A SIGN-BASED PHRASE STRUCTURE GRAMMAR FOR TURKISH

by

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Abstract

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This study analyses Turkish syntax from an informational point of view. Sign based linguistic representation and principles of HPSG (Head-driven Phrase Structure Grammar) theory are adapted to Turkish. The basic informational elements are nested and inherently sorted feature structures called signs.

In the implementation, logic programming tool ALE —Attribute Logic Engine— which is primarily designed for implementing HPSG grammars is used. A type and structure hierarchy of Turkish language is designed. Syntactic phenomena such as subcategorization, relative clauses, constituent order variation, adjuncts, nominal predicates and complement-modifier relations in Turkish are analyzed. A parser is designed and implemented in ALE.

Keywords: syntax, Turkish Grammar, parsing, phrase structure
Öz

Türkçe İçin İm Temelli Öbek Yapısal Sözdizimi

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Bu çalışmada, Türkçe sözdizimi bilgiye dayalı bir bakış açısıyla değerlendirilmiştir. İme dayalı dilbilimsel gösterim ve HPSG (Baş-sürümülü Öbek Yapısal Dilbilim) kuralı Türkçe’ye uyarlanmıştır. HPSG, dildeki nesnelere bilgisel içerikleriyle gösterimine dayanan çağdaş bir sözdizimi ve anlambirim kuramıdır. Temel bilgi öğesi İm denilen iççe ve kalıtsal türlemdirilmiştir özellik yapıldıkları.

Uygulamada mantık programlama dili olarak özellikle HPSG uygulamaları için tasarlanmış olan ALE kullanılmıştır. Türkçe’deki dil öğelerinin bir tür ve yapı tanımlı hazırlanmıştır. Altulamlama, yan cümleler, öbek sıra değişimi, tümleç-niteleyen ilişkileri ve ortaça yapıları ALE‘de çalışan bir ayrıştırıcı ile tasarlanmış ve uygulanmıştır.

Anahtar Kelimeler: sözdizimi, Türkçe Dilbilgisi, ayrıştırma, öbek yapısı
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List of Abbreviations

| Abbreviation | Description |
|--------------|-------------|
| 1Sg, 2Sg, 3Sg | Agreement suffixes first, second and third person singular |
| 1Pl, 2Pl, 3Pl | Agreement suffixes first, second and third person plural |
| 1SP, 2SP, 3SP | Possessive suffixes first, second and third person singular |
| 1PP, 2PP, 3PP | Possessive suffixes first, second and third person plural |
| Abl | Ablative Case |
| Acc | Accusative Case |
| Dat | Dative Case |
| Loc | Locative Case |
| Ins | Instrumental/commitative Case |
| Gen | Genitive Case |
| Equ | Equitative Case |
| Mun | Munitive Case |
| Relv | Noun Relativizer |
| Cop | Copula Suffix |
| Aux | Auxiliary Suffix |
| Pres | Present Tense (-Ar) |
| Prog | Progressive Tense (-Hyor) |
| Past | Past Tense (-dH, -mHg) |
| Fut | Future Tense (-yAcAk) |
| Asp | Aspect markers (-dH, -mHg, -sA) |
| Pass | Passive Suffix |
| Caus | Causative Suffix |
| Neg | Negation suffix |
| Ques | Question suffix |
| Part | Complement Participle Suffix (-DHk, -yAcAk) |
| Inf | Infinitive Suffix (-mAk) |
| Ger | Gerundive Suffix (-mA, -Hg) |
| Rel | Relative Participle Suffix (-An, -DHk, -yAcAk) |
| Cond | Conditional Suffix (-ySA) |
| Adv | Adverbial Suffix (-ken) |
| Nec | Necessity Suffix (-mA1H) |
Chapter 1

INTRODUCTION

This study has two purposes: first, to study Turkish grammar in light of the Head-driven Phrase Structure Grammar (HPSG) formalism, and second, to come up with a computational model of the languages based on the HPSG principles.

Turkish grammar has been analyzed from the perspective of linguistic theories such as Transformational Grammar [18], Government-Binding, and Functional Grammar [23], Lewis [16], Underhill [27], Bangunolu [1], and Şimşek [26] are also good sources in the traditional descriptive style. However these studies do not shed any light on how a computational model can be constructed from the linguistic description.

Recent linguistic theories, such as HPSG [20, 21] and Lexical Functional Grammar (LFG) [1], differ from the earlier ones in their rigorous definitions and incorporation of ideas from computer science and artificial intelligence. These ideas range from type-theory in programming languages to unification and knowledge representation. Due to the formal representations, there are meta-tools for constructing computational models from formal descriptions, such as Attribute Logic Engine (ALE) [5], CUF [6], and Typed Feature System (TFS) [15]; Tomita’s parser for LFG [19].

This work is one of the early attempts, together with LFG [10] and Categorial Grammar Models [13, 1] to study Turkish from the perspective of modern linguistic theories. Our motivation was to design a parser based on the principled account of Turkish syntax in the HPSG framework. It makes use of the ALE formalism to model HPSG-style definitions.

HPSG makes universal claims about human languages. The main point is that, although the grammars of languages differ in terms of phrase structure and how grammatical functions are realized, certain principles always hold across the languages. An example of such a principle roughly states that the ‘head’ of a phrase plays the most prominent role in propagating the syntactic and semantic properties of a phrase. Thus, an HPSG grammar for a language is a collection of specifications for phrase structure, realization of principles in the language, and the signature of the language in terms of linguistic features. This division of linguistic description is also reflected in the computational meta-level tools for writing HPSG-style grammars. We hope that these kinds
of experiments point out the advantages and disadvantages of such frameworks for underanalyzed language including Turkish.

We aimed to develop a competence grammar rather than a performance grammar for Turkish. This requires postulating the Turkish realizations of HPSG principles and their computational counterparts. We chose to provide a breadth of coverage in terms of lexical types and phrases instead of a comprehensive study with a large lexicon. Moreover, we have implemented some of the morphosyntactic operations (e.g. case marking, possessives, relativization) in the lexicon.

The remainder of the thesis is organized as follows: Chapter 2 introduces the basic concepts of HPSG. Chapter 3 is an outline of Turkish syntax. Chapter 4 describes HPSG model of Turkish and Chapter 5 elaborates on the implementation.
Chapter 2

HEAD-DRIVEN PHRASE STRUCTURE GRAMMAR

HPSG (Head-driven Phrase Structure Grammar) was introduced by Pollard and Sag as an information-based theory of syntax and semantics. HPSG views a human language as a device used for exchanging information, and tries to explain the relation between the phonetic form of a word or a phrase, its grammatical structure, and its informational content. In HPSG, a natural language is defined as a system of correspondences between certain kind of utterances and certain kinds of objects and situations in the world.

HPSG synthesizes most of the recent (principally nonderivative) syntactic theories such as Categorial Grammar (CG), Generalized Phrase Structure Grammar (GPSG), Arc Pair Grammar (APG), and Lexical Functional Grammar (LFG); semantic theories like Situation Semantics, and some basic concepts of computer science (data type theory, knowledge representation, unification).

In HPSG, every linguistic component (words, phrases, rules, etc.) is analyzed with a perspective of the information it provides to the speaker of the language. This information may include not only the syntactic features of the component, but also its grammatical information, semantic content and its background semantics.

HPSG is a system based on signs. Any structural element (words and phrases), and principles defining the language are modeled by sorted feature structures (ie. feature structures with an associated type or sort) and constraints and operations defined on them. As being one of the most recent examples of the family of the unification based grammar theories, the most fundamental operation of HPSG is unification, which combines a set of compatible feature structures, and returns a minimum informative feature structure containing all information present in the operands. Phonetic, syntactic and semantic information coded in the lexicon and information coming from other resources like lexical rules, universal and language specific principles of well-formedness, are combined by unification.

Similar to the majority of the contemporary linguistic theories, HPSG defines a lan-
guage by a finite set of recursively applicable rules which yields the judgment of gram-
maticality. Basically, principles are divided into two categories: 1) Universally applicable
basic set of constraints such as head feature principle and subcategorization principle;
and types of phrases available in any human language. 2) Language specific principles
of phrases lexicon itself and further articulation and specification of the principles of the
universal grammar such as constituent order [2].

One of the distinctive aspects of HPSG is that it not only models the language syn-
tactically, but also concerns itself with the interactions between all kinds of information
of a linguistic component. Both syntactic and semantic information content of a sign
is considered. Situation Semantics and Relational Theory of Meaning are chosen for
semantic modeling.

2.1 Feature Structures

HPSG, like other unification-based formalisms, uses recursively embedded feature-value
pairs representing linguistic objects. Feature structures have different names in each
theory: f-structures in LFG, feature bundles, feature matrices or categories in GPSG,
etc. Feature structures are informational objects that consist of feature (attribute)-value
pairs. Usually feature structures are represented by attribute-value matrices (AVM’s).

For example:

(1) \[
\begin{array}{c}
\text{PHON} & \text{“kedi”} & \% \text{cat} \\
\text{CAT} & \text{noun} \\
\text{AGR} & \left[ \begin{array}{c}
\text{PERSON} & \text{third} \\
\text{NUMBER} & \text{singular} \\
\end{array} \right] \\
\end{array}
\]

In (1), features PHON, CAT and AGR are defined where value of PHON is “kedi”,
CAT is noun and value of AGR is another feature structure with features PERSON and
NUMBER which have values third and singular respectively. As an alternative, feature
structures can be represented in graph notation where nodes are the intermediate feature
structures, vertices are attributes, and values are sink nodes.

(2)
As a fundamental property, feature structures can be recursively embedded. Value of an attribute can be an atomic value or another feature structure. To represent values embedded in feature structures, “path of attributes” notation is used as a shorthand. A path is an ordered sequence of attributes separated by ‘|’ to reach the value. In the example (2), AGR|PERSON has the value third, AGR|NUMBER is singular.

A relation defined on feature structures is the subsumption relation. When a feature structure A is subsumed by another feature structure B, A is equally or more informative than B. In other words, it contains all of the information provided by B and possibly more. It is often said A extends B or B subsumes A and written as A ≤ B. It indicates that any object described by B can be appropriately described by A. When a feature structure has no information, it subsumes every feature structure. It can describe any object whatsoever. This structure is the root element of the subsumption ordering (called Top), shown as ⊤:

\[ \top = \left[ \right] \]

Subsumption relation defines a partial ordering between information structures. It has the properties of reflexivity (∀A, A ≤ A), transitivity (A ≤ B and B ≤ C then A ≤ C), and antisymmetricity (A ≤ B and B ≤ A then A = B). For subsumption relation to hold between two feature structures, they should have compatible types and compatible values in the corresponding attributes. In the example below, feature structures have incompatible values so, A ̸≤ B and B ̸≤ A.

\[ (3) \quad A = \left[ \text{PERSON} \thinspace \text{third} \right], \quad B = \left[ \text{PERSON} \thinspace \text{first}, \text{NUMBER} \thinspace \text{singular} \right] \]

Another important property of feature structures is structure sharing. Two attribute paths in a feature structure may describe the same object. This implies the token identity which should not be confused with the structural identity where only type structure and feature values are equal. Usually structure shared object are denoted by tags (boxed numbers).

\[ (4) \quad \text{a.} \quad \begin{bmatrix}
\text{HD-DTR} \\
\text{SUBJ-DTR}
\end{bmatrix}
\begin{bmatrix}
\text{CAT} & \text{verb} \\
\text{AGR} & \left[ \text{PERSON} \thinspace \text{first}, \text{NUMBER} \thinspace \text{plur} \right] \\
\text{CAT} & \text{noun} \\
\text{AGR} & \left[ \right]
\end{bmatrix} \]
In (4a), HD-DTR|AGR attribute shares the same object with the SUBJ-DTR|AGR attribute. Although the paths in question have the same value, the source of the values may be different (i.e., not token identical) contain the same agreement in (4b). Intuitively, it is clear that the structure shared version is more informative than the other; it is subsumed by the other. Similarly, the effect of structure sharing is reflected in the formal definition of the subsumption:

\[(5) \text{ if } A \text{ and } B \text{ are atomic, then } A \preceq B \text{ iff } A = B.\]

else, \(A \preceq B\) holds iff,

(i) for every path in \(B\), same path exists in \(A\) and its value is subsumed by the value in \(B\).

(ii) for every structure sharing path in \(B\), same path is structure sharing in \(A\).

Perhaps the most important operation on feature structures is the unification, which constructs a base to a group of linguistic theories. Unification operation builds a new feature structure which contains all but not more of the information contained in its operand feature structures. For feature structures to be unified, they should have compatible types. Result of unification is the least informative (the most general) feature structure which extends all of the operands. Unification is denoted by the symbol \(\land\) and if \(C = A \land B\) then, \(C \preceq A\) and \(C \preceq B\).
When operands of the unification have incompatible types or values, the resulting feature structure does not exist and unification fails. This is indicated by the symbol \( \bot \) (\textit{bottom}) which represents inconsistent information. As \( \top \) is the maximal element in the subsumption ordering, \( \bot \) is the minimal element that is subsumed by all feature structures.

Also, unary negation operator \( \neg \) and disjunction operator \( \lor \) are defined. In negation, \( \neg a \) means any value other than \( a \). Similarly, disjunction \( a \lor b \) means the attribute may be equal to \( a \) or \( b \). Attributes may be list- or set-valued. Lists are denoted by comma separated values enclosed in angle brackets, \( \langle a, b, \ldots \rangle \). Sets are enclosed in curly braces \( \{a, b, \ldots\} \). List valued attributes are unified by unifying corresponding elements by order. Unification of set values is a more complex operation. For detailed information and formal definition about feature structures, consult Rounds and Kasper\cite{22}.

The most significant formal property of HPSG feature structures is that they are \textit{sorted}. Every feature structure has a type (sort), and a subtype relation is defined between these sorts. All defined sort symbols are partially ordered by the subsumption relation.

![Subtype hierarchy for the type defined for HEAD feature](image)

Figure 2.1: Subtype hierarchy for the type defined for HEAD feature

As the second formal property, HPSG feature structures should be \textit{totally well-typed}. For each sort, a set of appropriate features and types is defined, and this set is inherited by the subsorts of the sort. For example, if the CASE feature of sort case is defined for the sort noun in Figure 2.1, then it is appropriate for the sorts common, proper, pronoun, personal and demonstrative sorts. Any other feature which is not introduced in the sort is not allowed in the feature structure.

Third, HPSG feature structures should be \textit{sort-resolved} to satisfy the criteria of completeness as models of the linguistic entities. \textit{Sort-resolved} means: for every attribute defined, a sort should be assigned. This sort should be the most specific in the sort ordering (A leaf node in the subtype hierarchy). For example HEAD feature can be assigned proper or common but not head or noun which subsume other types in the ordering and actual sort (value) is not clear.
2.2 Sign Structure

Linguistic entities have the general sort sign. Information in all intermediate phrases, lexical entries, sentences and even multisentence discourses are described by a corresponding sign. The sign sort has two subtypes: word and phrase. word describes lexical entries, and phrase describes phrasal constructs. phrase has an additional feature DTRS (daughters) to represent the phrase structure.

![Figure 2.2: Basic Structure of a Lexical Sign (word).](image)

A basic graph briefly describing the structure of a sign can be given as in Figure 2.2. All signs should have at least two attributes: PHON and SYNSEM. PHON attribute is a feature representation of the phonetic content of the phrase or word. Usually, it has a list of strings describing phonological and phonetic structure of the sign. SYNSEM attribute contains both syntactic and semantic information of the sign. Using SYNSEM instead of two distinct features SYNTAX and SEMANTICS allows packing all information required for subcategorization into one attribute.

SYNSEM value is another structured object which has two attributes LOCAL and NONLOCAL. NONLOCAL represents the information which is not bound to the phrase described by the sign. This information is used to handle unbounded dependency constructs like filler-gap dependencies, relative clauses, etc. LOCAL feature describes the local information which consists of the attributes CATEGORY (CAT), CONTENT (CONT) and CONTEXT (CONX).

CAT value includes both the syntactic category of the sign and the grammatical arguments it requires. CONT value is the context independent semantic interpretation and semantic contribution of the sign.

CONX value contains context-dependent linguistic information such as indexicality, presupposition and conventional implication. The semantic features are not the object of this study so we will not go into details of CONT and CONX features.

CAT attribute consists of two attributes HEAD and SUBCAT. HEAD feature is roughly lexical category (part of speech) of the sign. It describes the information to be passed
to phrasal projections of the sign. Contents of HEAD feature varies according to the category of the sign. It typically contains basic features related with the category of the sign e.g. case, agreement, verb form, prepositional form, etc.

SUBCAT (subcategorization) describes the valence of the sign which specifies the group of signs that sign in question requires to become saturated. A saturated sign means all the subcategorization requirements are met. Group of signs in SUBCAT feature is described by a list of synsem values. synsem values are used for identifying the subcategorized objects, so that sign can select not only the syntactic category of the complement, but also semantic role and even nonlocal attributes.

The order of the synsem values in the SUBCAT list does not correspond to the surface order of the phrase. However, it may define an obliqueness order which can be used to describe the constituent order. For example, in English, linear precedence rules defining surface order is declared by this obliqueness order, as the least oblique element linearly precedes others for non-verbal heads. When the head is a verb, the first oblique element is the subject element which precedes the head. For languages having free constituent order, like Turkish, SUBCAT attribute may have different structure, e.g., unordered list.

2.3 Phrases and Syntactic Structure

HPSG is a constraint-based theory and constraints are defined by partial descriptions that model linguistic utterances. Descriptions are declarative, order independent and reversible. Judgment of whether a phrase is well-formed or not is done by a set of universal principles and language-specific rules. Universal principles are general constraints on universally available phrase types. The most basic principles in HPSG are Head Feature Principle and Subcategorization Principle. Language specific phenomenon like Linear Precedence (constituent order) is described by a set of language specific constraints and some kind of specialization of universal principles.

As mentioned in the preceding section, a sign has two subtypes: word and phrase. phrase has an additional feature DAUGHTERS (DTRS) in which phrase structure is represented. DTRS feature has a value of constituent-structure (cons-struc) representing the immediate constituents of the phrase. cons-struc may have several subsorts each has characterized by different daughter attribute. The most general sort of comp-struc is headed-structure (head-struct).

\[
\begin{bmatrix}
    \text{head-struc} \\
    \text{HEAD-DTR} & \text{sign} \\
    \text{COMP-DTRS} & \langle \text{sign, ....} \rangle
\end{bmatrix}
\]

Each head-struc has one HEAD-DTR attribute and another attribute which is a list of signs which are the sisters of the HEAD-DTR. For example tree and DTRS representation of the sentence “Ahmet kırmızı kitabı aldı.” (Ahmet took the red book.) is:
The HEAD value of a phrase is centrally important since it defines the syntactic properties of the mother phrase. For example, the lexical head of a sentence is of the sign *verb*. *Verb* combines with its complement sisters and forms a *Verb Phrase* (VP) which takes its syntactic properties from its head daughter (verb). Similarly, verb phrase combines with the subject complement forming a sentence. In other phrase types like Noun Phrase (NP), Prepositional Phrase (PP), Adjective Phrase (AP), HEAD feature is projected —propagated— along the upper phrases until phrase becomes saturated. The key idea behind this projection is the X-bar theory\[14\]. HPSG’s Head Feature Principle describes this syntactic phenomena which is adopted from the Head Feature Convention of GPSG\[8\].

