is capable of this crime.	4 a)	Li kapablas al tiu **krimo**.
2 f)	Linking verb with adjective and dependent prepositional object as a subject complement	BE + AP + PPdep	He is angry at him.	6 a)	Li koleras **kontraŭ** li.
2 g)	Linking verb with adjective and dependent direct object as a subject complement	BE + AP + $NP_{4\ dep}$	The fissure is twenty meters long.	**2 g)**	La fendo estas dudek metrojn **longa**.
2 g)	Linking verb with adjective and dependent direct object as a subject complement	BE + AP + $NP_{4\ dep}$	This is worth the trouble.	3 a)	Tio valoras la penon.
2 h)	Linking verb with adjective and dependent indirect object in the dative as a subject complement	BE + AP + $NP_{3\ dep}$	The tool is useful to me. He is similar to me. He is a stranger **to me**.	**2 h)**	La laborilo estas **serva** al mi. La laborilo estas **utila** al mi. Li estas **simila** al mi. Li estas **stranga** al mi.
2 h)	Linking verb with adjective and dependent indirect object in the dative as a subject complement	BE + AP + $NP_{3\ dep}$	The tool is useful to me. He is a stranger to me.	**2 f)**	La laborilo estas serva por mi. La laborilo estas utila por mi. Li estas stranga por mi.
2 h)	Linking verb with an adjective and dependent indirect object in the dative as a subject complement	BE + AP + $NP_{3\ dep}$	The tool is useful to me. He is similar to him.	4 a)	La laborilo **servas** al mi. Li **similas** al li.
3 a)	Transitive verb with	Vt + dO	He is reading a book. I like the	3 a)	Li **legas** libron. Mi **^satas** muzicon. Mi

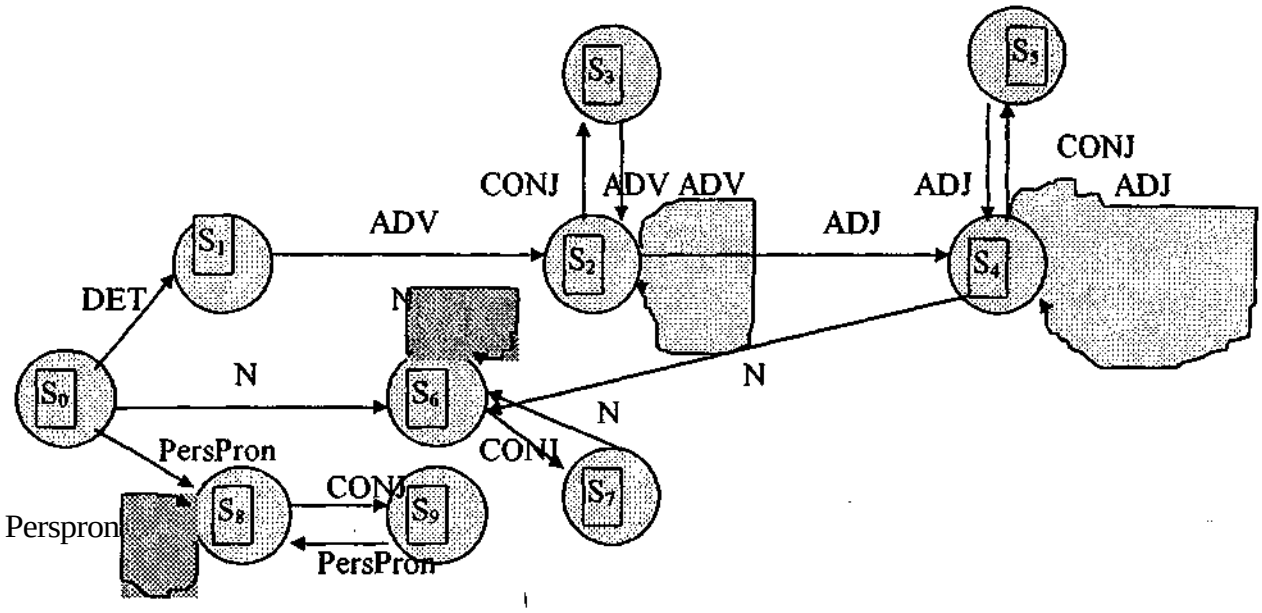
	an adjunct				
3 e)	Complex transitive verb with direct object and identifying accusative as an object complement	Vct + NP_4+ NP_4	He calls him a liar. They elected him president.	3 e)	Li **nomas lin mensogulo**. Hi **elektis** lin prezidanto.
3 e)	Complex transitive verb with direct object and identifying accusative as an object complement	Vct + NP_4+ NP_4	They elected him president.	3 k)	**Ili** elektis lin kiel prezidanton.
3 f)	Double transitive verb with a direct object and an indirect object (dative)	Vdt + dO + iO	I give him the book. I teach him the French language.	3 f)	Mi donas libron al li. Mi **instruas francan lingvon** al li.
3 f)	Double transitive verb with a direct object and **an** indirect object (dative)	Vdt + dO + iO	He **bears** resemblance to me.	2 h)	Li estas simila al mi.
3 f)	Double transitive verb with a direct object and an indirect object (dative)	Vt + dO + iO	He bears resemblance to me.	4 a)	Li **similas** al mi.
3 h)	Transitive verb with a direct object and an object of manner as an adjunct	Vt + dO + PP_M	He received me kindly.	3 h)	Li ricevis min agrable.
3 **i)**	Complex transitive verb with a direct object and an adjective as an object complement	Vt + dO + AP	The worker painted the wall white. He dyes his hair black.	3 i)	La **laboristo** faris la muron **blanka**. Li **tinkturas** la **hararojn nigraj**.
3 i)	Complex transitive verb with a direct object and an adjective as an object complement	Vt + dO + AP	Mother paints the table white.	3 a)	La **patrino blankpentras** la tablon.
3k)	Complex transitive verb with direct	Vi + NP_4+ PP	They elected him for president.	3 e)	**Ili** elektis lin prezidanto.