**Head Feature Principle** (HFP) is defined as follows:
The \textbf{HEAD} value of a headed phrase is structure-shared with the \textbf{HEAD} value of the head daughter.

Formally:
\[
\begin{array}{c}
\text{phrase} \\
\text{SYNSEM} | \text{LOC} | \text{CAT} | \text{HEAD} \\
\text{DTRS} | \text{HEAD-DTR} | \text{SYNSEM} | \text{LOC} | \text{CAT} | \text{HEAD}
\end{array}
\]

The other principle which together with HFP describes the basic Immediate Domi-
nance (ID) scheme of HPSG is \textbf{Subcategorization Principle}. Subcategorization checks the requirements of the phrasal head to be saturated and allows heads to select its complement sisters by structure sharing the \textit{SYNSEM} values of the sisters with that in the \textit{SUBCAT} list. \textbf{Subcategorization Principle} is defined as follows:

(11) In a headed phrase, \textit{SUBCAT} value of the head daughter of the phrase is the concatenation of the \textit{SYNSEM} values of the complement daughters.

Formally:
\[
\begin{array}{c}
\text{phrase} \\
\text{SYNSEM} | \text{LOC} | \text{CAT} | \text{SUBCAT} \\
\text{DTRS} | \text{HEAD-DTR} | \text{SYNSEM} | \text{LOC} | \text{CAT} | \text{SUBCAT} \\
\text{COMP-DTRS} \{ \text{SYNSEM}, \ldots, \text{SYNSEM} \}
\end{array}
\]

Where \(\oplus\) is defined to be list concatenation operation.

The \textbf{Subcategorization Principle} allows all constraints on the arguments of a phrase to be controlled by an argument. Any kind of argument restriction, complement structure like sentential complements, unbounded dependencies and other constraints can be directly controlled and coded into lexicon. In other words, HPSG crucially relies on the complex descriptions in the lexicon. To deal with the redundancy caused by the complexity of the lexical entries, lexical rules and multiple inheritance hierarchy describing relation between lexical entries can be expressed.

Phrase structure rules defining tree structure of phrases are described by immediate dominance (ID) and linear precedence (LP) constraints. There is a general trend in contemporary syntactic theories towards the lexicalization of grammar and elimination of construction-specific rules in favor of schematic immediate dominance templates. These schemata may vary for language-specific phrase types and constituent relations. Examples of typical phrase structures are head-complement, specifier-head, and adjunct-head, conjunct-daughters.

Linear precedence constraints are mostly defined as language-specific rules and constraints on the surface constituent order of the phrases. In English, LP rules are defined on the obliqueness hierarchy of the \textit{SUBCAT} list. Subject is the least oblique argument of a verb. The direct object and the indirect object come next in the obliqueness order.
Also, least oblique constituents precede the others. LP rules for English can be defined as follows:

(12) 1. Any lexical head sign precedes other signs:

\[ \text{HEAD-DTR} [\text{word}] \rightarrow [\text{[]} \leq [\text{[]} ]] \]

2. Subject complement precedes the Head daughter:

\[ \text{SUBJ-DTR} [\text{[]}] \rightarrow [\text{[]} \leq [\text{phrase}]] \]

3. Least oblique elements linearly precede the others:

\[ \text{COMP-DTRS} \langle ...[\text{[]} ...][\text{[]} ...\rangle \rightarrow [\text{[]} < [\text{[]} ]] \]

where \( \leq \) means immediately precede and < means precede.

### 2.4 Lexical Organization

Lexicalization and the use of meta-rules controlled by a set of universal principles results in a few number of simple grammar rules. However, the associated information structures become more complex. Lexical signs in lexically-oriented theories should be very rich in information content so it is not always possible to enter and maintain a lexicon without any organization.

In HPSG —as the other lexicalized formalisms— it is necessary to organize lexicon such that lexical entries should be represented as compact as possible. Two main devices, lexical type hierarchy and lexical rules, are the basic solutions to redundancy problem in the lexicon.

The main idea behind the lexical type hierarchy is the repetition of information in the lexical items of same category class. Only a small part of a lexical entry carries exceptional information from the other entries having the same category. For example, all nouns have noun as the value of the HEAD feature and empty SUBCAT value. All common nouns have third person in their agreement. So the idea is to create a hierarchy of types each of that is assigned a set of attribute-value pairs which are inherited along the hierarchy. Lexical entries can be defined by means of these types plus the special features.

Lexical hierarchies solve some portion of the redundancy. However, some specific features of lexical entries may be related to each other by recurrent patterns. These patterns include some derivational and inflectional phenomena in the language like passivization of verbs, case marking, verb inflections, nominalization etc. The solution that has been used by most of the unification-based formalisms is to define functions mapping one class of words to another, called lexical rules.
Lexical rules are generally expressed as procedures converting an input form to an output form. So that all inflections and derivations of a word can be generated from a base form by application of lexical rules several times. In the example (13a), a simplified lexical rule for passivization of verbs for English is given where $f_{PSP}$ is the function mapping verb base to its past-participle form. Also, it is possible to generate different readings and syntactic behaviors of the same word. Lexical rule in (13b) duplicates lexical entry of verbs for non-referential objects in preverbal position in Turkish.
Chapter 3

TURKISH SYNTAX
OVERVIEW

This chapter is adopted from [9]. Turkish is an agglutinative language where words are formed by affixation of derivational and inflectional morphemes to root words. So most of the syntactic properties of a word such as case, agreement, relativization of nouns, tense, modality, aspect of verbs, and even passivization, negation, causatives, reflexives and some auxiliaries are marked by suffixes.

(14) a. ev -imiz -de -ki -nin
    house -1PP -Loc -Rlvz -Gen
    ‘of the one that is in our house’

    b. bak -tırm -a -m -yor -muş -sun
    look -Caus -Able -Neg -Prog -Asp -2Sg
    ‘you were not able to make look (reported past)’

As a result, Turkish words—especially heads of phrases—have complex and rich syntactic forms and carry much information.

As another distinct property, Turkish is head-final. Specifiers and modifiers always precede the specified or modified. Similarly complements and arguments precede the head in their usual formation. However when head is a verb or predicative noun, complements and objects may follow the head.

(15) a. Benim kapıdaki kırmızı aramab
    ben-Gen door-Loc-Rlvz red car-ISP
    ‘my red car at the door’
b. Hicabi kitabı çok çabuk okudu.
   Hicabi book-Acc very quick read-Past-3Sg
   'Hicabi read the book very quickly.'

c. Kitapları verdim Ahmet’e.
   book-Plu give-Pass-1Sg Ahmet-Dat
   'I gave Ahmet the books.'

Also in Turkish, constituents have free order. The most usual sentence order is S-O-V. However they can scramble causing different readings and interpretations. Sentence-initial position marks the topic, pre-verbal constituent is the emphasis and post-verbal position is for the background or afterthought information.

(16) a. Onur kalemini çocuk’a verdi.
   Onur pencil-Acc child-Dat give-Past-3Sg
   'Onur gave the child the book.'

b. Onur çocuk’a kalemini verdi.
   'Onur gave the pencil to the child.'

c. Çocuğ’a kalemini Onur verdi.
   'It is Onur who gave the child the book.'

d. Kalemini Onur verdi çocuk’a.
   (c)

e. Onur verdi kalemini çocuk’a.
   'Onur did give the child the pencil.'

When the object is non-referential (ie. no case marked or specified), it should immediately precede the verb.

(17) a. Adam bahçede şiir yazıyordu.
   man garden-Loc poem write-Prog-Asp-3Sg
   'The man was writing poem in the garden'

b. (*) Şiir bahçede adam yazıyordu.
   'The poem was writing the man in the garden'

c. * Adam şiir bahçede yazıyordu.

Similarly, adverbs and sentential complements may scramble freely (18a–c). Also order variation of constituents is valid for the embedded sentences such as relative clauses,
infinitive and gerundive forms, and sentential complements. Relative clauses are strictly head-final; no constituent belonging to relative clause can follow the head verb (18d–f).

(18) a. Gerçekten onun sınavı kazanmasını herkes istemişti.
   really he-Gen exam-Acc pass-Inf-3Sg-Acc everyone want-Past-Asp
   ‘Everybody really wanted him to pass the exam.’

b. Onun sınavı kazanmasını herkes gerçekten istemişti.

c. Herkes onun sınavı kazanmasını gerçekten istemişti.

d. Bakkaldan dün aldığım kalem kırıldı
   store-Abl yesterday buy-Rel-1Sg pencil break-Pass-Past-3Sg
   ‘The pencil that I bought yesterday from the store was broken’

e. Dün bakkaldan aldığım kalem kırıldı.

f. * Dün aldığım bakkaldan kalem kırıldı.

3.1 Noun Phrase

Phrases with nominal heads are noun phrases. The head noun is the final constituent of the phrase and determines the syntactic role of the whole phrase. Noun phrases may act as a subject, object or complement of a sentence or modifier or specifier of another noun group. A noun —so a noun phrase— can have the cases listed in Table 3.1.

| case               | suffix | examples        |
|--------------------|--------|-----------------|
| nominative         | -(y/n)H| adami, kediyi   |
| accusative         | -(y/n)A| adama, kediye   |
| dative/allative    | -(n)DA | adamda, kedide  |
| locative           | -(n)DA | adaman, kediden |
| ablative           | -(y)lA | adamlı, kediyle  |
| genitive           | -(n)Hn | adamm, kedinin  |
| comitative/instrumental | -(y)lA | adamlı, kediyle  |

Also three suffixes -cA, -1H and -sHt (equative, munitive and privative respectively) are considered as cases by Banguoğlu. 

Footnote 1: We use A to stand for a or e, H to stand for i, i, u or ü, and D to stand for d or t.
Nominative case is used for marking subjects (19a), indefinite/nonreferential objects (19b). Also noun with the nominative case can be a classifier for another noun (19c).

(19) a. Köpek kediyi kovaladı.
   
   dog cat-Acc chase-Past-3Sg
   ‘The dog chased the cat.’

   b. Adam kuş avladı.
   
   man bird hunt-Past-3Sg
   ‘The man hunted a bird.’

   c. Güzel bir köpek evi yaptık.
   
   nice a dog house make-Past-1Pl
   ‘We made a nice dog house.’

The accusative case is used for marking definite objects. It is obligatory with pronouns and proper nouns in object position.

(20) a. Çocuk kitabı okumamış.
   
   child book-Acc read-Neg-Past-3Sg
   ‘The child hasn’t read the book.’

   b. Köpek Ayşe’yi ısırdı.
   
   dog Ayşe-Acc bite-Past-3Sg
   ‘The dog bit Ayşe.’

   c. Herkes onu suçluyor.
   
   everyone he/she-Acc blame-PROG-3Sg
   ‘Everyone blames him/her.’

Noun phrases with dative/allative case (-(y/n)A suffix) have three roles: they behave as prepositional phrases indicating target or aim (21a–b), mark the indirect object (21c), and they are subcategorized as the oblique object in some verbs (21d).

(21) a. Çocukları Ankara’ya gönderdik.
   
   child-Plu-Acc Ankara-Dat send-Pass-2Pl
   ‘(We) sent the children to Ankara.’

   b. Çiçekleri sana aldım.
   
   flower-Plu-Acc you-Dat buy-Past-1Sg
   ‘(I) bought the flowers for you.’
c. Mehmet ekmeği adama verdi.
   Mehmet bread-Acc man-Dat give-Past-3Sg
   ‘Mehmet gave the man the bread.’

d. Kadın bahçeye baktı.
   woman garden-Dat look-Past-3Sg
   ‘The woman looked at the garden.’

Noun phrases with locative case (-DA suffix) is used to express the location of an action or object (22).

(22) Kitabın masada duruyor.
   book-2SP table-Loc stand-Prog-3Sg
   ‘Your book lays on the table’

The ablative case (-DAn suffix) indicates the source of an action or object as the English preposition “from” (23a–b). Also can be subcategorized as direct object by a group of verbs (23c).

(23) a. İstanbul’dan yeni gelmiş.
   İstanbul-Abl just come-Past-3Sg
   ‘He has just come from İstanbul’

b. Genelde bu üzümlерden şarap yapılıyor
   usually these grape-Plu-Abl wine make-Pass-Prog-3Sg
   ‘Usually wine has been done from these grapes’

c. Ahmet kedilerden nefret eder.
   Ahmet cat-Plu-Abl hate--Pres-3Sg
   ‘Ahmet hates cats.’

The genitive case is used to mark the possessor in the possessive-possessor relation. Noun with the genitive case behaves as a specifier of possessed noun which is marked with the possessive suffix. Person and number information of the noun should agree with this possessive suffix.

(24) a. Arabanın anahtarını unuttum.
   car-Gen key-3SP-Acc forget-Past-1Sg
   ‘I forgot the key of the car.’
b. Senin kalemini kullandım.
   you-Gen pencil-2SP-Acc use-Past-1Sg
   'I have used your pencil.'

c. İlker'in arabasının motoru bozuk
   İlker-Gen car-3SP-Gen engine-3SP broken
   'The engine of the İlker's car is broken.'

The -(y)LA suffix is the combined form of the postposition ile with the noun. It marks the commutative (25a) and instrumental (25b) relationships.

(25) a. Kitabını Ahmet'le gördük.
   book-Acc Ahmet-Ins see-Past-1Pl
   'Ahmet and I saw the book together.'

   b. Kuşları dürbünle seyrediyoruz.
   bird-Plu-Acc binocular-Ins watch-Prog-1Pl
   'We could see the birds with telescope.'

-cA suffix is used for marking subject of a passive sentence. Postposition tarafından is more commonly used compared to equative case.

(26) a. Kampanyaya vatandaşlarca destekleniyor.
   campaign citizen-Plu-Equ support-Pass-Prog-3Sg
   'The campaign is supported by citizens.'

-1H and -sHz (minimative and privative) suffixes have similar meaning with the prepositional phrases formed by ‘with’ and ‘without’ in English. Noun phrases with these suffixes behave as adjective. However, -1H suffix saves some of the properties of the noun it is attached to. Noun may be still the head of a noun group and can be modified (27).

(27) a. kırmızı kanatlı böcek
   red wing-Mun insect
   'the insect with red wings'

   b. üç tekerlekli bisiklet
   three wheel-Mun bicycle
   'The bicycle with three wheels'
Another inflection that a noun group may have is the relativizer (-ki suffix). This suffix is attached to some temporal adverbs and nouns with locative case. A relativized noun becomes a specifier for another noun group (28).

(28) bahçedeki çiçekler
garden-Loc-Rlz flower-Plu
‘The flowers in the garden’

-ki suffix following a genitive noun group behaves as a pronoun meaning ‘one that belongs to’ and different from the relativizer -ki.

(29) Ayşe’ninkiler yarım gelecek
Ayşe-Gen-Pro-Plu tomorrow come-Fut-3Sg
‘Ones that Ayşe owns will come tomorrow.’

A noun group consists of an optional group of specifier and modifiers and a head noun. Head noun can be a common noun, a pronoun or a proper noun. Order and grammatical combinations of specifiers and modifiers change according to the type of specifiers and modifiers. Order and valid combinations of specifiers and modifiers are pragmatically controlled. Some specifiers/modifiers put some restrictions on the specifier/modifier types that can further specify/modify the noun.

General structure of a noun group can be viewed as a sequence of segments, head noun being the last one. These segments are listed in Table 3.2.

Table 3.2: Segments of a noun group.

| Segments   | Alternatives | Examples                  |
|------------|--------------|---------------------------|
| Specifier  | Quantifier   | her, bazı, biraz, kim, herbir, birçok |
| Article    |              | bir                       |
| Demonstrative Adjective |         | bu, şu, o, diğer, ilk, sonuncu |
| Genitive noun |          | bahçenin                  |
| Classifier noun |        | mutfak dolabı             |
| Modifier   | Quantitative Adjective | dört, yarım, ikişer, üçlü |
| Qualitative Adjective |       | güzel, zor                |
| Relativized noun |         | evdeki, akşamki            |
| Relative clause |          | postadan çıkan, yolda gördüğüm |
| Unit noun  |              | bardak, salkım, tane      |
| Head       | Common noun  | ev, kitap                 |
| Proper noun |              | Deniz, Ankara             |
| Pronoun    |              | ben, sen, onlar           |
Specifier and modifier segments are optional:

(30) a. bahçenin kapısı
   garden-Gen gate-3SP
   ‘the gate of the garden’

b. şu kız
   that girl
   ‘that girl’

c. Ankara

The order of the specifier and modifier segments may vary.

(31) a. Her kırmızı çiçek
    every red flower
    ‘every red flower’

b. kırmızı her çiçek
    red every flower
    ‘every flower that is red’

c. güzel bir kız
    beautiful a girl
    ‘a beautiful girl’

d. bir güzel kız
    a beautiful girl
    ‘one beautiful girl’

Each segment of the noun group are elaborated below.

3.1.1 Specifier segment

Specifiers pick out noun(s) out of a set of possible nouns. In Turkish, specifier segment position is filled by a specifier that can be a quantifier (32a), an article (32b), a demonstrative adjective (32c), a genitive noun (32d) or a a classifier noun (32e).

(32) a. Yazdiklarımız bazı insanları rahatsız edecek.
    write-Part-1PP some people-Acc disturbed make-Fut
    ‘What we have written will disturb some people.’

b. Yolda bir kalem buldum.
    road-Loc a pencil find-Past-1Sg
    ‘I found a pencil on the street.’

c. İlk sınavımı geçtim.
    first exam-1SP pass-Past-1Sg
    ‘I passed my first exam.’
The valid combinations and order of specifiers are pragmatically controlled. A noun group may have only one quantifier (33a–b). Also quantifiers cannot be used with demonstrative adjectives and article (33c,d).

(33) a. *her **çoğu kitap
   every most book

   b. *bircok kimi **öğrenciler
      many some student-Plu

   c. *her bu kitap
      Quant. Dem. Adj.
      every this book

   d. *kimi bir insan
      Quant. Art.
      some a person

The use of the article with demonstrative adjectives and quantifiers depends on some selectional restrictions.

(34) a. *ilk bir kitap
      first a book

   b. bir ilk kitap
      a first book

   c. bir üçüncü kitap
      a third book
      'yet a third book'

   d. *sonuncu bir kitap
      last a book
There are some points to be underlined here, about the different meanings of “bir” and about some exceptions:
The sequence depicted in (34b) has a limited usage referring to the first book of an author. In (34c), “bir” is an adverb meaning “yet” or “another”. In (34e), “bir” is an adverb with a meaning “only”. In (34f), “bir” is not an article but a cardinal number (a modifier). In (34g), “diğer” acts as an adverb.

Concerning the demonstrative adjectives, there are two subgroups:

i) bu, şu, o

ii) ilk, sonuncu, ordinal numbers, diğer

Only one element from each group can be used within a noun group. The elements of the first group can sometimes be used in front of the elements of the second group for emphasizing the demonstration.

(35) a. Bu ikinci kitabı pek beğenmedim
    this second book-Acc much like-Neg-Past-1Sg
    ‘I didn’t like the second book much’

b. Şu diğer valiz benim ki
    that other suitcase mine
    ‘The other suitcase is mine’

c. *diğer sonuncu kız
    other last girl

Nouns or noun groups with genitive marking also function as specifiers within a noun group. Genitive nouns can be used in combination with other specifiers (36a–b).
The main restriction is that all specifiers and modifiers modifying the possessive marked noun should follow the genitive noun. Otherwise they specify/modify the genitive noun (36c):

(36) a. yazarın bir kitabı
   author-Gen a book-3SP
   ‘a book of the author’

b. kitabın bu sayfası
   book-Gen this page-3SP
   ‘this page of the book’

c. ilk seminerin konuşmacısı
   first seminar-Gen speaker-3SP
   ‘the speaker of the first seminar’

Genitive nouns can rather be interpreted as complements of possessive marked nouns since possessive nouns require a genitive noun which is subject of the owner relation in the possessive group.

Classifier nouns resemble genitive nouns in that they require a possessive-marked noun group modified by the classifier noun. However, classifier nouns take no genitive suffix. The difference between a genitive noun and a classifier noun is that the former provides a definite reading where the latter provides an indefinite or nonreferential one.

(37) a. duvar boyası
    wall paint-3SP
    ‘wall paint’

b. duvarın boyası
    wall-Gen paint-3SP
    ‘the paint of the wall’

Classifier noun groups can act as specifiers of other classifier nouns:

(38) kredi kartı faiz yüzdesi
    credit card-3SP interest percentage-3SP
    ‘credit card interest rate’

2These noun groups are called izafet by Lewis 16
A classifier noun is the immediate predecessor of the head noun. Hence, other specifiers and modifiers precede it.

(39) a. her çocuk arabası
   every child  car-3SP
   ‘every stroller’

 b. o dere yatağı
   that stream bed-3SP
   ‘that river bed’

 c. *çocuk her arabası
 d. *dere o yatağı
 e. *ev bir kapısı
 f. *duvar evin boyası
 g. evin duvar boyası
    home wall  paint-3SP
    ‘wall paint of the house’

3.1.2 Modifier segment
Modifiers provide information about the properties of the entity or its relations with other entities. A modifier is either an adjective group, or a noun group. More than one modifier may exist within a noun group.

(40) güzel mavı eteğin
    beautiful blue  skirt-2SP
    ‘your beautiful blue skirt’

As a general rule, “whatever precedes modifies” in Turkish. Hence, if a modifier itself is a noun group or a clause containing a noun, any preceding modifier modifies the first of the succeeding nouns.
For example, in the phrase below, the modifier “yaşlı” modifies “adam” rather than the head noun “kadın”.

(41) yaşlı adamın konuştuğu kadın
    old  man-Gen talk-Part-3SP woman
    ‘the woman to which the old man talked/talks’
Certain restrictions apply to the combinations of modifiers. When a noun is modified by both a qualitative and a quantitative adjective, order of the adjectives may vary but the quantitative adjective usually precedes the qualitative one.

(42) a. üç kırmızı kalem
   three red pencil
   ‘three red pencils’

b. hassas ikili ilişkiler
   sensitive dual relationship-Plu
   ‘sensitive dual relationships’

c. ikişer kalın battaniye
   by-two thick blanket
   ‘two thick blankets for each’

d. rahat üçlü kanepe
   comfortable triple sofa
   ‘a comfortable triple sofa’

e. yarım çürük elma
   half rotten apple
   ‘a half rotten apple’

f. çürük yarım elma
   rotten half apple
   ‘a half rotten apple’

When used as modifiers, unit nouns are preceded by a cardinal number (43a), a fractional number (43b), or a distributive adjective (43c):

(43) a. iki bardak süt
   two glass milk
   ‘two glasses of milk’

b. yarım somun ekmek
   half loaf bread
   ‘half loaf of bread’

c. birer dilim pasta
   by-one slice cake
   ‘a slice of cake (for each)’
When the unit noun denotes a container, the word *dolusu* (“full”-3SP) may optionally be inserted between the unit noun and the head.

(44) üç kaşık dolusu şeker

three spoon full-3SP sugar
‘three spoonful of sugar’

The other group of modifier is the relativized nouns which are inflected by relativizer suffix -ki. If the head noun is modified by a relativized noun, all other modifiers and specifiers of the head come after the relativized noun (45a). Otherwise, any modifier preceding a relativized noun modifies the relativized noun rather than the head (45b).

(45) a. çantamdaki üç küçük anahtar
handbag-1SP-Loc-Rlvz three small key
‘three small keys in my handbag’

b. küçük çantamdaki üç anahtar
small handbag-1SP-Loc-Rlvz three key
‘three keys in my small handbag’

Noun groups can also be modified by relative clauses. In Turkish, the noun on which the relativization is performed is placed at the final position of the relative clause.

(46) a. Ağabeyim Ankara’da çalışıyor.
brother-1SP Ankara-Loc work-Prog-3Sg
‘My elder-brother works in Ankara.’

b. Ankara’da çalışan ağabeyim
Ankara-Loc work-Rel brother-1SP
‘My elder-brother who works in Ankara’

As seen above, the main verb of the relative clause is used in participle form. The example depicts the suffix -en (phonological realization of -(y)än after morphophonemic processes) which is used in producing subject participle (in present). Other subject suffixes are given below:
| Suffix         | Tense      |
|---------------|------------|
| -mHq (olan)   | past       |
| -(y)AcAk (olan)| future    |
| -Hyor (olan)  | progressive|

The word *olan* (“being”) can optionally be used with past, future or progressive participles, but not with present participle.

(47) a. Ankara'da çalışan olan ağaçım
Ankara-Loc work-Part be-Rel elder-brother-1SP
‘my elder brother who have worked in Ankara’

b. Ankara'da çalışacak olan ağaçım
Ankara-Loc work-Part be-Rel elder-brother-1SP
‘my elder brother who will work in Ankara’

c. * Ankara'da çalışan olan ağaçım

*Olan* can also be used in forming participle form of the copula.

(48) a. Arkadaşımın annesi hasta.
friend-1SP-Gen mother-3SP ill
‘My friend’s mother is ill.’

annesi hasta olan arkadaşım
mother-3SP ill be-Rel friend-1SP
‘my friend whose mother is ill’

b. Evin pencereleri geniş.
house-Gen window-Plu-Acc wide
‘Windows of the house are wide.’

pencereleri geniş olan bir ev
window-Plu-3SP large be-Rel a house
‘a house which has large windows’

Apart from the subject participle form, the verb of a relative clause may take *complement participle* form, which is obtained by attachment of either `-DHq` or `-yAcAk` suffixes.

-DHq suffix, as itself, produces adjectives from verbs, although it is not productive:

(49)
bilmek → bildik
‘to know’ ‘known’

umulmamak → umulmadık
‘to be not expected’ ‘unexpected’

When used in complement participles, –DHk is always followed by a possessive (marks the agreement in this case) and participle suffix group becomes DHg-Agr. The tense of this participle can be past or present, as examples (50) and (51) depicts, respectively. Actual tense is usually determiner from the discourse.

(50) Kitabı kızı geri verdim.
book-Acc girl-Dat back give-Past-1Sg
‘I gave back the book to the girl.’

a. kızı geri verdğim kitap
girl-Dat back give-Rel-1Sg book-Acc
‘The book that I gave back to the girl.’

b. kitabı geri verdğim kız
book-Acc back give-Rel-1Sg girl
‘The girl to whom I gave back the book.’

If there is an overt subject noun in the clause, it is marked with the genitive suffix:

(51) Öğrenci sınıfında şarkı söyleyör.
student class-Loc song sing-Prog-3Sg
‘The student is singing a song in the classroom.’

a. öğrencinin sınıfında söylediği şarkı
student-Gen class-Loc sing-Rel-3Sg song
‘the song that the student is singing in the classroom’

b. öğrencinin şarkıını söylediği sınıf
student-Gen song-Acc sing-Rel-3Sg class
‘the classroom in which the student is singing the song’

Complement participles in future tense are formed by attaching -(y)AcAk suffix to verb stem. Just like –DHk suffix, -(y)AcAk combines with a possessive suffix to produce
- (y)AcAg-Agr as the future complement participle.

(52) a. öğrencinin söyleyeceği şarkı
   student-Gen sing-Rel-3Sg song
   ‘the song that the student will sing’

   b. kitabı geri vereceğim kız
   book-Acc back give-Rel-1Sg girl
   ‘the girl to whom I will give back the book’

Relative clauses can be embedded as adnominals:

(53) köyde yaşayan kızın yetiştirdiği ineğin öldüğü yer
    village-Loc live-Rel girl-Gen breed-Rel-3Sg cow-Gen die-Rel-3Sg place
    ‘the place at which the cow that was bred by the girl who lives in the village died’

3.1.3 The head

The last segment of the noun group is the head, and this position is filled either by a common noun (54a), a proper noun (54b) or a pronoun (54c).

(54) a. küçük bir elma
    small a apple
    ‘a small apple’

   b. güzel Ayşe
    beautiful Ayşe
    ‘beautiful Ayşe’

   c. unutkanlılığıyla bilinen sen
    forgetful-3Sg-Ins know-Pass-Rel you
    ‘you who are known as forgetful’
Pronouns
When the head is a pronoun, no determiner or modifier segments are allowed:

(55) *bazı sen
    some you

    *sarısun ben
    blond I

Proper Nouns
When it is used as the head, a proper noun imposes certain restrictions on the selection of the preceding segments. For example, particular determiners can be used in front of a proper noun, while others are not applicable.

(56) a. Bu İstanbul nasıl düzeltir?
    this İstanbul how get-better-Pres-3Sg
    ‘How could this İstanbul get better?’

     b. Nerede kaldı şu Hasan?
    where left that Hasan
    ‘Where on the earth is Hasan?’

     c. Trakya’da birkaç Yeşilköy’e rastladım
    Thrace’-Loc several Yeşilköy’-Dat come-across-Past-1Sg
    ‘I came across more than one Yeşilköy in Thrace’

     d. Ailemizdeki diğer/ikinci Mehmet dedemdir.
    family-1PP-Loc-Rlvz other/second Mehmet grandfather-1SP-Cop
    ‘The other/second Mehmet in our family is my grandfather’

3.2 Postposition group
By postposition group, we mean a group of elements whose head is a proposition. Postposition group consists of a head and an optional complement noun group. The former always occupies the final position.
3.2.1 Postpositions

Postpositions form a closed class of words. They can be viewed in subgroups, with respect to the case of the complement they subcategorize for. (10, pp. 85-89) Various types of postpositions exist which subcategorize for: infinitives or nouns with nominative case (57a,b), nouns with accusative case (57c), dative case (57d) and ablative case (57e).

(57) a. gelmek üzere
   come-Inf for
   ‘for the purpose of coming’

b. sokak boyunca
   street along
   ‘along the street’

c. Sınavı müteakiben
   exam-Acc following
   ‘after the exam’

d. şimdiye dek
   now-Dat until
   ‘until now’

e. Dünden beri
   yesterday-Abl since
   ‘since yesterday’

3.2.2 Postposition Attachment

Attachment of a sequence of postpositions is determined without ambiguity by morphosyntactic cues (e.g., relative suffixes and case marks) and positional cues (head-final structure). However, if a sentence involves relative clauses and postpositions, ambiguities may arise (58a). In “I read the newspaper on the couch”, if on the couch were an adnominal, it would be relativized in Turkish (cf.,58b-c). Chained postposition groups are not ambiguous because the predecessor modifies the successor.

(58) a. Bu bilgilere göre yazdığımız rapor değişmeyecek.
   this data-Plu-Dat according write-Rel-1Pl report change-Neg-Fut-3Sg
   ‘The report that we wrote according to these data will not change.’

3 In writing, it this may be disambiguated by seperating the sentential complement with a coma (before yazdığımız in 58a).
3.3 Adjective group

Adjective group is a sequence of words last of which is an adjective. Adjective groups are typically formed by comparative and superlative adjectives.

3.3.1 Comparative adjectives

The head of a comparative adjective group is a qualitative adjective. Three comparatives can precede the head: “daha”, “az” and “çok” meaning “more”, “less” and “very”, respectively.

(59) a. Elvan daha büyük bir eve taşındı.  
   Elvan more big a house-Dat move-in-Past-3Sg  
   ‘Elvan moved in to a bigger house.’

b. Az şekerli kahve içerdii.  
   less sweet coffee drink-Pres-Asp  
   ‘(S)he used to drink coffee with a little sugar.’

c. Çok hızlı arabalardan hoşlanmyorum.  
   very fast car-Plu-Abl like-Neg-Prog-1Sg  
   ‘I don’t like very fast cars.’

d. Annem benden çok daha iyi yemek yapar.  
   mother-1SP I-Abl very more good dish  make-Pres-3Sg  
   ‘My mother cooks much better than I do.’
3.3.2 Superlative adjectives

The head adjective is qualitative for this group, too. Superlative form is obtained by preceding the head with “en” (“most”).

(60) Sınıfin en çalıskan öğrencisi Ali’ydi.
    class-Gen most hardworking student-3SP Ali-Cop
    ‘Ali was the most hardworking student of the class.’

3.4 Adverb group

An adverb group is a segment which has an adverb as its head. Modifiers of an adverbial head may be adverb or adjective groups, including the comparative daha and the superlative en. Adverbial heads may be classified as manner (alelacele), temporal (sonra, önce), position (aşağı, beri, ileri), repetition (gene, yeniden, tekrar), sentential (besbelli, asla, kuşkusuz), frequency (seyrek, sık), possibility (herhalde, belki), definiteness (katiyen, muhakkak), and question (nasıl, hani) adverbs. Basic types of adverb groups are described below.

3.4.1 Reduplications

Nouns and adjectives can be reduplicated to form an adverb group.

(61) a. Yemeğimizi quàc quàc yedik.
    meal-1PP-Acc quick quick eat-Past-1Pl
    ‘We ate our meal quickly.’

b. Akşam akşam canımızı sıktı.
    evening evening soul-1PP-Acc bother-Past-3Sg
    ‘It bothered us at this time of the evening.’

c. Geçen yaz bu sahilleri koy koy dolaştık.
    last summer this shore-Plu-Acc cove go-around-Past-1Pl
    ‘We visited each and every cove of this shore last summer.’

Some of the reduplicated adverbs are onomatopoeic words:
Sırıl sırıl akan derenin sesini dinledim.
‘splashing’ flow-Part stream-Gen sound-3SP-Acc
‘I listened to the sound of the stream that flows gently.’

Distributive adjectives, when used as adverbs, are reduplicated:

Merdivenleri üçer üçer çıktık.
stairs-Plu-Acc three-Dist three-Dist go-up-Past-1Pl
‘We went upstairs three steps by three steps.’

Adverbs or adjectives can be intensified by phonological reduplication to produce adverbs as well:

çabuk quick çarçabuk very quickly
hızlı fast hıphızlı very fast

3.4.2 Case-marked place adverbs

Adverbs of place act as the head of an adverb group either by themselves or by taking a case suffix.

içeri inside dışarı outside
yukarı up aşağı down
ileri forward geri backward
öte yonderberapa hitter
ön front arka behind
karsı opposite

a. Evden dışarı çıkmadım.
house-Abl outside go-out-Neg-Past-1Sg
‘I didn’t go out from the house.’

b. Yolun ilerisi görülüyor.
road-Gen forward-POSS see-Pass-Neg
‘The forward part of the road is not visible.’

c. Nehirden öteye nasıl geçilir?
river-Abl yonder-Dat how pass-Pass-Pres-3Sg
‘How can one go beyond the river?’
3.4.3 Temporal adverb groups

“sonra” (“after”) and “once” (“before”) succeed noun groups denoting a time period or a point in time, and form adverb groups.

(65) a. Dört gün sonra yola çıkacağız.
    four day after road go-out-Fut-1Pl
    ‘We’ll set out on a journey in four days.’

b. Umarım Perşembeden önce burada olmaz.
    hope-Pres-1Sg Thursday-Ab1 before here be-Neg
    ‘I hope he/she won’t be here before Thursday.’

Another type of adverb group denoting time is the one that uses special temporal nouns in head position. These temporal nouns are some time units (gün: “day”, hafta: “week”, ay: “month”, mevsim: “season”, yıl: “year”, yüzyıl: “century”, dönem: “semester, age”, çag: “era, epoch”), days of week, months and year. In such adverb groups, however, the set of words that may modify the head is rather limited: önceki (“previous”, “before”), ertesi (“following”, “after”), geçen (“last”), gelecek (“next”), bu (“this”), o (“that”).

(66) a. Ertesi gün eski bir arkadaşına rastladım.
    following day old a friend-1SP-Dat come-across-Past-1Sg
    ‘The following day, I came across with an old friend of mine.’

b. Gelecek yaz Paris’e gideceğim.
    next summer Paris-Dat go-Fut-1Sg
    ‘I will go to Paris next summer.’

3.4.4 Verb groups with adverbial use

Verb stems may function as adverbs with the addition of certain suffixes. These suffixes are discussed below.

~(y)A suffix denotes a repeated action that takes place at the same time with the main verb. Verb groups in this gerundive form consist of two gerunds (either of the same verb or different verbs).
(67) a. Ağacı budaya budaya biçimlendirdi.
    tree-Acc prune prune shape-Past-3Sg
    ‘He/she shaped the tree pruning.’

b. Çocuk düşe kalka büyür.
    child fall rise grow-Pres
    ‘A child grows falling and rising.’

(y)ArAk suffix denotes a continuous action or a point action which takes place either
at the same time with the main verb or just before it.

(68) a. Op sûrek ayrıldilar.
    kiss-Recep leave-Past-3Pl
    ‘They kissed each other as they said goodbye.’

b. Koşarak karşıya geçtık.
    run opposite-Dat pass-Past-1Pl
    ‘We crossed the street running.’

(y)Hp suffix is attached to the first of consecutive verb stem pairs and provides a
connection (e.g., temporal sequence) between these stems.

(69) a. Şemsiyemi işyerinde unutup gelmişim.
    umbrella-1SP-Acc office-Loc forget come-Past-1Sg
    ‘I came, having forgotten my umbrella at the office’

b. Oturup konuşalım
    sit-down talk--Wish-1Pl
    ‘Let’s sit down and talk.’

(y)HncA suffix marks its stem as the temporal predecessor of the main verb.

(70) a. Eve varınca seni ararm.
    house-Dat arrive you-Acc call-Pres-1Sg
    ‘I’ll call you when I arrive home.’

b. Haberleri dinleyince yolculuğunu erteledim.
    news-Acc listen travel-1SP-Acc postpone-Past-1Sg
    ‘I postponed my travel when I listened to the news.’
-DHkçA suffix is a composite one which combines participle suffix -DHk with çA. This composite suffix has the meaning “so long as” or “the more”.