4 a)	Intransitive verb with an indirect object	Vi + iO	The music appeals to me.	3 a)	Mi ^**satas muzicon**.
4 b)	Intransitive verb with an indirect object and a prepositional object as an adjunct	Vi + iO+ PP	I talk to him about the book.	**4 b)**	Mi parolas **al li** pri la **libro**.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	He talks about the book. I work for him.	6 a)	Li parolas pri libro. Mi laboras por li.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	I work for him.	**2 b)**	Mi estas en lia servo.
6 a)	Intransitive verb with a prepositional object as an adjunct	Vi + PP	I am waiting for him.	3 a)	Mi atendas **lin**.
6 b)	Intransitive verb with two prepositional objects as adjuncts	Vi + PP + PP	They discuss with us about the book.	**6 b)**	**Ili diskutas kun** ni pri la libro.
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	He will come tomorrow.	7)	Li venos **morga**().
7)	Intransitive verb with a temporal object as an adjunct	Vi + PP_T	The meeting takes place tomorrow.	**2 e)**	La **renkonto** estos **morga**().
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	The children have come home.	8)	La **infanoj venis** hejme.
8)	Intransitive verb with a spatial object as an adjunct	Vi + PP_S	I go upstairs.	1)	Mi **supreniras**.
9)	Intransitive verb with an object of causality as an adjunct	Vi + PP_C	He did it for friendship's sake.	9)	Li **faris** tion pro **amikeco**.
10 a)	Intransitive verb with an object of manner as an adjunct	Vi + PP_M	He goes by taxi. He came quickly.	10 a)	Li iras taksie. Li venis rapide.
10 a)	Intransitive verb with an object of	Vi + PP_M	He goes by taxi.	1)	Li **taksias**.

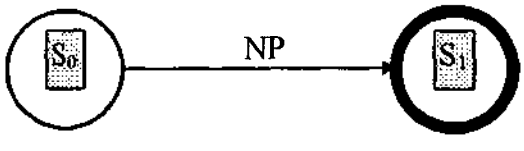
D. AUGMENTED TRANSITION NETWORKS OF POSSIBLE LINGUISTIC COMPONENTS

1. Possible Noun Phrases in English, German, and Esperanto:

Noun phrases stand as a subject and objects to each sentences. They can be said to be the basic elements of the sentence. For each language, these noun phrases must have a prescribed structure. With German, English, and Esperanto, the structure of noun phrases is practically the same. Here is an atn of possible noun phrases in German, English, and Esperanto:



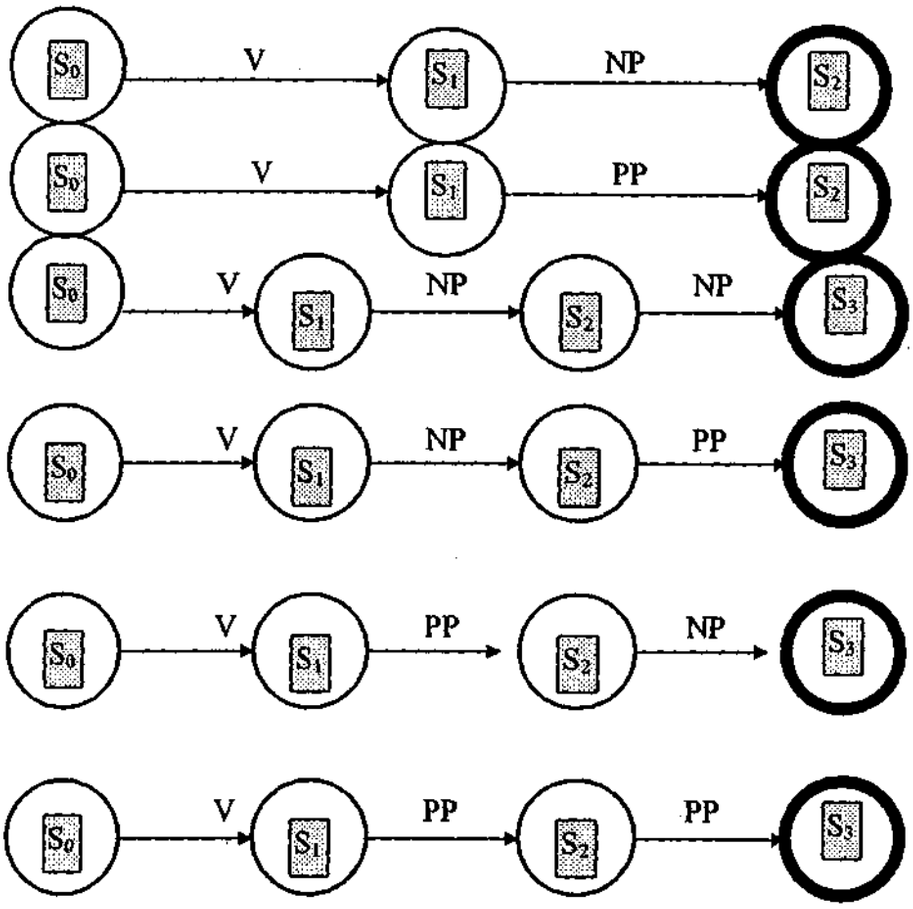
This means that the determiner comes before the noun, and if there are attributes depending on the noun, they must be placed before the noun and, if there is a determiner, after the determiner. An adjective cannot be placed after the noun neither in English nor in German, and in Esperanto it is so unusual that this was not taken into consideration here.



2. Possible Adjective Phrases and Adverb Phrases in English, German, and Esperanto:

Adjective phrases usually consist of an adjective or an adjective with a dependent noun phrase. Adverb phrases usually consist of an adverb or an adverb with a dependent noun phrase. They occur in German as well as in Esperanto and English, but in German the most complex ones

a subject, a verb, and a direct object, are most often found there. In German, more adjectives, adjective phrases, and adverbs are used, thus rendering the sentences more complex.