(71) a. Çalışmadıkça başarılı olamazsın.
study-Neg successful be-Neg-Pres-2Sg
’So long as you don’t study, you cannot be successful.’

b. Ankara’ya gel dikçe bize uğrar.
Ankara-Dat come we-Dat visit-Pres-3Sg
‘Every time he/she comes to Ankara, he/she visits us.’

c. İp atladıkça susuyorum.
rope skip be-thirsty-Prog-1Sg
‘The more I skip, the more I get thirsty.’

The suffix sequence -(Ý)r· · ·mAz attach to the same verb stem to produce a verb group that can be used like an adverb. This construction has a meaning similar to “as soon as”.

(72) a. İbiçikler öter ötmey oradayım.
hoopoe-Plu sing sing-Neg there-Loc-Cop(1Sg)
‘I will be there as soon as the hoopoes sing.’

b. Otobüsten iner inmez onu gördüm.
bus-Abl get-off get-off-Neg he/she/it see-Past-1Sg
‘I saw her/him/it as soon as I got off the bus.’

-(y)ken suffix is the last one that is to be discussed in this section. It can be translated to English as “as”. This suffix differs from the previous ones as it attaches not to a verb stem, but usually to third person singular inflection of the verb in aorist. It may also attach to narrative past, present and future tense forms for third person singular. The suffix does not harmonize with the vowels of the verb stem.

(73) a. Çayımı içerken gazete başlıklara göz atıyorum.
tea-1SP-Acc drink newspaper headline-3PP-Dat eye throw-Pres-1Sg
‘I glance through newspaper headlines as I drink my tea’

b. Düşünde dövüşmekten kenen yarında yatam tekmelemişim.
dream-1Sg-Loc fight side-1Sg-Loc lie-Rel-Acc kick-Past-1Sg
‘I had kicked the one lying next to me as I was fighting in my dream.’
c. Buraya kadar gelmişken geri dönmek olmaz
    here-Dat up to come back turn-Inf be-Neg-Pres
    ‘It’s impossible to go back now that we came up to here.’

### 3.5 Verb group

#### 3.5.1 Predicate types

Predicates in Turkish can be verbal (74a), nominal with an attached auxiliary suffix (74b), nominal with a copula (74c–d), or existential(74e–f).

(74) a. Adam topa sert vurdu.
    man ball-Dat hard hit-Past-3Sg
    ‘The man hit the ball hard.’

b. Kitabin arabadaydı.
    book-2SP car-Loc-Aux
    ‘(Your) book was in the car.’

c. Benimki en hızlı arabadır.
    I-Gen-Pro most fast car-Cop
    ‘Mine(my car) is the fastest car.’

d. Gökyüzü hep mavidir.
    sky always blue-Cop
    ‘The sky is always blue.’

e. Ayşe’nin iki çocuku var.
    Ayşe-Gen two child-Acc exist
    ‘Ayşe has two children (there exist two children of Ayşe).’

f. Sokakta kimse yok.
    street-Loc nobody not-exist
    ‘There is (there exists) no one on the street.’

#### 3.5.2 Subcategorization

Every verb—except the intransitives—subcategorize for a noun group or a set of noun groups. These noun groups may be in accusative (75a), dative (75b), locative (75c), ablative (75d) or instrumental/committative case (75e).
a. Raporu henüz bitirmedik.
   report-Acc yet finish-Neg-Past-1Pl
   ‘We haven’t finished the report yet.’

b. Yarın sinemaya gidelim.
   tomorrow cinema-Dat go-Wish-1Pl
   ‘Let’s go to the cinema tomorrow.’

c. Buzdolabında hiçbir şey kalmamıstı.
   refrigerator-Loc no-at-all thing remain-Neg-Past-Asp-3Sg
   ‘Nothing was left at all in the refrigerator.’

d. Atakule‘den dönerken Evrim‘i gördüm.
   Atakule-Abl return-Adv Evrim-Acc see-Past-1Sg
   ‘I saw Evrim as I was coming back from Atakule.’

e. Çocuklar oyuncaklarıyla oynuyorlar.
   child-Plu toy-3PP-Ins play-Prog-3Pl
   ‘The children are playing with their toys.’
   Ufuk bir arkadaşyla çalışacak.
   Ufuk a friend-3SP-Ins work-Fut-3Sg
   ‘Ufuk will work with a friend of his.’

The number of required noun groups depend on the valency of the verb.

Transitive verb: Kitap okuyordu.
   book read-Prog-Asp-3Sg
   ‘He/she was reading a book.’

Ditransitive verb: Mehmet’e gitarımı verdim.
   Mehmet-Dat guitar-1SP-Acc give-Past-1Sg
   ‘I gave my guitar to Mehmet.’

More noun groups may be provided to increase the amount of information provided; they act as complements.

(76) Sandıkları İzmir‘den Samsun’a gemiyle yolladık
    chest-Plu-Acc İzmir-Ab Samsun-Dat ship-Ins send-Past-2Pl
    ‘We sent the chests from İzmir to Samsun by ship.’

Some verbs subcategorize for a complement clause:
söylemek: “to say”, söz vermek: “to promise”, iddia etmek: “to claim”, inanmak: “to believe”, zanetmek: “to assume”, tahmin etmek: “to guess”, sanmak: “to suppose”, ispat etmek: “to prove”, inkar etmek: “to deny”, yemin etmek: “to swear”, düşünmek:
“to think”, **emin olmak**：“to be sure”, **kuşkulanmak**：“to suspect” etc.

(77) a. Dosyayı bulacağına söz vermiştin.
   file-Acc find-Part-2Sg-Dat promise-Past-Asp-2Sg
   ‘You had promised that you would find the file.’

b. Randevumuzu unuttuğunu iddia ediyor.
   Appointment-1PP-Acc forget-Part-1Sg-Acc claim-Prog-3Sg
   ‘She/he claims that I forgot our appointment.’

Some verbs (**yeğlemek**：“to prefer”, **kabul etmek**：“to accept”, **çalışmak**：“to try”, **cabalamak**：“to struggle”, **alışmak**：“to get accustomed to”, **özenmek**：“to desire”, **karar vermek**：“to decide”, **niyetlenmek**：“to intend”, **bahsetmek**：“to mention”, **vazgeçmek**：“to give up”, **anlamak**：“to understand” etc.) subcategorize for an infinitive form of the verb.

(78) a. Bu işi bitirmeye söz verdik.
   this job-Acc finish-Inf-Dat promise-Past-1Pl
   ‘We promised to finish this job.’

b. Bugün alışveriş yapmaktan vazgeçtik.
   today shopping make-Inf-Abl give-up-Past-1Pl
   ‘We gave up (the idea of) shopping today.’

### 3.5.3 Auxiliary verbs

In Turkish, some verbs are composed of a noun and an auxiliary verb. The auxiliary verbs used in such constructions are **etmek**：“to do” and **yapmak**：“to make”, the former being more frequent.

(79) a. alay → alay etmek
   ‘mockery’ ‘to mock’

b. kabul → kabul etmek
   ‘acceptance’ ‘to accept’

c. alışveriş → alışveriş yapmak
   ‘shopping’ ‘to shop/to do shopping’
There is another auxiliary which attaches to nouns to form nominal predicates: **olmak** ("to be"). This auxiliary differs from **etmek** and **yapmak** in two respects. First, it does not appear as a separate word, but rather a morpheme when the sentence is in past or present tense. Second, its inflection does not resemble that of a verb but the copula.

(80) a. Babam geçen ay yurtdışındaydı.  
    father-ISp last month abroad-Loc-Aux  
    ‘My father was abroad last month.’

b. Üç gündür çok uykusuzdum.  
    three day very sleepless-Aux  
    ‘I have been very sleepless for three days.’

c. Kitaplar masanın üstünde mis.  
    book-plu table-gen top-ISp-Loc-Aux  
    ‘The books were on the table.’

This auxiliary is not present for third person form if the sentence is in the present tense.

(81) Bardaklar rafta.  
    glass-plu shelf-Loc-(Cop)  
    ‘The glasses are on the shelf.’

For future tense as well as conditional and necessitative forms, **olmak** succeeds the noun as a separate word.

(82) a. Babam geçen ay yurtdışında olmasaydı...  
    father-ISp last month abroad-Loc be-Neg-Cond-Asp  
    ‘If my father weren’t abroad last month...’

b. Kitaplar masanın üzerinde olacak.  
    book-plu table-gen top-ISp-Loc be-Fut-3sg  
    ‘The books will be on the table.’

Another point to be emphasized about this auxiliary is that it has a different negative form than the other verbs when the sentence is in past or present tense. Negativization is performed by introducing the word **değil** ("not") just after the nominal. The tense marker, if exists, attaches to **değil**.
(83)  Cem evde de˘ gildi.
Cem house-Loc not-Aux-3Sg
‘Cem wasn’t at home.’

An ambiguity may arise with negative questions of predicates. This ambiguity is resolved by stress in speech and by a comma preceding de˘ gil in writing.

(84)  Kedi bah¸ cede de˘ gil mi?
cat garden-Loc not Ques
‘The cat is in the garden, isn’t it?’
‘Isn’t the cat in the garden?’

3.5.4 Existential predicates

Existential predicates are formed using var (“existent”) and yok (“non-existent”).

(85)  a. Odada d¨ ort koltuk vardı.
room-Loc four armchair exist-Aux
‘There were four armchairs in the room.’

b. Burada kimse yok.
here anybody non-existent
‘There isn’t anybody here.’

c. Arabasi yokmus.
car-POSS non-existent
‘She/he doesn’t have a car.’

var and yok cannot be used in future, conditional or necessitative forms. For these cases, olmak replaces var and yok.

(86)  a. Odada d¨ ort koltuk olmali
room-Loc four armchair be-Nec
‘There should be four armchairs in the room.’

b. Burada kimse olmayacak.
here nobody be-Fut-3Sg
‘There won’t be anybody here.’
3.5.5 Infinitive form of the verbs

Infinitive form of a verb is formed with suffix -mAk attached to the stem.

(87) Fransa’ya gitmek çok para ister.
    France-Dat go-Inf much money require-Pres
    ‘Going to France costs much’

Infinitive suffix cannot be followed by genitive or possessive suffixes. However case suffixes are allowed.

(88) a. Koşmaktan yoruldum.
    run-Inf-Abl tire-Pass-Past-1Sg
    ‘I got tired of running.’

b. Kızmakta hakkın.
    get-angry-Inf-Loc right-Cop(2Sg)
    ‘You are right to be angry.’

3.5.6 Gerundive forms of the verbs

There are a couple of suffixes for producing gerundive forms of a verb: -mA and -(y)Hs. -mA is used for referring to the action or its result. Genitive and possessive suffixes can be attached to -mA.

(89) a. Onunla görüşmenin bana faydası olmaz.
    he/she-Gen-Ins meet-Ger-Gen me use be-Neg-Pres-3Sg
    ‘Meeting with him/her is of no use to me.’

b. Okuması düzeliyor.
    read-Ger-3SP improve-Prog-3Sg
    ‘His/her reading is improving.’

-(y)Hs produces a gerundive which emphasizes the manner the action is performed. This suffix can also be succeeded by genitive and possessive suffixes.

(90) Gülüşiñünü hatırlıyorum.
    smile-Inf-3SP-Acc remember-Prog-1Sg
    ‘I remember the way you/(s)he smile/s.’
3.5.7 Syntax of causative verbs

In Turkish, verbs are causativized by attaching the causative suffixes -DHr, -Hr, -t, -Ht and -Ar to the stem. Using these suffixes, one can obtain a causative verb almost from any verb, including the causatives themselves.

(91) a. inanmak → inandırmak
    ‘to believe’ ‘to persuade’

    b. doğmak → doğurmak
    ‘to be born’ ‘to give birth to’

    c. oturmak → oturtmak
    ‘to sit’ ‘to seat’

    d. korkmak → korkutmak
    ‘to fear’ ‘to frighten’

    e. çıkmak → çikartmak
    ‘to go out/to go up’ ‘to remove/to raise’

Appropriate combinations of causative suffixes allow production of multiple causatives:

(92) ölmek → öldürmek → öldürtmek
    ‘to die’ ‘to kill’ ‘to have someone killed’

From syntactical point of view, causativization process has two important results: increase in the valency of the verb, and the changes in the grammatical functions of the noun groups.

Any verb form of valency $n$ will require $n + 1$ noun groups after causativization:

**Intransitive verb:** uyumak → uyutmak
    ‘to sleep’ ‘to send to sleep’

**Transitive verb:** bir şeyi okumak → birine birşeyi okutmak
    ‘to read something’ ‘to make someone read something’

**Ditransitive verb:**
    bir şeyi bir yere koymak → birine birşeyi bir yere koydurtmak
    ‘to put something to somewhere’ ‘to make someone put something to somewhere’

Another effect of causativization is that the noun groups of the original clause change their grammatical functions:
Causativization of an Intransitive Verb: The subject of the intransitive verb becomes the direct object (accusative-marked noun group) in the causative clause. A new noun group is introduced for subject position of the causative clause.

(93) Yiğitcan güldü → İşık Yiğitcan’ı güldürdü  
NOM NOM ACC  
‘Yiğitcan laughed’ ‘İşık caused Yiğitcan to laugh’

Causativization of a Transitive Verb: The subject of the transitive verb becomes the dative-marked indirect object in the causative clause, whereas the direct object (e.g., şiir in 94)) preserves its grammatical function in the causative clause. Also, a new noun group is introduced for subject position.

(94) Arzu şiir okudu → Öğretmen Arzu’ya şiir okuttu  
NOM NOM NOM DAT NOM  
‘Arzu read a poem’ ‘The teacher made Arzu read a poem’

The indirect object of the causative clause may sometimes be omitted:

(95) Öğretmen şiir okuttu.  
teacher poem read-Caus-Past-3Sg  
‘The teacher caused a poem to be read.’

If the main verb subcategorizes for a dative noun group, this noun group remains unaltered in the causative clause. In such a case, the subject of the main verb is marked as accusative and becomes the direct object of the causative clause.

(96) Çocuk okula başladı → Çocuğunu okula başlattık  
NOM DAT ACC NOM  
‘The child started school’ ‘We made the child start school’

Causativization of a Ditransitive Verb: The subject of the ditransitive verb becomes the dative-marked indirect object in the causative clause, whereas the accusative-marked direct object and the dative-marked object of the main verb preserve their grammatical functions in the causative clause. Subject position is again filled by a new noun group.
(97) Hakan kitabını masaya koydu → Ali Hakan’a kitabını masaya koydurdu
NOM ACC DAT NOM DAT ACC DAT
‘Hakan put the book on the table’  ‘Ali made Hakan put the book on the table’

Just as for the transitive verb, the subject of the main verb may be omitted:

(98) Ali kitabı masaya koydurdu.
Ali book-Acc table-Dat put-Caus-Past-3Sg
Chapter 4

DESIGN

Every language is expected to have a different realization of the language-independent principles. Some solutions proposed by Pollard and Sag [21] for English have to be modified to model Turkish. The basic features that distinguish Turkish from English are: importance of morphology in the specification of grammatical functions, overt case and agreement marking, final head position, free constituent order, pronoun drop, complement drops, and the nature of unbounded dependency constraints. Some of these items are resolved by extending the sign structure and introducing Turkish-specific versions of some principles.

4.1 Sign Structure

The template for phrases is given in Figure 4.1. A structure similar to that of English is used for signs in Turkish, with minor changes. In category \( \text{cat} \) type, an additional feature \( \text{SUBJ} \) is added, which is coindexed with the subject complement if it exists in the subcat list. It is used to distinguish subject complement from other complements which may have the same case and agreement. It refers to the subject complement directly. This is necessary for implementing some syntactic phenomena like subject raising relative clauses and other bindings to subject complement. Example (99) shows a simplified version of the \( \text{CAT} \) feature of a lexical entry for the verb “seviyor” (love-Prog-3Sg).
One of the major differences in sign structure is the \texttt{SUBCAT} feature. Since Turkish has free constituent order\footnote{For more information on order-freeness, see Chapter \ref{sec:order-freeness} and Section \ref{sec:order-freeness}.}, a type which is a nested combination of ordered and unordered lists is used instead of lists indicating obliqueness of the complements. Unordered lists are denoted with curly braces similar to sets.

Only the \texttt{SLASH} feature of type $null \lor local$ is defined as a nonlocal feature. Nonlocal features are used to process the information coming from arbitrary daughters (not only head daughter) which will be transmitted to upper phrases and bound to outer structures. Unbounded dependency and other binding constraints are defined by nonlocal features. HPSG defines three basic nonlocal features: \texttt{SLASH}, \texttt{REL} and \texttt{QUE} which are used to implement filler-gap dependencies, relative clauses and questions respectively. In this study, we only used the \texttt{SLASH} feature.

Since adjuncts may exist in any position preceding the head and probably between any subcategorized constituent, we have chosen to combine adjunct and complements of the phrase into one “daughters” attribute. Daughters (\texttt{DTRS}) attribute consists of adjunct daughters (\texttt{ADJ-DTRS}) and complement daughters (\texttt{COMP-DTRS}) which are lists

\begin{figure}
\centering
\includegraphics[width=\textwidth]{turkish-sign-structure.png}
\caption{Sample sign structure for Turkish}
\end{figure}
of sign. Head daughter (HD-DTR) is of type sign. If phrase has a subject complement, there is another feature subject complement (SUBJ-COMP) which is coindexed with the subject in the COMP-DTRS list.

4.2 Major Categories and Head Features

Since derivations involving category change is possible in Turkish, (e.g. relativizer –ki turning a noun into a specifier), and derived words preserve their syntactic behavior, head features must be extendable. For example, finite verbs are not nominalized hence do not carry case. However, sentential complements have inflections which make them behave as nominals and take case:

(100) Eve gündüğümüzdeki manzarayı gördünüz.
    house-Dat enter-Part-1Pl-Loc-Rlvz view-Acc see-Past-2Pl
    ‘You saw the view of the house when we entered.’

Basic major categories are: nouns, verbs, adjectives, adverbs and conjunctives. Category information consists of HEAD, SUBJ and SUBCAT features. Each category has its own set of appropriate features in head attribute. HEAD feature is of type head which has the following categories defined as subsorts.

Figure 4.2: Sort hierarchy of type head

Appropriate features for the head sort noun are case, agreement, relativized, nominal-index and possession (cf. 101). CASE can be nominative, objective, genitive, dative,
ablative, genitive or instrumental. In Turkish, there is no gender of objects so agreement (AGR) consists of person and number information. Since possession (if noun is used in the possessive group) is overtly marked, it is included as a head feature of type either none or agreement. Also feature nominal index (N-IND) is defined to handle adjuncts modifying the derived noun (see Section 4.5) and coindexed with the semantic index of the root noun.

As can be seen in Figure 4.2, head sort verb has three subsorts, finite, infinitival and adverbial. Finite verbs are the heads of the finite sentences. Infinitivals are verbal heads which modify or specify other phrases or subcategorized by other heads as complements. However, they still have the properties of verbs and construct embedded sentences. Relative clauses are verbs inflected by suffixes -An, -dHk-Poss, -AcAk+-Poss and contain a gap which is filled by a following noun phrase. Another group of verbal heads are sentential complements which can be arguments of some verbs. These are verbs inflected by suffixes -mA(k), -Hğ-Poss, -dHk-Poss, and -AcAk-Poss where the possessive suffix marks agreement rather than possession. Similarly, sentential adverbs modify the matrix verb.

In addition to the syntactic roles, there are structural differences in these three sorts. Finite verbs take an secondary tense or aspect marker which is one of none, past, dubitative or conditional. Infinitivals carry case information so they have the CASE feature. The following attribute definitions are appropriate for these groups:
(102)  
\[
\begin{align*}
\text{verb:} & \\
\text{AGR} & \quad \text{null} \lor \text{agr} \\
\text{NEG} & \quad \text{plus} \lor \text{minus} \\
\text{TENSE} & \quad \text{base} \lor \text{present} \lor \text{continuous} \lor \text{past} \lor \text{dubitative} \lor \text{wish}
\end{align*}
\]

\[
\begin{align*}
\text{finite:} & \\
\text{AGR} & \quad \text{agr} \\
\text{AUX-TENSE} & \quad \text{past} \lor \text{dubitative} \lor \text{conditional}
\end{align*}
\]

\[
\begin{align*}
\text{infinitival:} & \\
\text{CASE} & \quad \text{case}
\end{align*}
\]

4.3 Complement Selection and Linear Precedence

Heads select their arguments using the SUBCAT feature. The SUBCAT feature is a structured type consisting of arguments of sort synsem. Therefore, a head can select any syntactic property of its arguments like category, case, agreement, nonlocal features and even semantic content. Any type of category is allowed including sentential complements, adverbs, adjectives, etc.

As mentioned in the preceding section, scrambling of constituents is handled by unordered lists. Linear precedence constraints of Turkish can be described generally as:

\[
\begin{align*}
(103) \quad & \text{a.} \quad \left[ \text{HD-DTR} \begin{array}{l}
\text{COMP-DTRS} \quad \langle \ldots, \text{sign} \ldots, \rangle \\
\text{SYNSEM} \mid \text{CAT} \mid \text{HEAD} \quad \neg \text{verb}
\end{array} \right] \quad \Rightarrow \quad [\square] \quad < \quad [\square] \\
\text{b.} & \quad \left[ \text{HD-DTR} \begin{array}{l}
\text{ADJ-DTRS} \quad \langle \ldots, \text{sign} \ldots, \rangle
\end{array} \right] \quad \Rightarrow \quad [\square] \quad < \quad [\square]
\end{align*}
\]

(103a) describes the constraint “complement daughters should precede the head daughter when head daughter is not a verb” and (103b) describes the constraint “adjunct daughters should precede the head daughter”.

To handle the cases such as ‘nonreferential object should immediately precede the verb’, we use a special sort for subcat feature. This sort has a nested mixed structure of list and set. Subcat type can be either a list or a set, and recursively, element of a set can be either a synsem-arg value or a list. Element of a list can be either a synsem-arg value or a set. synsem-arg sort is used to enable optional arguments (104a). If

\[
\text{Set is used to indicate the property of order-freeness where all permutations of the members of the set is possible at the surface.}
\]
OPT attribute of an argument is \textit{plus} than it is optional and can be omitted. Optional arguments are generally denoted with enclosing parentheses.

\begin{equation}
\text{a.} \begin{bmatrix}
\text{synsem-arg} \\
\text{OPT} & \text{plus} \lor \text{minus} \\
\text{ARG} & \text{synsem}
\end{bmatrix}
\end{equation}

\begin{equation}
\text{b.}
\begin{align*}
\text{subcat-type} \\
\text{list-subcat} \\
\text{HD} & \text{synsem-arg} \lor \text{set-subcat} \\
\text{TL} & \text{e-list} \lor \text{list-subcat}
\end{align*}
\begin{align*}
\text{set-subcat} \\
\text{EL} & \text{synsem-arg} \lor \text{list-subcat} \\
\text{ELS} & \text{e-list} \lor \text{set-subcat}
\end{align*}
\end{equation}

In the surface form, lists are ordered and sets are permuted. For example, the sign in (105a) has the surface forms listed in (105b). It is assumed that \textit{adam} (man) is substituted for the subject, \textit{çocuğa} (child-Dat) is substituted for the dative object, \textit{evden} (house-Abl) is for ablative argument and \textit{kalem} (pencil) is the nonreferential object.

\begin{equation}
\text{a.} \begin{bmatrix}
\text{PHON} & \langle 'getirdi' \rangle & \% \text{bring-Past-3Sg} \\
\text{SYNSEM} | \text{LOCAL} | \text{CAT} & \\
\text{HEAD} & \text{verb} \\
\text{SUBJ} & \bullet \\
\text{SUBCAT} & \{ \text{NP[nom | dat | abl]}, \text{NP[nom]} \}
\end{bmatrix}
\end{equation}

\begin{align*}
\text{b.} & \text{“Adam çocuğa evden kalem getirdi”} \\
& \text{“Adam evden çocuğa kalem getirdi”} \\
& \text{“Çocuğa adami evden kalem getirdi”} \\
& \text{“Çocuğa evden adam kalem getirdi”} \\
& \text{“Evden çocuğa adam kalem getirdi”} \\
& \text{“Evden adam çocuğa kalem getirdi”}
\end{align*}

Sentential complements and any kind of argument-head relation can be declared in this manner. For example the verb “söyledi” (told) can be defined as:
Verbal categories have the most complex complement structures. All verbal heads (finite verbs, infinitivals, sentential adverbs) require one or more complements according to their valence. Turkish is a complement-drop language so complements can be dropped even if they are obligatory arguments.

Other typical complement-head relationship is in the possessive noun group (107a). A possessive marked noun subcategories for a genitive noun and the part of speech of the complement should agree with the possessive suffix (107b).

The order of the complements and adjuncts are variable which means adjuncts specifying the head can be in any position. So, instead of generating the surface form from the subcat list directly by a phrase structure rule, we chose to retrieve the complements one at a time. This allows the adjunct rule which will be described in following sections to be applied to the head at any position.

Where selectlast selects the last synsem value from the SUBCAT structure, and rest is stored in third parameter.
This rule applies to the head-final complements. Handling scrambling of verbal head to pre-complement position is made possible by another schema:

\[
(109) \begin{array}{c}
\text{SYNSEM} | \text{LOCAL} | \text{CAT} \quad [\text{HEAD} \quad {}_{1} \quad \text{SUBCAT} \quad {}_{2}]
\end{array}
\rightarrow
\begin{array}{c}
\text{SYNSEM} | \text{LOCAL} | \text{CAT} \quad [\text{HEAD} \quad {}_{1} \quad \text{verb}]
\end{array}
\begin{array}{c}
\text{SYNSEM} \quad {}_{3}, \quad \text{selectfirst} \quad {}_{3}, \quad {}_{4}, \quad {}_{2}
\end{array}
\]

Where \text{selectfirst} selects the first \text{synsem} value \( {}_{3} \) from the \text{SUBCAT} structure \( {}_{4} \), and rest is stored in third parameter \( {}_{2} \).

### 4.4 Pronoun Drop

One of the distinct properties of Turkish is the pronoun drop; pronoun in the subject position can be omitted since it is marked by agreement of the head. There are three constructs where pronouns drop: subject of the verbal heads, substantive predicates and possessive noun groups. In both cases, including embedded sentences in which the subject has genitive case, the dropped pronoun has either nominal or genitive case.

\[(110)\]

\begin{align*}
\text{a. (bizi) Treni g"ord"uk.} & \quad \text{We train-Acc see-Past-1Pl} \\
& \quad \text{We saw the train.}'
\end{align*}

\begin{align*}
\text{b. (benim) G"uzel bah"cem.} & \quad \text{I-Gen nice garden-1SP} \\
& \quad \text{My beautiful garden.}'
\end{align*}

\begin{align*}
\text{c. (o) (benim) Eve gitti"gimi g"ord"u.} & \quad \text{he I-Gen house go-Part-1Sg-Acc see-Past-3Sg} \\
& \quad \text{He saw that I went to house.'}
\end{align*}

\begin{align*}
\text{d. (o) (benim) En yakın arkada"s"md"ur.} & \quad \text{(he) (I-Gen) most close friend-1SP-Cop(3Sg)} \\
& \quad \text{He is my best friend.’}
\end{align*}

A solution to pro-drop is using \textit{empty categories}, which have null surface forms. A possible declaration for dropped pronoun as empty category is:
This declaration will fill the subject position required by any head feature. However, empty categories usually cause major problems. In most of the implementations, they are inserted into any position available in the sentence. This is simply inefficient. More critically, when the order of the complement filled by the empty category has free order as it is in Turkish, superfluous parses are generated for each possible position that the subject can occupy. Therefore, more constraints may be necessary to deal with the empty categories. The same problem also exists for management of the trace in relative clauses (Section 4.6). For the time being we have chosen the keep dropped pronouns as empty categories.

4.5 Adjuncts

Adjuncts are optional elements in the phrase structure. Adjuncts cannot be modeled in the same way as the complements. Their most distinct property is that they do not change the valence of the phrase they combined with. In other words, a head can be specified/modified by any number of adjuncts, which may possibly have the same category.

Another problem about adjuncts is whether the heads should select their adjuncts or adjuncts should select their heads. One solution proposed by Pollard and Sag [20] takes the approach where heads select their adjuncts. A new set-typed feature called \textit{adjuncts} is added to sort \textit{cat}, and adjunct is checked by whether it is unified with one of the elements of the set. The number of elements in the set does not change. However, adjuncts may come in many different varieties and this set may grow to an unmanageable size.

In the other approach, adjuncts select their heads [21]. This provides a simpler solution because the heads that an adjunct can modify are more restricted. MOD attribute of type \textit{synsem} defined in the lexical entry for the adjunct is used to select the syntactic category of the head. MOD is a head feature containing the restrictions for the head to be modified, and is unified with the \textit{SYNSEM} value of the head. In examples (112a–b), the adjunct category of adjective/adverb subcategorizes for the head noun/verb respectively.

\begin{enumerate}
\item[(112) a.] \begin{align*}
\text{PHON} \quad \langle 'mavi' \rangle \quad \% \text{ blue} \\
\text{SYNSEM} | \text{LOCAL} | \text{CAT} \\
\text{HEAD} \quad \text{qualitative-adj} \\
\text{MOD} \quad \text{LOCAL} | \text{CAT} | \text{HEAD} \quad \text{noun}
\end{align*}
\end{enumerate}
With this model, all adjuncts have similar structure and can be handled by the same rule. In Turkish, an adjunct with the appropriate MOD attribute can precede the phrase anywhere. So a preliminary version of adjunct principle can be written as:

\[(113) \begin{align*}
&\begin{bmatrix}
\text{DTRS} & 
\text{HD-DTR} & 0 \\
\text{ADJ-DTRS} & 0 & 0
\end{bmatrix} \\
&\begin{bmatrix}
\text{SYNSEM} & 
\text{LOCAL} & 0 & 0 & 0 & 0 \\
\text{CAT} & 0 & 0 & 0 & 0 & 0 \\
\text{HEAD} & 0 & 0 & 0 & 0 & 0
\end{bmatrix} \\
&\begin{bmatrix}
\text{MOD} & 0 & 0 \\
\text{LOC} & 0 & 0 \\
\text{CAT} & 0 & 0 \\
\text{HEAD} & 0 & 0
\end{bmatrix} \\
&\begin{bmatrix}
\text{SYNSEM} & 
\text{LOCAL} & 0 & 0 & 0 & 0 \\
\text{CAT} & 0 & 0 & 0 & 0 & 0 \\
\text{HEAD} & 0 & 0 & 0 & 0 & 0 \\
\text{MOD} & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
\end{align*}
\]

Although adjuncts can modify a phrase in any preceding position, there are restrictions on the possible combinations and order of the adjuncts modifying the same head. Rules defining the grammatical combinations vary; an adjunct modifying the head may prevent other adjuncts to modify the same head. In (114a) “güzel” modifies “bahçedeki” and does not modify “çiçek”. Similarly, the quantitative adjective “iki” cannot modify the noun phrase “bu çiçek”. However “iki” does not prevent “bu” from specifying “çiçek” (114b–c).

(114) a. güzel bahçedeki çiçek
   beautiful garden-\textit{Loc-Rlvz} flower
   ‘The beautiful flower in the garden’

b. * iki bu çiçek
   two this flower

c. bu iki çiçek
   this two flower
   ‘These two flowers’

In order to control the combinations of adjuncts, we introduce a new feature for all categories under the CAT feature called ADJUNCTS. This structure consists of a group of boolean attributes that keep track of the adjuncts that have been applied to the category. In the adjunct part, the MOD attribute is divided into two attributes: a synsem value (MODSYN) with the same purpose of MOD in (113), and MODADJ defining the resulting
ADJUNCTS structure which will be projected to the mother phrase. Adjunct still selects the head together with the ADJUNCT value included in the SYNSEM of the head, and defines which flags will be set and passed to the mother phrase. For example, assume that ADJUNCTS consist of three flags: RLV indicating that the relativized noun has been applied, DEM indicating the demonstrative adjective has been applied and QLT indicating that the qualitative adjective is applied. Simplified lexical entries for each category could be as in the example (115).

(115) a.  
\[
\begin{array}{c}
\text{PHON} \\
\text{SYNSEM} | \text{LOCAL} | \text{CAT} | \text{HEAD} | \text{MOD}
\end{array}
\]

\[
\begin{array}{c}
\langle 'güzêl' \rangle \% \text{beautiful} \\
\text{MODSYN} | \text{LOCAL} | \text{CAT} | \text{ADJUNCTS} \\
\text{MODADJ} \quad \begin{cases}
\text{RLV} & - \\
\text{DEM} & - \\
\text{QLT} & +
\end{cases}
\end{array}
\]

b.  
\[
\begin{array}{c}
\text{PHON} \\
\text{SYNSEM} | \text{LOCAL} | \text{CAT} | \text{HEAD} | \text{MOD}
\end{array}
\]

\[
\begin{array}{c}
\langle 'bu' \rangle \% \text{this} \\
\text{MODSYN} | \text{LOCAL} | \text{CAT} | \text{ADJUNCTS} \\
\text{MODADJ} \quad \begin{cases}
\text{RLV} & - \\
\text{DEM} & + \\
\text{QLT} & \square
\end{cases}
\end{array}
\]

c.  
\[
\begin{array}{c}
\text{PHON} \\
\text{SYNSEM} | \text{LOCAL} | \text{CAT} | \text{HEAD} | \text{MOD}
\end{array}
\]

\[
\begin{array}{c}
\langle 'bahçedeki' \rangle \% \text{one that is in the garden} \\
\text{MODSYN} | \text{LOCAL} | \text{CAT} | \text{ADJUNCTS} \\
\text{MODADJ} \quad \begin{cases}
\text{RLV} & - \\
\text{DEM} & \square \\
\text{QLT} & \square
\end{cases}
\end{array}
\]

With these definitions, a revised adjunct principle can be written as:

(116)  
\[
\begin{array}{c}
\text{DTRS} \\
\text{SYNSEM} | \text{LOCAL} | \text{CAT} | \text{HEAD} | \text{MOD}
\end{array}
\]

\[
\begin{array}{c}
\text{HEAD} \\
\text{ADJUNCTS}
\end{array}
\]

\[
\begin{array}{c}
\text{MODSYN} \quad \square \\
\text{MODADJ} \quad \square
\end{array}
\]

\[
\begin{array}{c}
\text{DTRS} \quad \text{ADJ-DTRS} \quad \square \\
\text{ADJ-DTRS} \quad \square + \square
\end{array}
\]

58
When relative clauses, quantifiers, article ‘bir’, classifier nouns, and quantitative adjectives are defined, all noun phrase combinations can be covered. On the other hand, genitive noun in possessive noun group is not a specifier. It is an argument of the possessive noun. Thus it requires a special interpretation. Specifiers and modifiers can specify/modify the possessive marked noun as long as they are between the genitive noun and the possessive noun. Otherwise they specify/modify the genitive noun. To prevent adjuncts from passing over the genitive noun, we defined another constraint which can be informally expressed as: “a noun modifier/specifier modify/specify a possessive marked noun if it is not saturated”. This constraint can be shown as:

\[(117) \begin{array}{c}
\text{SYNSEM} | \text{LOCAL} | \text{CAT} | \text{HEAD} | \text{MOD} | \text{LOCAL} | \text{CAT} \\
\text{HEAD} \left[ \begin{array}{c}
\text{noun} \\
\text{POSS} \sim \text{none}
\end{array} \right] \\
\text{SUBCAT} \left[ \langle \rangle \right]
\end{array} \Rightarrow
\]

4.6 Relative Clauses

Filler-gap dependencies are the contracts in which elements are extracted from their positions (leaving gaps) and appear in other positions (filler). In Turkish, typical filler-gap construction is the relative clauses. Two basic strategies exist for relative clauses which are called \(wa\) and \(ga\) by Hankamer and Knecht [12] which are realized respectively by \-(y)An and \-DHk-Agr or \-(A)cAk-Agr relative participles:

\[(118) \begin{array}{l}
i. \text{When the gap is the relative clause subject, or a subconstituent of the relative clause subject, use the } \text{wa} \text{ strategy.} \\
ii. \text{When there is no relative clause subject, use the } \text{wa} \text{ strategy.} \\
iii. \text{When the gap is not a part of relative clause subject, use the } \text{ga} \text{ strategy.}
\end{array}
\]

\[(119a–b) \text{ are examples of } \text{wa}, \ (119c–d) \text{ are examples of } \text{ga} \text{ strategy.}
\]

\[(119) \begin{array}{l}
a. \underline{1} \text{ Adama kalemi veren } \underline{1} \text{ cocuğ} \underline{1} \text{ gördüm.} \\
\text{man-Dat pencil-Acc give-Rel child-Gen see-Past-1Sg} \\
\text{‘I saw the child who gave man the pencil.’}
\end{array}
\]

\[(119) \begin{array}{l}
b. \underline{1} \text{ yakınına k} \underline{1} \text{prü yap} \underline{1} \text{ olan ev} \underline{1} \\
\text{near-3SP-Dat bridge build-Pass-Rel house} \\
\text{‘The house to which a bridge is built next } \underline{1} \text{.’}
\end{array}
\]
c. Çocuğun adama **1** vereceği **1** kalem **1** gördüm.  
    child-Gen man-Dat give-Rel-3Sg pencil-Acc see-Past-1Sg  
    'I saw the pencil that the child will give **1** to the man.'

d. Çocuğun kalem **1** verdiği adam **1** gördüm.  
    child-Gen pencil-Acc give-Rel-3Sg man-Acc see-Past-1Sg  
    'I saw the man **1** to whom the child gave **1** the pencil.'

(118ii) introduces a special condition where the relative clause has no subject. In Turkish there are two cases for clauses with no subject: impersonal passives and verbs with incorporated subject. In these cases, the real agent of the verb does not exist. The noun in the subject position incorporates to the verb. In the example (119b), 'köprü' is an incorporated subject. Similarly, examples below show the relativization of an adjunct NP—a locative adjunct in this case, with subject incorporation (120a) and no incorporation (120b).