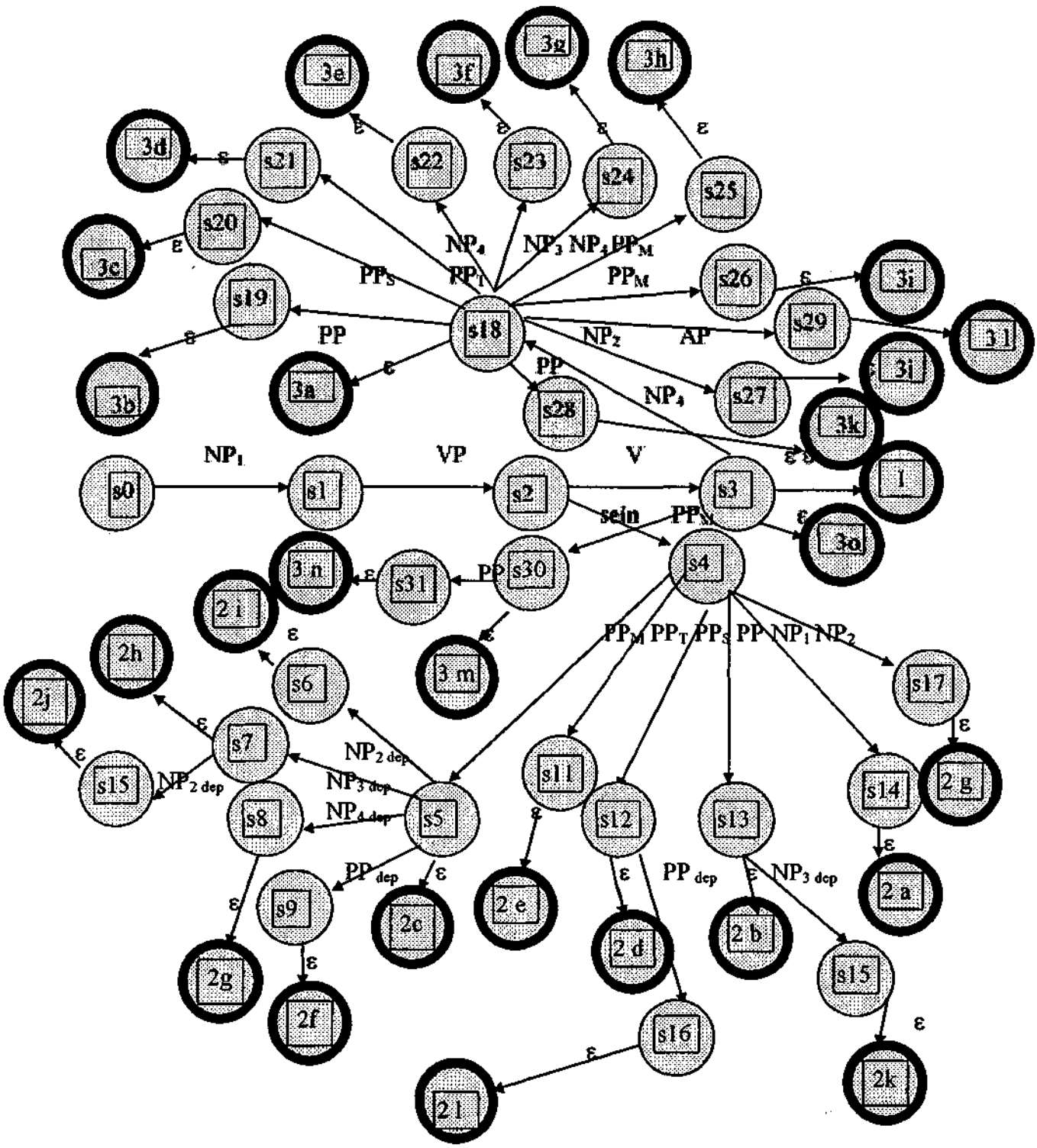


E. THE AUGMENTED TRANSITION NETWORKS OF THE SENTENCE PATTERNS

A good way to show the possible sentence patterns of a given language is to depict them with an augmented transition network. In this way, they can also be stored efficiently in a computer. The edges show the possible transitions as well as the components by means of which these transitions can be effectuated. e means that nothing (or a full stop) has been typed in, which means that the sentence has been finished. The nodes refer to the states after the components in question have been typed in. These are shown by ingoing arrows, whereas the outgoing arrows indicate what type of component can be input next. The terminal states are marked by nodes with bold frames. each terminal state represents one sentence pattern. At each node, only transitions indicated by outgoing arrows are possible. Any attempt to use other than the indicated transitions will result in an error message.