(120) a.1 Kedi **1** çocuğun **1** yatağında uyudu.  
    cat child-Gen bed-3SP-Loc sleep-Past-3Sg  
    'The cat slept in the child’s bed.'

    a.2 yatağında kedi uyuyan **1** çocuk  
    bed-3SP-Loc cat sleep-Rel(wa) child  
    'the child whose bed cat slept in'

    b.1 Ayşe **1** çocuğun **1** yatağında uyudu.  
    child-Gen bed-3SP-Loc sleep-Past-3Sg  
    'Ayşe slept in the child’s bed.'

    b.2 yatağın-da **1** Ayşe’nin uyuyDuğ-u **1** çocuk  
    bed-3SP-Loc Ayşe-Gen sleep-Rel(ga)-3Sg child  
    'the child whose bed Ayşe slept in'

Gaps in relative clauses may involve dependencies which exist in nested constituents (121a–b). Infinitival verbs and possessives produce gaps from missing noun phrase constituents and pass them to the upper clause. This gap information is nonlocal to phrase, and projected until a verb with the relative suffix is reached. The clause headed by the verb behaves as a modifier and gap is filled (i.e, structure-shared) by the noun phrase at modified position.

(121) a. **1** Çocuğun kaybolan kadın **1** çok telaşlandı.  
    child-3SP lost-Rel woman very panic-Past-3Sg  
    'The woman whose child is lost has panicked.'

60
b. Babama beğendiğimi söylediğim araba satılmış.
father-1SP-Dat like-Part-1Sg-Acc tell-Rel-1Sg car sell-Pass-Past-3Sg
‘The car\textsubscript{1} that I told my father that I like\textsubscript{1} is sold.’

Such dependencies and information interaction with the other phrases over the local phrase boundary are called non-local features by HPSG. These features are ruled by a principle called Non-local Feature Principle\textsuperscript{[21]} which is adapted from Foot Feature Principle of GPSG. For filler-gap dependencies, a nonlocal feature called SLASH is introduced. In English more than one gap is possible in a clause, so set type is used for SLASH attribute. However in Turkish, a relative clause can contain only one trace at any intermediate phrase. In case of nested relative clauses, the gap is always filled and bound to a sister NP. Therefore in our design, SLASH attribute can be null or of type local. When the trace (empty category) is introduced, non-local feature SLASH is coindexed with the LOCAL feature of the gapped argument position.

\begin{align*}
(122) \quad & \begin{bmatrix}
\text{PHON} & \langle \rangle \\
\text{SYNSEM} & \begin{bmatrix}
\text{LOCAL} & \checkmark \\
\text{NONLOCAL} & \text{INHERITED} & \text{SLASH} & \square
\end{bmatrix}
\end{bmatrix} \\
\end{align*}

Slash feature introduced by the trace is inherited to upper levels. However, in some position, inheritance should be broken and filler should be searched. In case of Turkish, this is the level where a relative verb is the head of the phrase. HPSG marks these positions by dividing NONLOCAL feature into two attributes INHERITED and TO-BIND of the same structure. TO-BIND|SLASH feature of relative verbs are marked as local (not null) and coindexed with the INHERITED|SLASH feature. The resulting phrase becomes a modifier of which the LOCAL feature of the modified phrase is also coindexed with the slash, so that the filler and its trace are combined (Figure 123).

A lexical entry for relativized verbs is given in (123). However, some head features such as case, relativization, possession and subcategorization are not supposed to be the same for the filler and the trace. To handle this, selected features CONT|INDEX, HEAD|AGR are passed to modified structure instead of LOCAL feature.

\begin{align*}
(123) \quad & \begin{bmatrix}
\text{PHON} & \langle \text{şöyledğimîm} \rangle & \% \text{tell-Rel-1Sg} \\
\text{SYNSEM} & \begin{bmatrix}
\text{LOCAL} | \text{CAT} & \begin{bmatrix}
\text{HEAD} & \begin{bmatrix}
\text{obj-rel-verb} & \begin{bmatrix}
\text{AGR} & \begin{bmatrix}
\text{PERSON} & \text{first} \\
\text{NUMBER} & \text{sing}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix} \\
\text{NONLOCAL} & \begin{bmatrix}
\text{INHERITED} & \text{SLASH} & \square \\
\text{TO-BIND} & \text{SLASH} & \begin{bmatrix}
\text{local} & \text{CONT} | \text{INDEX} & \square
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{align*}
The problem with the dropped pronouns also exists in relative clauses. When trace is realized with empty category, efficiency and superfluous ambiguity problems may arise. In our design, we used a simple technique for raising slash feature, relying on two properties: First is valid for most of the languages. Every trace should be subcategorized by a head. Second is the free constituent order of Turkish. Since complement order is relatively free in Turkish, we could assume that the missing item is the last constituent. Because any constituent may be in the last (first in the surface but retrieved last) position in the complement list. So we have introduced the following rule to introduce trace instead of empty category:
When the argument is the last item in the SUBCAT list, it is deleted, and the trace is introduced. This solves the ambiguity in subcategorized constituents. However yet another problem exists with the traces which may occur in adverbs, which are not subcategorized for. In English, prepositions subcategorize for an NP so that the trace could be generated from subcategorization. However two case suffixes –dA (locative) and -(y)lA (instrumental) in Turkish produce nominal adjuncts that act as VP modifiers. When they are missing, since they have no surface form, it is impossible to introduce them by the rule above. We introduce the trace as an empty category for these two cases:

The second problem is the definition of the constraints for the use of wa and ga strategies described in (118). When the slash value is introduced in the subject position (subject daughter or one of its daughters is missing), wa strategy is used, otherwise ga strategy is used. These are expressed as:

Relative Clause Principle

(126) a)
In cases where the subject NP is incorporated, the *wa* strategy can be used even though the gap is not the subconstituent of the subject. Such verbs are marked with a boolean head feature called N-INCORP standing for the noun incorporation. The main constraint on this type of relative clause is that the type of the noun in the subject position should be indefinite (or nonreferential) because it is incorporated. The following additional constraint solves the problem:

\[
\begin{aligned}
\text{SYNSEM} & \begin{cases}
\text{LOCAL} | \text{CAT} & \text{HEAD} \langle \text{object-relative} \rangle \\
\text{SUBC} & \langle \rangle \\
\end{cases} \\
\Rightarrow & \\
\text{LOCAL} | \text{CAT} | \text{SUBJ} & \text{NONLOCAL} | \text{INHERITED} | \text{SLASH} \\
\text{NONLOCAL} | \text{TO-BIND} & \neg
\end{aligned}
\]

When a relative clause satisfying these constraints is saturated, and its TO-BIND feature is bound to the INHERITED feature, it acts as a noun modifier. The content index of the modified noun is coindexed with the index of the gap to bind the semantic features of the relative clause and the filler. The rest is handled by the adjunct schema. Nested relative clauses can modify the same noun so that multiple gaps may be bound to the same filler (128).

\[
\begin{aligned}
\text{SYNSEM} & \begin{cases}
\text{LOCAL} | \text{CAT} & \text{HEAD} \langle \text{subject-relative} \rangle \\
\text{SUBC} & \langle \text{N-INCORP} + \rangle \\
\end{cases} \\
\Rightarrow & \\
\text{LOCAL} | \text{CAT} | \text{SUBJ} & \text{LOCAL} | \text{CAT} | \text{ADJUNCTS} | \text{DEFINITE} \\
\end{aligned}
\]



\[
\begin{aligned}
\text{annemin} & \text{yaptığı} \text{çok seviyorum kurabiye ler} \\
& \text{mother-POSS cook-Rel much like-Rel cookie-Plu} \\
& \text{‘the cookies that my mother cooked, that I like’}
\end{aligned}
\]

### 4.7 Substantive Predicates

As mentioned in Chapter 3, Turkish sentences may have verbal, existential or substantive heads. Substantive predicates are formed by substantive heads with auxiliary (-DH-Agr, -mHs-Agr) or copula suffixes. Syntactically, substantive heads subcategorize for an NP which have the same semantic index. In other words, substantive head and the subcategorized NP describe the same nominal object (129a–b). Copula and agreement suffixes marks the agreement of the categorized NP.
a. Ben çok hastayım.
   I much ill-Cop(1Sg)
   ‘I’m too sick.’

b. Bütün kadınlar çiçekir.
   every woman-Plu flower-Cop(3Sg)
   ‘Every woman is a flower.’

Another design consideration is to distinguish predicative NP’s from the others. First, this is necessary to determine whether a saturated NP forms a sentence or not. Second, the same problem with the possessive NP exists for substantive predicates. A saturated predicative NP should not be further modified by another adjective. For these two reasons, we have added a boolean type head feature for substantial types called PREDICATIVE. The following is a sample entry for a predicative noun “insanım”.

(130) 
| PHON | “insanım” |
| SYNSEM | LOCAL |
| CAT | [HEAD noun PREDICATIVE +]
| SUBCAT | ⟨NPunker⟩ |
| CONT | INDEX |

After this feature is defined, the following constraint is added to the constraint (117) for the adjunct rule:

(131) [| SYNSEM | LOCAL | CAT | HEAD | MOD | LOCAL | CAT | HEAD | noun PREDICATIVE +] ⇒
                 |                     |   |                     |
                                                                 | SUBCAT ¬ ⟨⟩

In the implementation, substantive predicates are realized by a lexical rule which maps lexical entry for a non-predicative substantive word to substantive predicate by an auxiliary or copula suffix:

(132) 
| PHON | |
| SYNSEM | LOCAL |
| CAT | [HEAD subst PREDICATIVE −]
| SUBCAT | |
| CONT | INDEX |

| PHON | apply-cop |
| SYNSEM | LOCAL |
| CAT | [HEAD PREDICATIVE +]
| SUBCAT | ⟨NP[AGR INDEX⟩ ⊕⟩ |

| PHON | |
| SYNSEM | LOCAL |
| CAT | [HEAD PREDICATIVE +]
| SUBCAT | ⟨NP[AGR INDEX⟩ ⊕⟩ |
Where `apply-cop` is a general predicate applying the copula suffix corresponding to agreement feature marked with the second argument to the first argument and returning the resulting string.
Chapter 5

ALE IMPLEMENTATION

In the implementation, we have used ALE (Attribute Logic Engine). ALE is an integrated system of definite clause logic programming and phrase structure parsing. All operations and declarations in ALE use typed feature structures as terms. ALE is designed and suited for implementations of unification-based language formalisms.

ALE is a strongly typed language. Every structure must have a declared type. Types are defined by an inheritance structure and subtype relation. Basic representation scheme used is the typed feature structures. Types are assigned to appropriate feature-value pairs. Type structure of ALE is very similar to the HPSG including properties like inheritance, nesting, and well-typedness. However it is most restricted in favor of efficiency and implementation considerations.

ALE allows definition of general constraints on types. One can put restrictions on the feature structures of a particular type. Another feature of ALE is the definite clauses in which all functionality of PROLOG definite clauses is provided with feature structure unification instead of simple term unification. Also complex descriptions can be simplified by the use of macros.

One of the most distinct features of ALE from other tools like TFS and CUF is the support for phrase structure grammars. ALE provides phrase structure rules to be coded like Definite Clause Grammars of PROLOG. It has a built-in bottom-up chart parser in addition to feature structure unification. DCG’s are top-down and depth-first. However ALE parser works in a combined manner asserting edges to chart right to left while applying rules left to right. ALE also allows lexical rules for dealing with lexical redundancy. Lexical rules can be defined for inflectional or derivational morphology as well as zero derivations like nominalization of adjectives. Morphological constraints (suffixation, affixation etc.) can be controlled by some built in mechanisms or PROLOG predicates. It also allows empty categories to be integrated into grammar.
5.1 Grammar Rules and Principles

We have four phrase structure rules, each corresponding to a schema that we have introduced in the preceding chapter. First two (108, 109) handle the complement retrieval and subcategorization. Applying both rules cause superfluous parses due to the application order. The third is the adjunct schema (116) which handles the adjunct-head relation. And the fourth is the rule introducing the slash (124).

Rules are coded by standard Immediate Dominance and Linear Precedence notation. The application of rules are governed and constrained by a set of ALE definite clauses. These include two simple clauses modifying the DAUGHTER and PHON features of the mother phrase. The others are constraints and basic principles.

head-feature-principle applies the Head Feature Principle of HPSG; head feature of the mother is structure shared with the head feature of the head daughter. selectlast and selectfirst implements the Subcategorization Principle of HPSG. The surface form of the combined SUBCAT structure of list and sets with optional arguments is generated, one item is selected, and rest is returned as the SUBCAT feature of the mother phrase. Figure 5.1 shows the source for the simplified versions of these two principles.

% head-feature-principle(MothSign,HeadSign)
% head-feature-principle(synsem:local:cat:head:X,synsem:local:cat:head:X)

 Linear precedence and word order constraints of the system are realized by the definite clauses removeop and surface. The mixed subcat structure (cf. 104) consisting of nested sets and lists with optional arguments is converted into permutations of the surface form by these clauses. removeop produces omitted and existed permutations of optional arguments, and surface produces the flattened lists from the resulting structure.
nonlocal-principle combines the NONLOCAL features of the daughters and modifies the mother. It inherits the gap information in one of the daughters from INHERITED feature to the mother phrase. If TO-BIND feature of the head is not null it binds the gap and applies the constraint for the relative clauses. adjunct-principle puts the constraints in schema (116) and two constraints introduced in (117) and (131). Grammar rules are coded in file T.rule and principles are coded in T.clause in Appendix A.

5.2 Lexicon and Lexical Rules

Lexical redundancy becomes a crucially important problem in agglutinative languages where a large number of derivations and inflections of a root word exists. It is almost impossible to store all derivations and inflections of Turkish words into a lexical database. Therefore some sort of morphological analysis and application of lexical rules are essential. Also application of a lexical inheritance hierarchy could be used to deal with redundancy.

ALE does not suggest a standard mechanism for implementing lexical type hierarchies. Two methods seem to be applicable: use of macros, and type hierarchies with general constraints. Macro definitions in ALE allow variable substitution and —not recursive— nesting. Each node in the lexical hierarchy can be defined by a macro which contains the calls for the parent macros. At the lexical level, items are defined by one or more macros. Macros are expanded at run time, and ALE operates on the expanded descriptions. Second solution is to construct a type hierarchy under the type word which is the type of the lexical elements, and put general constraints on these types. However, in this approach, it is impossible to assign a lexical item to several nodes in the type hierarchy since each item can belong to only one type. Besides, ALE has a very restricted type mechanism so multiple inheritance is very limited. On the other hand, constraints are evaluated at compile time which is efficient compared to macros.

In implementation, we have used a lexical type hierarchy. We defined a lexical type tree under the type word for the lexical entries. Each common class of lexical entries are defined as a node in the tree (Figure 5.2). We have used “_l” as the last two characters in the names of these lexical types to distinguish them from head types.

We also defined constraints on these types (see source files T.type and T.cons in Appendix 4). After all these declarations, defining a lexical entry as one of the types above will apply all constraints associated with the supertypes along the path to word.

ALE supports lexical rules. At the feature structure level, unification and use of user defined ALE definite clauses are provided. At the surface level, the user can define string operations by concatenation and user defined PROLOG predicates. Use of PROLOG at string level enables user to implement any kind of complex morphological phenomena like affixation, vowel harmony, drops etc. Also complex structure changes in signs can be coded by the help of the ALE’s definite clauses.

However, ALE lexical rules are inefficient for an agglutinative language like Turkish. First, ALE applies all rules at compile time and asserts all generated combinations as PROLOG predicates which consumes too much memory and increases compilation time.
considerably. Second, it implements all kinds of string-to-string mappings to handle a wide range of languages. However this makes it very slow for a large number of lexical rules and lexical entries. Both inefficiencies make the development very difficult. So we have tried to edit some portion of ALE source code and made some changes which will apply lexical rules at runtime and apply lexical mappings only to closed class of words. This increased the efficiency to a reasonable level.

We have coded lexical rules for nominal cases, possessive suffixes (which mark agreement in case of sentential complements and relative clauses), and noun relativizer suffix. Zero derivations like adjective-to-noun promotion and production of non-referential object case of verbs are implemented by lexical rules. These lexical rules are defined in the file \texttt{T.lex_rule} (Appendix A). For reusability considerations, similar feature structure transformations are grouped into ALE definite clauses which are defined in the file \texttt{T.clause}. For example, rules for application of case suffixes are implemented in clause \texttt{apply-case/3} and lexical rules for all cases call this clause with case passed as argument.

In the appendix A, some part of grammar code is given. It requires Quintus or SICStus Prolog. Full system can be obtained via anonymous ftp from \texttt{ftp.lcs1.metu.edu.tr} in path \texttt{/pub/theses/sehitoglu-ms-96.tar.gz}.
Chapter 6

CONCLUSION

In recent years, computational studies on Turkish have proliferated. These studies are important in two respects: First, building foundations of linguistic description of Turkish within the light of the contemporary linguistic theories. Second, providing basic tools for natural language processing which has applications in computer science ranging from simple text processing utilities to translation and learning tools.

HPSG is the synthesis of some of the recent linguistics theories. It is a developing theory, and new principles and approaches are being introduced for expanding the universal coverage. Being one of the most powerful among the other unification based and phrase structure formalisms, it models the language in informational perspective and describes the linguistic events by a set of universal principles and metarules. It is a general theory trying to be as flexible as possible to cover principles of all natural languages.

In this study, we have worked on a computational sign-based model of Turkish, following and adapting the HPSG framework. HPSG uses feature structures to describe linguistic phenomena. This allows the grammar designers to concentrate on the constraints imposed by a particular language on a well-defined set of linguistic features. This is in contrast to earlier context-free grammar rules, where language-specific rules do not allow generalizations. Postulating principles and writing constraints on these principles show how different languages model the same phenomenon in different ways. To this end, we have analyzed and implemented the general principles such as subcategorization, adjunct-head selection, relative extraction. We have also studied the principles such as word-order variation, pronoun and complement drops and unbounded dependencies, which are particularly important for Turkish.

For the time being, the parser has not been combined with a lexical analyzer and tested on a real corpus. Since most of the syntactic information is coded in the lexicon, an intelligent mechanism for gathering all lexical entries for Turkish should be employed. HPSG proposes solutions like lexical inheritance hierarchy, and lexical rules. Turkish is an agglutinative language and has many syntactically effective and productive suffixes. This means that there is more interactions between morphology and syntax, compared
to a language such as English.

The computational tool we have used for HPSG, ALE, supports lexical rules with morphological analysis. However it is inefficient for running a grammar with large lexicon and all lexical rules. As the main problem about lexicon, ALE does all lexical processing at compile time and generates all possible results of lexical rules statically, which is not suitable for agglutinative languages. Also, since morphological rules are defined in PROLOG, they are very inefficient. We made some changes to apply lexical rules at run time and make morphology a little bit faster. However, for an efficient lexical analysis, use of an external lexicon and morphological analyser is necessary. Necessary interface routines can be coded into PROLOG source code of ALE as the changes we have already done.

Another approach could be integration of syntactic and morphological analysis. This is achieved by encoding morphological analysis combined with syntactic rules in the style of HPSG principles. This is also desirable from the linguistic point of view; morphological and syntactic phrasing can affect each other in a principled way. ALE has some drawbacks as well as powerful features. The strong typing cause description domain to be restricted. Type hierarchies requiring lattice-like multiple inheritances cannot be coded efficiently. Also it disallows the usage of atomic types without type declaration. It has a unification based description language and type inferencing mechanism provided with definite clauses with all functionality of PROLOG. However ALE lacks some sort of overwrite operation especially in lexical rules which are procedural in nature. Overwrite operation changes some part of a feature rather than unifying it. Such an operator may ease the formulations and descriptions of lexical rules.

We have limited semantic analysis of signs to minimum. Since HPSG is a complete linguistic theory for both syntax and semantics, for a complete HPSG analysis of Turkish, semantic principles and model should be analyzed.

\[\text{for an integrated analysis of morphology and syntax cf.} \]
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Appendix A

PARSER SOURCE

A.1 Type Definitions

%=======================================================================
% @(#)T.type Rev:1.6 1/7/96
%=======================================================================
% Type definitions
%=======================================================================

bot sub [bool, sign, null_synsem, cat, head, case, null_agr, per, num, posses, list, char, set, tense, aux_tense, nonloc, null_adjstr, null_mod, list_or_set_subcat, subcat_or_ne_set, subcat_or_ne_list, psoa_arg, qfpsoa, sem_det, sem_obj, null_local, arg_type, subcat, conx, null_local, nonlocal, daughters].

sign sub [lexical, phrase]
intro [phon: list_string, synsem: synsem, qstore: set_quant, qretr: list_quant].
lexical sub [word].
word sub [noun_l, adj_l, adv_l, verb_l].
noun_l sub [common_l, proper_l, pronoun_l, relativized_l].
common_l sub [].
proper_l sub [].
pronoun_l sub [].
relativized_l sub [].
adj_l sub [quantif_l, article_l, demonstra_l, quantitative_l, qualitative_l].
quantif_l sub [].
article_l sub [].
demonstra_l sub [].

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quantitive_l sub [].
qualitative_l sub [].
adv_l sub [].
verb_l sub [finite_l,sadv_l,inf_l].
finite_l sub [].
sadv_l sub [].
inf_l sub [relcl_l,complement_l].
relcl_l sub [subj_rel_l,obj_rel_l].
subj_rel_l sub [].
obj_rel_l sub [].
complement_l sub [].
phrase sub []
  intro [dtrs: daughters ].
null_synsem sub [null,synsem].
null sub [].
synsem sub []
  intro [local:local, nonlocal:nonlocal].
null_local sub [null,local].
local sub []
  intro [cat:cat,cont:sem_obj,conx:conx].
conx sub [].
nonlocal sub []
  intro [inherited:nonloc,tobind:nonloc].
nonloc sub []
  intro [slash:null_local].
daughters sub [hd_subj_st,hd_st]
  intro [hd_dtr:sign, comp_dtrs: list_sign, spec_dtrs: list_sign].
hd_subj_st sub []
  intro [subj_dtr:sign].
hd_st sub [].

bool sub [plus,minus].
plus sub [].
minus sub [].
cat sub []
  intro [head:head, subj:null_synsem, adjuncts:null_adjstr, subcat:list_or_set_subcat].
head sub [subset,prep,adverb,verb]
  intro [mod:null_mod].
subst sub [adj,noun]
  intro [pred:bool].
adj sub [determiner,quantitative_adj,qualitative_adj,questional_adj]
  intro [countable:bool,gradable:bool].
determiner sub [article, demonstrative_adj, quantifier].
article sub [].
demonstrative_adj sub [].
quantifier sub []
quantitative_adj sub [number,distributive_adj,grouping_adj].
number sub [cardinal,fractional].
cardinal sub [].
restr:set_psoa].
pron sub [ana, ppro].
ana sub [recp, refl].
recp sub [].
refl sub [].
ppro sub [].
quant sub []
  intro [det:sem_det, restrind:npro].
psoa sub []
  intro [quants:list_quant,nucleus:qfpsoa].

subcat sub [optionalcat,subcat_type].
  optionalcat sub [opt,obl]
    intro [s_arg:subcat_type].
opt sub [].
obl sub [].

subcat_type sub [char,synsem,sign].

list_or_set_subcat sub [set_subcat,list_subcat,list_xxx].
subcat_or_ne_set sub [subcat,ne_set_subcat].
subcat_or_ne_list sub [subcat,ne_list_subcat].

list sub [e_list,ne_list,string,list_sign,
  list_quant,list_xxx,list_psoa_arg].
e_list sub [].
ne_list sub [ne_list_cat,ne_list_string,
  ne_list_xxx,ne_list_sign,ne_list_quant,ne_list_psoa_arg]
  intro [hd:bot, tl:list].
ne_list_xxx sub [ne_list_subcat,ne_list_synsem].
list_cat sub [e_list,ne_list_cat].
  intro [hd:cat, tl:list_cat].
string sub [e_list,ne_string].
  intro [hd:char, tl:string].
ne_string sub []
  intro [hd:char, tl:string].
list_xxx sub [list_subcat,list_synsem,ne_list_xxx].
list_subcat sub [e_list,ne_list_subcat].
ne_list_subcat sub []
  intro [hd:subcat_or_ne_set, tl:list_subcat].
list_synsem sub [e_list,ne_list_synsem].
ne_list_synsem sub []
  intro [hd:synsem, tl:list_synsem].
list_string sub [e_list,ne_list_string].
ne_list_string sub []
  intro [hd:string, tl:list_string].
list_sign sub [e_list,ne_list_sign].
ne_list_sign sub []
  intro [hd:sign, tl:list_sign].
list_quant sub [e_list,ne_list_quant].
ne_list_quant sub []
  intro [hd:quant, tl:list_quant].
list_psoa_arg sub [e_list,ne_list_psoa_arg].
A.2 Phrase Structure Rules

subcat_retr1 rule
(Mother,phrase,phon:PhonMot,
synsem:local:cat:(subcat:SubMot,adjuncts:Adjs,subj:Subj),
dtrs:DtrsMot)
====>
(Arg,phon:PhonArg,synsem:SynArg),
cat> (Head,phon:PhonHead,synsem:local:cat:(subcat:SubHead,adjuncts:Adjs,
subj:Subj)),
goal> (append(PhonArg,PhonHead,PhonMot),
head_feature_principle(Mother,Head),
selectlast(SynArg,SubMot,SubHead),
combine_semantics(Head,Arg,Mother),
append_comp(DtrsMot,Head,Arg),
nonlocal_principle(Arg,Head,Mother)).

subcat_retr2 rule
(Mother,phrase,phon:PhonMot,
A.3 Constraints and Macros
% Constraints
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

determiner cons (gradable: minus).
article cons (countable: plus).
quantitative_adj cons (gradable: minus,countable: plus).
word cons (qretr:e_list,synsem:nonlocal:inherited:slash:null).
subj_rel cons (tense:base,vagr:null).
obj_rel cons (tense:(future;past)).
mak cons (tense:base).
ı¸ s cons (tense:base,vagr:agr).
complemented cons (tense:(future;past),vagr:agr).
noun_l cons (synsem:local:cat:head:(n_ind:I, [agr] == [n_ind])).
common_l cons (synsem:local:cat:head:(n_ind:I),
adjuncts:(qtfd:minus,
 dmstrtd:minus,
 rltvzd:minus,
 qntfcd:minus,
 qltfd:minus,
 non_ref:plus)),
 cont:index:I)).

pronoun_l cons (synsem:local:cat:head:n_ind:I,
adjuncts:
 qtfd:minus,
 dmstrtd:minus,
 rltvzd:minus,
 qntfcd:minus,
 qltfd:minus,
 non_ref:minus)),
 cont:index:I)).

quantif_l cons
 (synsem:local:cat:head:(quantifier,
 mod:(modsyn:(local:cat:(head:(common),
 adjuncts:(qtfd:minus,
 dmstrtd:minus,
 rltvzd:minus,
 qntfcd:minus,
 qltfd:minus,
 non_ref:minus))),
 cont:index:I)),
 modadj:(qtfd:plus,
 dmstrtd:minus,
 rltvzd:minus,
 rltclsd:A,
 qntfcd:B,
 qltfd:C,non_ref:minus))).

demonstra_l cons
 (synsem:local:cat:head:(demonstrative_adj,
 mod:(modsyn:(local:cat:(head:(common),
 adjuncts:(qtfd:minus,
 dmstrtd:minus,
 rltvzd:minus,
 rltclsd:A,
 qntfcd:B,
 qltfd:C,non_ref:minus))),
 modadj:(qtfd:minus,
 dmstrtd:plus,
 rltvzd:minus,
qualitative_l cons
(synsen:local:cat:head:{qualitative_adj,
  mod:(modsyn:local:cat:head:(common),
    adjuncts:(qtfd:A,
      dmstrtd:minus,
      rltvzd:minus,
      rltclsd:minus,
      qntfcd:B,
      qltfd:plus,
      non_ref:C))},
  modadj:(qtfd:A,
    dmstrtd:minus,
    rltvzd:minus,
    rltclsd:minus,
    qntfcd:B,
    qltfd:plus,
    non_ref:C)))).

relativized_l cons
(synsen:local:cat:head:{
  mod:(modsyn:local:cat:head:(common),
    adjuncts:(qtfd:A,
      dmstrtd:B,
      rltclsd:minus,
      qntfcd:D,
      qltfd:E)}),
  modadj:(qtfd:A,
    dmstrtd:B,
    rltvzd:plus,
    rltclsd:minus,
    qntfcd:D,
    qltfd:E,
    non_ref:minus)))).

subj_rel_l cons
(synsen:local:cat:head:{
  mod:(modsyn:local:cat:head:(common,
    n_ind:NInd),
    adjuncts:(
      qtfd:A,
      dmstrtd:B,
      rltvzd:minus,
      qntfcd:D,
      qltfd:E)
  ),
  cont:(Cont,index:Ind)),
  modadj:(qtfd:A,
    dmstrtd:B,
    rltvzd:minus,
    rltclsd:plus,
    qntfcd:D,
    qltfd:E,
    non_ref:minus)))).

obj_rel_l cons
(synsen:local:cat:head:{
  mod:(modsyn:local:cat:head:(common,
finite_l cons
  (synsem:(local:(cat:head:finite),
          nonlocal:tobind:slash:null)).

%===============================================================================
% 0(#)T.macro  Rev:1.5  1/7/96
%===============================================================================
% Macros
%===============================================================================

common_noun macro
 (common_l,
   synsem:(local:(cat:(head:(common,
                          case:nom,
                          agr:(num:sing,
                          per:third),
                          mod:null,
                          n_ind:NInd,
                          pred:minus,
                          rel:minus,
                          poss:none),
                          subcat:e_list,
                          subj:null),
                          cont:(Cont,index:NInd),
                          nonlocal:(inherited:slash:null,
                                     tobind:slash:null)
                     ),
   qstore:e_list
   ).

opt(X) macro
 (opt,s_arg:X).

obl(X) macro
 (obl,s_arg:X).

np(Head,Ind) macro
 (local:(cat:(head:(Head,noun,mod:null,rel:minus,pred:minus),
                 subcat:e_list),
                 cont:index:Ind),
                 nonlocal:( tobind:slash:null)
        ).

vp(Head,Cont) macro
A.4 Definite Clauses

%---------------------------------------------------------------
% 0(#)T.clause        Rev:1.9    1/7/96
%---------------------------------------------------------------
% Principles & Clauses
%---------------------------------------------------------------

%-------
% Head Feature Principle:
% Head Feature of the mother is token identical to head feature of
% the Head.
head_feature_principle(synsem:local:cat:head:X,synsem:local:cat:head:X) if
true.

%-------
% Combine Semantics: (Head,Dtr,Mother)
combine_semantics( synsem:local:cont:(index:HInd,restr:Hrest),
synsem:local:cont:(index:DInd,restr:Drest),
synsem:local:cont:(index:HInd,restr:MRest)) if
appendset(Hrest,Drest,MRest).

combine_semantics( synsem:local:cont:(index:HInd,restr:Hrest),
synsem:local:cont:(Drest,psoa),
synsem:local:cont:(index:HInd,restr:MRest)) if
appendset(Hrest,(el:Drest,els:[]),MRest).

combine_semantics( synsem:local:cont:(nucleus:HNuc,quants:HQ),
synsem:local:cont:(DCont),
synsem:local:cont:(nucleus:HNuc,
quants:([det:the,restind:DCont]HQ) )) if
true.

combine_semantics( synsem:local:cont:(nucleus:HNuc,quants:HQ),
synsem:local:cont:(psoa),
synsem:local:cont:(nucleus:HNuc,quants:HQ)) if true.
%------------------
% adjunct_principle(mother,adjunct,head)
% adjunct_principle((synsem:local:cat:(subj:Subj,subcat:Subcat,adjuncts:MAdjs)),
  (synsem:local:cat:(head:mod:(modsyn:(Mod),
    modadj:MAdjs),
    subcat:[])),
synsem:(Mod,local:cat:(CatH,subj:Subj,subcat:Subcat))) if
checkposs(Mod),
checksubst((CatH)).
checkposs(local:cat:head: = noun) if true,!.
checkposs(local:cat:head:poss:none) if true.
checkposs(local:cat:head:(poss:poss,pred:minus),subcat:ne_set)) if true.
checkposs(local:cat:head:(poss:poss,pred:minus),subcat:ne_list)) if true.
checkposs(local:cat:head:(poss:poss,pred:plus),subcat:tl:ne_set)) if true.
checkposs(local:cat:head:(poss:poss,pred:plus),subcat:tl:ne_list)) if true.
checksubst(head: = noun) if true,!.
checksubst(head:(pred:minus)) if true.
checksubst((head:(pred:plus),subcat:ne_set)) if true.
checksubst((head:(pred:plus),subcat:ne_list)) if true.
%------------------
% nonlocal_principle
% nonlocal_principle((@slashtob((local,LAdj)),@slashinh((LAdj))),
  (@slashtob((HT,null)),@slashinh(null)),
  (@slashtob(HT),@slashinh(null))) if true.
nonlocal_principle((@slashinh(null),@slashtob(null)),
  (@slashinh(HI),@slashtob(HT)),
  (@slashinh(HI),@slashtob(HT))) if true,!
nonlocal_principle((@slashinh(null),@slashtob(null)),
  (@slashtob((HT),@slashinh(null)),@slashinh(null)),
  (@slashtob((null)),@slashinh(null))) if true.
nonlocal_principle((@slashinh(AI),@slashtob(null)),
  (@slashtob((null)),@slashinh(null)),
  (@slashtob((null)),@slashinh(null))) if true.
nonlocal_principle((@slashinh(AI),@slashtob(null)),
  (@slashtob((null)),@slashinh(null)),
  (@slashtob((null)),@slashinh(null))) if true.
nonlocal_principle((@slashinh(AI),@slashtob(null)),
  (@slashtob((null)),@slashinh(null)),
  (@slashtob((null)),@slashinh(null))) if true.
nonlocal_principle((@slashinh(AI),@slashtob(null)),
  (@slashtob((null)),@slashinh(null)),
  (@slashtob((null)),@slashinh(null))) if true.
nonlocal_principle((@slashinh(S)),
  (synsem:local:cat:(head:subj_rel,
    subj:nonlocal:inherited:slash:S),
    nonlocal:toobind:slash:S)) if true.
check_rel((@slashinh(S)), (synsem:local:cat:(head:subj_rel,
  subj:nonlocal:inherited:slash:S),
    nonlocal:toobind:slash:S)) if true.
check_rel((@slashinh(S), synsem:local: =\ = S),
  (synsem:local:cat:(head:subj_rel,n_inc:plus,
    subj:local:cat:adjuncts:non_ref:plus)),
    nonlocal:toobind:slash:S)) if true.
check_rel((@slashinh(S)),
  (synsem:local:cat:(head:obj_rel,
    subj:nonlocal:inherited:slash: =\ = S),
    nonlocal:toobind:slash:S)) if true.
% Clauses
%===============================================

append([], Xs, Xs) if true.
append([H|T1], L2, [H|T2]) if append(T1, L2, T2).

appends(e_list, X, X) if true, !.
appends([A], X, ne_set), [A[X]]) if true, !.
appends(X, [], X) if true, !.
appends([X, set], [Y, list], [X|Y]) if true.
appends([X|Rz], Y, [X|Rz]) if append(Rz, X, Res).
appends((el:X, els:Rs), (Y, set), (el:X, els:Res)) if append(Rz, Y, Res).

listlast(X, (hd:X, tl:e_list), e_list) if true, !.
listlast(X, [H|T], [H|R]) if listlast(X, T, R).

permut(e_list, e_list) if true , !.
permut((X, set), (X, set)) if true.
permut((el:X, els:R), (el:Y, els:(el:X, els:R2))) if permut(R, (el:Y, els:R2)).

selectlast(Arg, (ne_list_synsem, Sursub), Reslist) if listlast(Arg, Sursub, Reslist), !.
selectlast(Arg, Sub, Reslist) if removeop(Sub, SubRem),
        surface(SubRem, Sursub),
        listlast(Arg, Sursub, Reslist).

selectfirst(Arg, (ne_list_synsem, [Arg|Rest]), Rest) if !, true.
selectfirst(Arg, Sub, Reslist) if removeop(Sub, SubRem),
        surface(SubRem, Arg|Reslist).

select(Arg, (s_arg:Arg), []) if true.
select(Arg, (Arg, subcat_type), []) if true.
select(T, (X, set), Z) if permut(X, (el:Cr, els:Cr)),
        select(T, Ct, Res),
        appends(Res, Cr, Z).
select(T, (Xt|R), Z) if select(T, Xt, Res),
        appends(Res, R, Z).

appendset(e_list, (set, X), X) if true.
appendset((el:E1, els:Res), (set, S2), (el:E1, els:Res)) if appendset(Res, S2, Res).

removeop([], []) if true.
removeop(s_arg:X, @obl(X)) if true.
removeop((opt|R), R2) if removeop(R, R2).
removeop(B[R], [R2|R2]) if removeop(R, [R2|R2]).
removeop(EOpt, els:R), (el:R2, R2) if removeop(R, R2).
removeop((el:opt, els:R), (el:R2, els:R2)) if removeop(R, H2), removeop(R, R2).
surface(e_list,e_list) if true.
surface(X,[T|Rs]) if
select(T,X,R),surface(R,Rs).

append_comp((hd_dtr:Head,comp_dtrs:[],spec_dtrs:[],subj_dtr:Comp),
(Head,word,(synsem:local:cat:subj:Subj)),
(Comp,synsem:Subj)) if true,!.
append_comp((subj_dtr:Comp,comp_dtrs:Cdtrs,spec_dtrs:Sdtrs,hd_dtr:Hdtr),
(synsem:local:cat:subj:Subj),
dtrs:(comp_dtrs:Cdtrs,spec_dtrs:Sdtrs,hd_dtr:Hdtr)),
(Comp,synsem:Subj)) if true,!.
append_comp((hd_dtr:Hdtr,comp_dtrs:[Comp],spec_dtrs:Sdtrs),
dtrs:(comp_dtrs:Comp1,hd_dtr:Hdtr,spec_dtrs:Sdtrs)),
(Comp,synsem:Subj)) if true,!.
append_comp((hd_dtr:Hdtr,comp_dtrs:ResComp,spec_dtrs:Sdtrs),
dtrs:(comp_dtrs:Comp1,hd_dtr:Hdtr,spec_dtrs:Sdtrs)),
Comp) if
append([Comp],Comp1,ResComp).

append_spec((hd_dtr:Head,comp_dtrs:[],spec_dtrs:[Adjunct]),
(Head,word), Adjunct) if true,!.
append_spec((hd_dtr:Hdtr,comp_dtrs:Cdtrs,subj_dtr:SUdtr,spec_dtrs:ResSpec),
dtrs:(hd_dtr:Hdtr,comp_dtrs:Cdtrs,subj_dtr:SUdtr,spec_dtrs:Spec1),
Spec) if
append([Spec],Spec1,ResSpec).