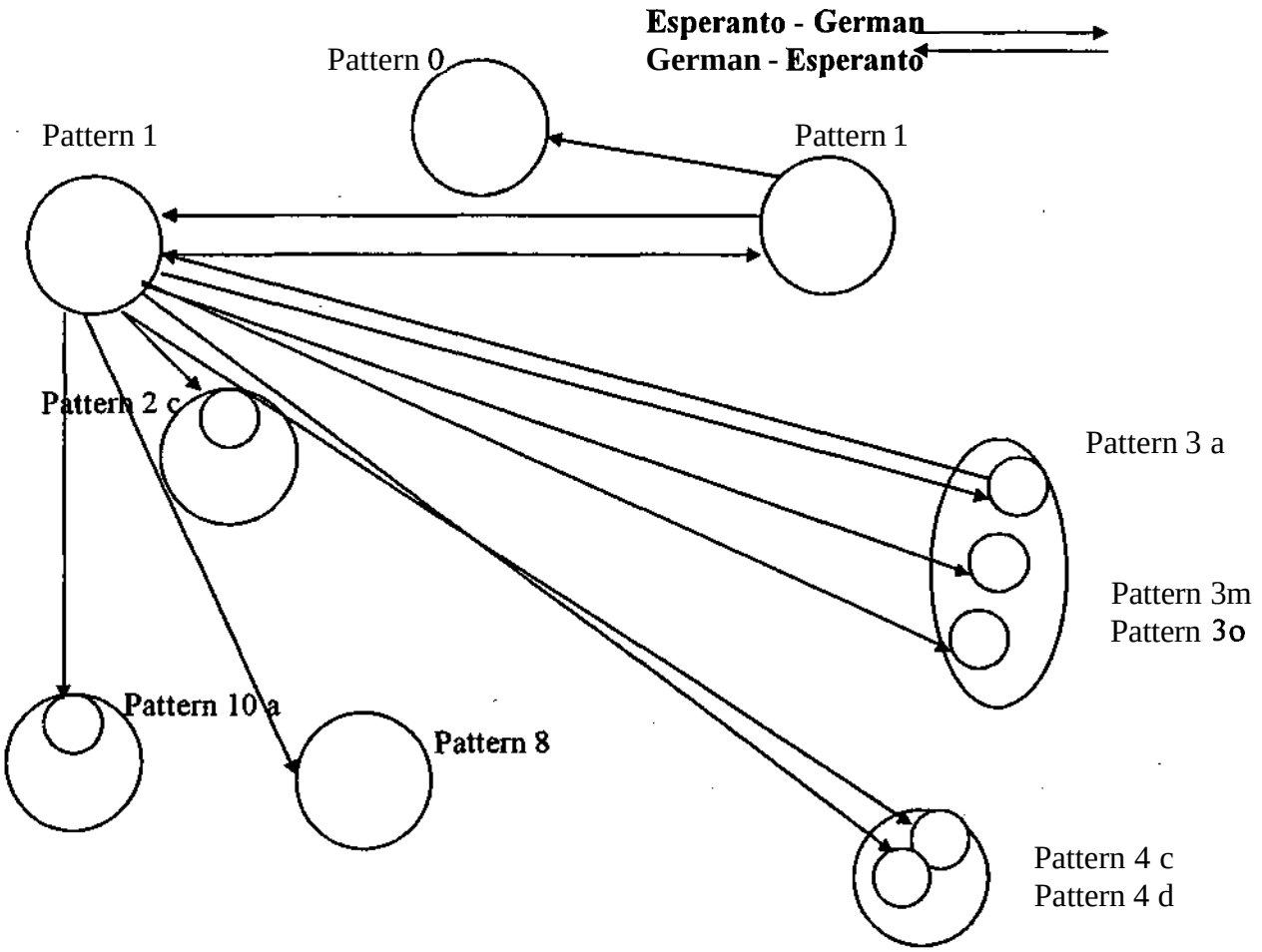
2. German

Here is the ATN with the first three German sentence patterns.