%=====================================================================%
% Clauses applying the constraints of the Lexical Rules....
%=====================================================================%

apply_case(
(word, synsem:(local:(cat:(head:(common,
case:nom, agr:(num:Num,per:third),
mod:Mod, rel:(Rel,minus),
pred:(Pred,minus),
n,ind:NInd, poss:Poss),
subcat:Subcat, adjuncts:Adjuncts,
subj:Subj)),
cont:Cont, conx:Conx), nonlocal:Nonlocal), qstore:Qs),
(word, synsem:(local:(cat:(head:(common,
case:Case, agr:(num:Num,per:third),
mod:Mod, rel:Rel, pred:Pred,
n,ind:NInd, poss:Poss),
subj:Subj, adjuncts:Adjuncts,
subcat:Subcat)),
cont:Cont, conx:Conx),
nonlocal:Nonlocal), qstore:Qs) , Case , ChMod ) if check_case_mod(Poss,ChMod).

check_case_mod(none,a) if true.
check_case_mod(by:per:first,a) if true.
check_case_mod(by:per:second,a) if true.
check_case_mod(by:per:third,b) if true.

apply_poss(
  (word,
   synsem:(local:(cat:(head:(common,
       case:nom,
       agr:(Agr,per:third),
       mod:Mod,
       rel:(Rel,minus),
       pred:(Pred,minus),
       poss:none),
       subj:Subj,
       subcat:Subcat),
       cont:(index:Ind,restr:(el:EL)),
       conx:Conx),
       nonlocal:Nonlocal),
   qstore:Qs) , By ) if
   appends([@obl((Subj,@np((case:gen,agr:By),Ind2))],Subcat,Subcat2).

%---------------------------------------------------------------------
apply_copula(
  (word,
   synsem:(local:(cat:(head:(common,
       case:nom,
       agr:Agr,
       mod:Mod,
       rel:Rel,
       pred:Pred,
       poss:Poss),
       subj:Subj,
       subcat:Subcat),
       cont:(C1,restr:Restr),
       conx:Conx),
       nonlocal:Nonlocal),
   qstore:Qs) , (noun,1,
   synsem:(local:(cat:(head:(common,
       case:nom,
       agr:Agr),
       mod:null),
       subj:Subj,
   qstore:Qs) , By ) if
   appends([@obl((Subj,@np((case:gen,agr:By),Ind2))],Subcat,Subcat2).

%====================================================================
apply_adj2noun(  
  (word,  
  synsem:(local:(cat:(head:{(qualitative_adj:rel:plus),  
    mod:{modsyn:Mod,modadj:Modadj}),  
    subj:Subj,  
    subcat:Subcat),  
    cont:(index:Ind,Cont),  
    conx:Conx),  
    nonlocal:Nonlocal),  
    qstore:Qs),  
  (noun_l,  
  synsem:{Mod,local:(cat:(head:{mod:null,  
    case:nom,  
    agr:{per:third,num:sing},  
    rel:minus,  
    pred:minus,  
    n_ind:Ind,  
    poss:none),  
    subj:Subj,  
    subcat:Subcat),  
    cont:Cont,  
    conx:Conx),  
    nonlocal:Nonlocal},  
    qstore:Qs)) if true.

A.5 Lexicon

kırmızı --->
(qualitative_l,phon:[k,i,r,m,i,z,i]],
synsem:{local:(cat:(head:{countable:plus,gradable:plus,  
  mod:modsyn:{local:(cat:head:n_ind:Ind),  
    cont:(index:Ind))},  
    subcat:[],  
    subj:null),
ben --->
(word,phon: [['b', 'e', 'n']],
    synsem: local: cont: (npro,
                index: (agr, Ind, per: first, num: sing),
                restr: (el: (nucleus: (name: ['d', 'o', 'o', 'r'], inst: Ind),
                                quants: []), els: []))
).

kapı --->
( @common_noun,
    phon: [['k', 'a', 'p', 'ı']],
    synsem: local: cont: (npro,
                index: (agr, Ind, per: third, num: sing),
                restr: (el: (nucleus: (name: ['d', 'o', 'o', 'r'], inst: Ind),
                                quants: []), els: []))
).

ev --->
( @common_noun,
    phon: [['e', 'v']],
    synsem: local: cont: (npro,
                index: (agr, Ind, per: third, num: sing),
                restr: (el: (nucleus: (name: ['h', 'o', 'u', 's', 'e'], inst: Ind),
                                quants: []), els: []))
).

gitti --->
( finite_l,
    phon: [['g', 'i', 't', 't', 'ı']],
    synsem: local: (cat: (head: (finite, mod: null,
       tense: past,
       vagr: (agr, (per: third, num: sing)))),
       subcat: @obl({@subj, @np((agr, agr, case: nom), SInd)},
            @opt(@np(case: abl, FInd)),
            @opt(@np(case: dat, TInd))),
       subj: Subj
    )
    cont: (quants: [], nucleus: (name: ['g', 'o'],
          args: [[@argname: ['g', 'o', 'e', 'r, arg: SInd],
                @argname: [t, o], arg: TInd],
                @argname: [f, r, o, n], arg: FInd])
  )
)
ouden -->
(subj_rel, phon: [g,i,d,e,n], synsem:(local:(cat:(head:(subj_rel, vcase:nom)), subcat: obl({Subj, mp(case:nom,SInd)}), opt(mp(case:abl,FInd)), opt(mp(case:dat,TInd)), subj:Subj )), cont:restr:(el:{quant:[], nucleus:{name:[g,o], args:[{argname:[g,o,e,r], arg:SInd}, {argname:[t,o], arg:TInd}, {argname:[f,r,o,n], arg:FInd}]}, els:[])) )),

gelidigi -->
(obj_rel, phon: [g,e,l,d,i,˘ g,i], synsem:(local:(cat:(head:(obj_rel, tense:past, vagr:(Agr,(per:third,num:sing)))), subcat: obl({Subj, mp((agr:Agr, case:gen),SInd)}), opt(mp(case:abl,FInd)), opt(mp(case:dat,TInd)), subj:Subj )), cont:restr:(el:{quant:[], nucleus:{name:[g,o], args:[{argname:[c,o,m,e,r], arg:SInd}, {argname:[t,o], arg:TInd}, {argname:[f,r,o,n], arg:FInd}]}, els:[])) )),
s¨ oy¨ uyor -->
(finite, phon: [s,¨ o,y,l,u,y,o,r], synsem:(local:(cat:(head:(finite, tense:past, mod:null, vagr:(Agr,(per:third,num:sing)))), subcat: obl({Subj, mp((agr:Agr, case:nom),SInd)}), opt(mp(case:abl,FInd)), opt(mp(case:dat,TInd)), subj:Subj )), cont:quant:[], nucleus:{name:[t,e,l,l], args:[{argname:[t,e,l,l,e,r], arg:SInd}, {argname:[t,o], arg:TInd}, {argname:[w,h,a,t], arg:Spsoa}]}) )),

empty 
(word, phon: [p,r,o], synsem:(local:(cat:(head:(pronoun, case:(nom;gen), agr:Agr, mod:null, n_ind:Agr, pred:minus, ...

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A.6 Lexical Rules

%=================================================================================================
% % 0(#)T.lex_rule       Rev:1.9     1/7/96
% %=================================================================================================
% Lexical Rules
%--
% Morphological clauses used in lexical rules...
%---

back(a).
back(i).
back(o).
back(u).
kalın_hece([X]) :- back(X),!.
kalın_hece([X,_,_]) :- back(X).

front(e).
front(i).
front(ı).
front(o).
ince_hece([X]) :- front(X),!.
ince_hece([X,_,_]) :- front(X).
wovel(X) :- front(X),!.
wovel(X) :- back(X).

backrounded(o).
backrounded(u).
b_r_hece([X]) :- backrounded(X),!.
b_r_hece([X,_,_]) :- backrounded(X).

frontrounded(o).
frontrounded(i).
f_r_hece([X]) :- frontrounded(X),!.
f_r_hece([X,_,_]) :- frontrounded(X).

backunrounded(a).
backunrounded(ı).
b_u_hece([X]) :- backunrounded(X),!.
b_u_hece([X,_,_]) :- backunrounded(X).

fronturnrounded(e).
fronturnrounded(ı).
f_u_hece([X]) :- fronturnrounded(X),!.
f_u_hece([X,_,_]) :- fronturnrounded(X).

yunusa(p,b).
yumusa(¢,c).
yumusa(t,d).
yumusa(k,˘ g).

kal_yum([X,Y],Yum) :- back(X),yumusa(Y,Yum).
ince_yum([X,Y],Yum) :- front(X),yumusa(Y,Yum).
f_u_yum([X,Y],Yum) :- frontunrounded(X),yumusa(Y,Yum).
b_u_yum([X,Y],Yum) :- backunrounded(X),yumusa(Y,Yum).
f_r_yum([X,Y],Yum) :- frontrounded(X),yumusa(Y,Yum).
b_r_yum([X,Y],Yum) :- backrounded(X),yumusa(Y,Yum).

%=====================================================================
% Lexical rules...
%=====================================================================
:-lex_rule_depth(4).

plural lex_rule
Cat1 $$\Rightarrow$$ Cat2
if apply_plural((Cat1,phon:[Phon]),(Cat2,phon:[Phon2])),
append(Phon,[,p,l,u],Phon2)
morphs
(X,L2) becomes (X,L2,lar) when kalin_hece(L2),
(X,L2) becomes (X,L2,ler) when ince_hece(L2).

%--
accusative_a lex_rule
Cat1 $$\Rightarrow$$ Cat2
if apply_case((Cat1,phon:[Phon]),(Cat2,phon:[Phon2]),obj,a),
append(Phon,[,o,b,j],Phon2)
morphs
(X,[L]) becomes (X,[L],yı) when backunrounded(L),
(X,[L]) becomes (X,[L],yi) when frontunrounded(L),
(X,[L]) becomes (X,[L],yu) when backrounded(L),
(X,[L]) becomes (X,[L],yu) when frontrounded(L),
(X,[L1,L2]) becomes (X,[L1,Y],[i]) when b_u_yum([L1,L2],Y),
(X,[L1,L2]) becomes (X,[L1,Y],[ı]) when f_u_yum([L1,L2],Y),
(X,[L1,L2]) becomes (X,[L1,Y],[u]) when b_r_yum([L1,L2],Y),
(X,[L1,L2]) becomes (X,[L1,Y],[¨ u]) when f_r_yum([L1,L2],Y),
(X,L2) becomes (X,L2,ı) when b_u_hece(L2),
(X,L2) becomes (X,L2,i) when f_u_hece(L2),
(X,L2) becomes (X,L2,u) when b_r_hece(L2),
(X,L2) becomes (X,L2,¨ u) when f_r_hece(L2).

accusative_b lex_rule
Cat1 $$\Rightarrow$$ Cat2
if apply_case((Cat1,phon:[Phon]),(Cat2,phon:[Phon2]),obj,b),
append(Phon,[,o,b,j],Phon2)
morphs
(X,[L]) becomes (X,[L],nı) when backunrounded(L),
(X,[L]) becomes (X,[L],ni) when frontunrounded(L),
(X,[L]) becomes (X,[L],nu) when backrounded(L),
(X,[L]) becomes (X,[L],nu) when frontrounded(L).

%--
possessive_3_s lex_rule
Cat1 $$\Rightarrow$$ Cat2
if apply_poss((Cat1,phon:[Phon]),(Cat2,phon:[Phon2]),(num:sing,per:third)),
append(Phon,[t,s,g],Phon2)
morphs

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(X,[L]) becomes (X,[L],și) when backunrounded(L),
(X,[L]) becomes (X,[L],si) when frontunrounded(L),
(X,[L]) becomes (X,[L],su) when backrounded(L),
(X,[L,L2]) becomes (X,L1,[Y],[ı]) when b_u_yum([L1,L2],Y),
(X,[L,L2]) becomes (X,L1,[Y],[ı]) when f_u_yum([L1,L2],Y),
(X,[L,L2]) becomes (X,L1,[Y],[u]) when b_r_yum([L1,L2],Y),
(X,[L,L2]) becomes (X,L1,[Y],[¨u]) when f_r_yum([L1,L2],Y),
(X,L2) becomes (X,L2,ı) when b_u_hece(L2),
(X,L2) becomes (X,L2,i) when f_u_hece(L2),
(X,L2) becomes (X,L2,u) when b_r_hece(L2),
(X,L2) becomes (X,L2,¨u) when f_r_hece(L2).

%--
obj_rel_to_compl lex_rule
(obj_rel_l,
 phon:[Phon],
synsem:(local:(cat:(head:(obj_rel,
   vcase:nom,
   neg:Neg,
   vagr:Agr,
   n_inc:N_Inc,
   tense:Tense
   ),
   subj:Subj,
   adjuncts:Adj,
   subcat:Subcat),
   cont:restr:el:Rest,
   conx:Conx)) **>
(complement_l,
 phon:[Phon],
synsem:(local:(cat:(head:(complemented,
   vcase:nom,
   neg:Neg,
   mod:null,
   vagr:Agr,
   n_inc:N_Inc,
   tense:Tense
   ),
   subj:Subj,
   adjuncts:Adj,
   subcat:Subcat),
   cont:Rest,
   conx:Conx),
   nonlocal:tobind:slash:null))
)morphs
  X becomes X.

%--
relativizer lex_rule
Cat1 ==> Cat2
if apply_reltvzr((Cat1,phon:[Phon]),(Cat2,phon:[Phon2])),
  append(Phon,[r,1,t],Phon2)
morphs
  (X) becomes (X,ki).

%--
copula1_s lex_rule
Cat1 ==> Cat2
if apply_copula((Cat1,phon:[Phon]),(Cat2,phon:[Phon2]),(num:sing,per:first)),

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append(Phon,[,c,o,p],Phon2)
morphs
(X,[L2]) becomes (X,[L2],yım) when backunrounded([L2]), (X,[L2]) becomes (X,[L2],yım) when frontunrounded([L2]),
(X,[L2]) becomes (X,[L2],yım) when backrounded([L2]), (X,[L2]) becomes (X,[L2],yım) when frontrounded([L2]),
(X,[L1,L2]) becomes (X,[L1],L2),yım) when b_u_yum([L1,L2],Y), (X,[L1,L2]) becomes (X,[L1],L2),yım) when f_u_yum([L1,L2],Y),
(X,[L1,L2]) becomes (X,[L1],[Y],[i,m]) when b_u_yum([L1,L2],Y), (X,[L1,L2]) becomes (X,[L1],[Y],[i,m]) when f_u_yum([L1,L2],Y),
(X,[L2]) becomes (X,[L2],yım) when b_r_yum([L2],Y), (X,[L2]) becomes (X,[L2],yım) when f_r_yum([L2],Y),
(X,[L2]) becomes (X,[L2],yım) when b_r_yum([L2],Y), (X,[L2]) becomes (X,[L2],yım) when f_r_yum([L2],Y),
(X,L2) becomes (X,L2,im) when b_u_hece(L2), (X,L2) becomes (X,L2,im) when f_u_hece(L2),
(X,L2) becomes (X,L2,im) when b_r_hece(L2), (X,L2) becomes (X,L2,im) when f_r_hece(L2).

%--
copula3_s lex_rule
Cat1 >>> Cat2
if apply_copula((Cat1,phon:[Phon]),(Cat2,phon:[Phon2]),(num:sing,per:third)),
append(Phon,[,c,o,p],Phon2)
morphs
(X,[L1,L2]) becomes (X,[L1,L2],tir) when b_u_yum([L1,L2],Y), (X,[L1,L2]) becomes (X,[L1,L2],tir) when f_u_yum([L1,L2],Y),
(X,[L1,L2]) becomes (X,[L1,L2],tir) when b_r_yum([L1,L2],Y), (X,[L1,L2]) becomes (X,[L1,L2],tir) when f_r_yum([L1,L2],Y),
(X,L2) becomes (X,L2,dır) when b_u_hece(L2), (X,L2) becomes (X,L2,dır) when f_u_hece(L2),
(X,L2) becomes (X,L2,dır) when b_r_hece(L2), (X,L2) becomes (X,L2,dır) when f_r_hece(L2).

adj_promotion lex_rule
Cat1 >>> Cat2
if apply_adj2noun((Cat1,phon:[Phon]),(Cat2,phon:[Phon2])),
append(Phon,[,a],Phon2)
morphs
X becomes X.

%--
non_ref_object lex_rule
(verb_l,
 phon:[PhonV],
synsem:(local:(cat:(head:HeadV,
 subj:SubjV,
 adjuncts:AdjV,
 subcat:SubcatV),
 cont:ContV,
 conx:ConxV),
 nonlocal:NonlocalV))

(verb_l,
 phon:[PhonV],
synsem:(local:(cat:(head:HeadV,
 subj:SubjV,
 adjuncts:AdjV,
 subcat:[ SubcatV,
 @obl((local:(cat:(head:(common,
 case:nom,

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if selectlast(
  (local:(cat:(head:(common,
    case:obj,
    agr:AgrN,
    mod:ModN,
    rel:(RelN),
    pred:(PredN),
    n_ind:NIndN,
    poss:PossN),
    subcat:SubcatN,
    adjuncts:(AdjunctsN,
      non_ref:plus),
    subj:SubjN),
    cont:ContN,
    conx:ConxN),
    nonlocal:NonlocalN)),
  ),
  cont:ContV,
  conx:ConxV),
  nonlocal:NonlocalV)
)
}

if selectlast(
  (local:(cat:(head:(common,
    case:obj,
    agr:AgrN,
    mod:ModN,
    rel:(RelN),
    pred:(PredN),
    n_ind:NIndN,
    poss:PossN),
    subcat:SubcatN,
    adjuncts:AdjunctsN,
    subj:SubjN),
    cont:ContN,
    conx:ConxN),
    nonlocal:NonlocalN),
  (local:(cat:(head:(common,
    case:obj,
    agr:AgrN,
    mod:ModN,
    rel:(RelN),
    pred:(PredN),
    n_ind:NIndN,
    poss:PossN),
    subcat:SubcatN,
    adjuncts:(AdjunctsN,
      non_ref:plus),
    subj:SubjN),
    cont:ContN,
    conx:ConxN),
    nonlocal:NonlocalN),
  )
)
}

morphs
X becomes X.