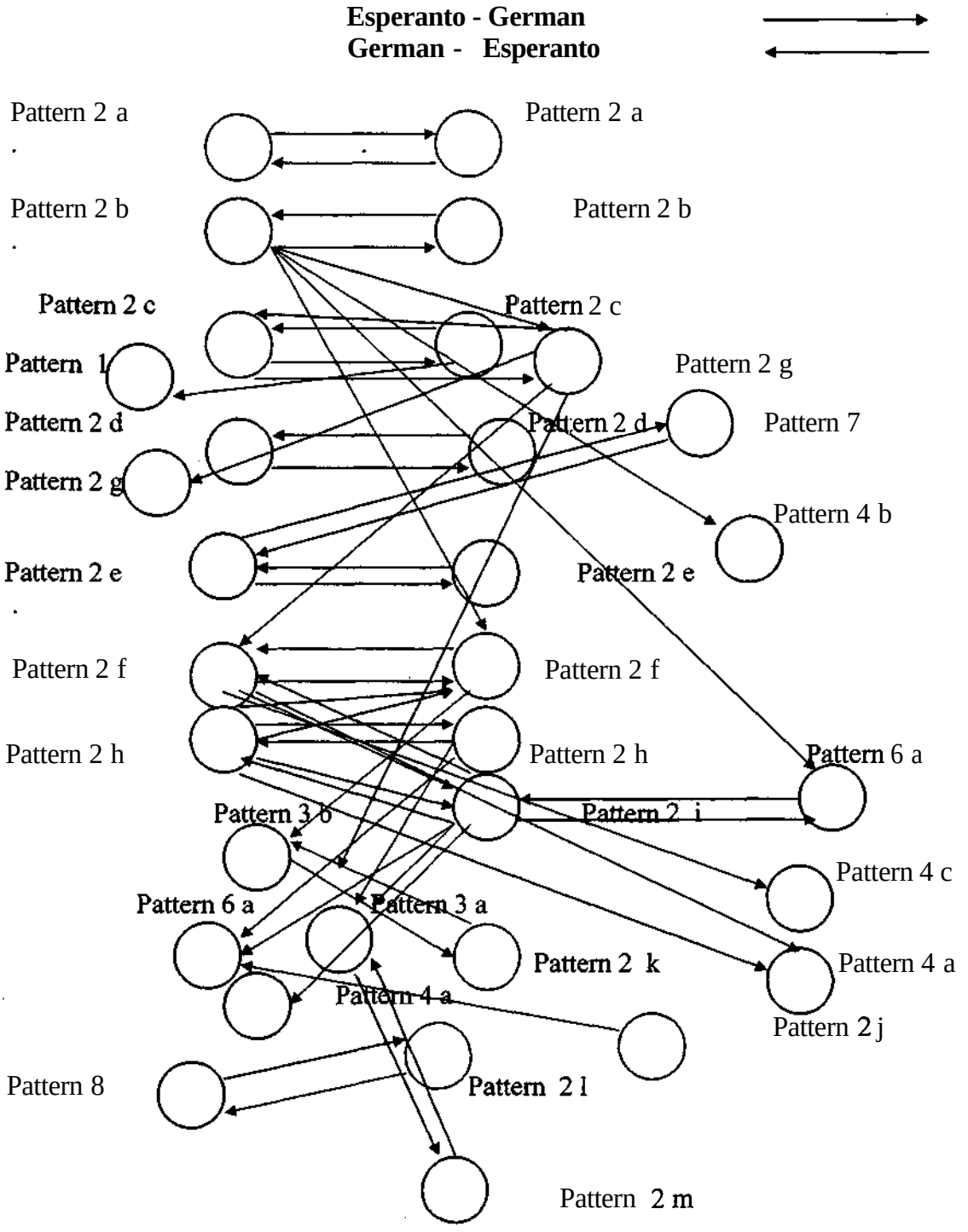


F. DIAGRAMS FOR TRANSLATION

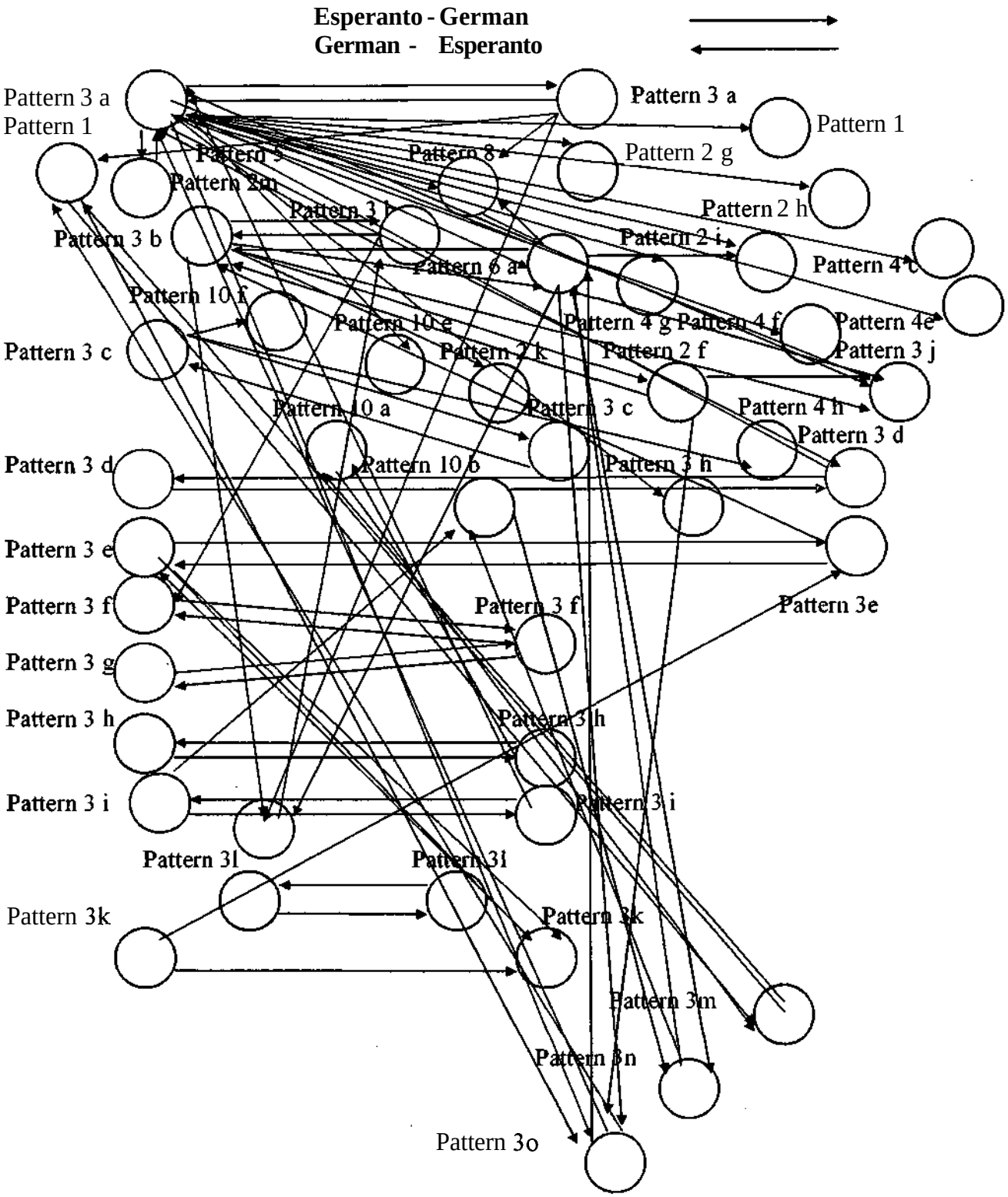
1. Pattern 0 and Pattern 1



2. Pattern 2


Esperanto - German
German - Esperanto
Pattern 2 a
Pattern 2 a
Pattern 2 b
Pattern 2 b
Pattern 2 c
Pattern 2 c
Pattern 1
Pattern 2 g
Pattern 2 d
Pattern 2 d
Pattern 7
Pattern 2 g
Pattern 4 b
Pattern 2 e
Pattern 2 e
Pattern 2 f
Pattern 2 f
Pattern 2 h
Pattern 2 h
Pattern 6 a
Pattern 3 b
Pattern 2 i
Pattern 4 c
Pattern 6 a
Pattern 3 a
Pattern 2 k
Pattern 4 a
Pattern 4 a
Pattern 2 j
Pattern 8
Pattern 2 l
Pattern 2 m

3. Pattern 3


Esperanto - German
German - Esperanto
Pattern 3 a
Pattern 1
Pattern 3 a
Pattern 1
Pattern 2 g
Pattern 2 h
Pattern 3 b
Pattern 2 i
Pattern 4 c
Pattern 6 a
Pattern 10 f
Pattern 10 e
Pattern 4 g
Pattern 4 f
Pattern 4e
Pattern 3 c
Pattern 2 k
Pattern 2 f
Pattern 3 j
Pattern 10 a
Pattern 3 c
Pattern 4 h
Pattern 3 d
Pattern 3 d
Pattern 10 b
Pattern 3 h
Pattern 3 e
Pattern 3 f
Pattern 3 f
Pattern 3e
Pattern 3 g
Pattern 3 h
Pattern 3 h
Pattern 3 i
Pattern 3 i
Pattern 3l
Pattern 3l
Pattern 3k
Pattern 3k
Pattern 3m
Pattern 3n
Pattern 3o

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