Syntax

- Syntax is the area of linguistics which studies the structure of natural languages.
- The underlying assumption is that languages have *structure*: not all sequences of words over the given alphabet are valid; and when a sequence of words is valid (*grammatical*), a natural structure can be induced on it.
- It is useful to think of this structure as a *tree* (although we shall see other structures later).
- Given a sentence in some language, not all possible trees define the structure that native speakers of the language intuitively recognize.

Natural languages have structure

Example:

- Even though I klaw through the valley of the shadow of death, I will raef no evil
- Even though I walk through the valley of the shadow of death, I will fear no evil
- Even though I ordinary through the valley of the shadow of death, I will slowly no evil
- Even though I slowly gaze through the valley of the shadow of death, I will unsurprisingly do no evil
- Even though I walk through the valley of the shadow of death, I will fear no evil

Natural languages have structure

- Natural languages are *infinite*:
  - The water put out the fire
  - The water put out the fire, that burned the stick
  - The water put out the fire, that burned the stick, that hit the dog
  - The water put out the fire, that burned the stick, that hit the dog, that chased the cat
- But it is possible to characterize an infinite set with finite expressions.

Natural languages have structure

- Intuitively, words combine to form *phrases*:

  (Jacob (served (seven years) (for Rachel))), and (they seemed to him but a few days (because of ((the love) (he had for her))))).

- but not:

  (Jacob served) seven (years for) Rachel, and they (seemed to) him but (a few days because) of the love he had for her.

- Phrases which correspond to our native speaker intuitions are called *constituents*.

Determining constituents

- The criteria for defining constituents are sometimes fuzzy.
- The main criterion is equivalent distribution: if two word sequences are mutually interchangeable in every context, preserving grammaticality, then both are constituents and both have the same grammatical category.

Determining constituents

Certain grammatical operations apply only to constituents:

- Topicalization:

  For Rachel, Jacob served seven years

- Cleft:

  It was for Rachel that Jacob served seven years

- Interjection:

  Jacob served seven years, the Bible tells us, for Rachel

Determining constituents

Certain grammatical operations apply only to constituents:

- Question formation:

  How long did Jacob serve for Rachel?

- Coordination:

  Jacob served seven years for Rachel, and they seemed to him but a few days

- Anaphors refer to constituents:

  ... and for Leah, too

Types of constituents

- Inducing structure on a grammatical string is done recursively, starting with the words. To this end, words are classified into *categories* according to their distribution.
- In many languages, words are classified into *substantial* and *functional* categories.

  substantial: table, dogs, walked, purple, quickly
  functional: the, in, or

- Another classification is according to whether the category is *open* or *close*.

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Types of constituents

Word categories (parts of speech):

N	Noun	table, dogs, justice, oak
V	Verb	run, climb, love, ignore
ADJ	Adjective	green, fast, mild, imaginary
ADV	Adverb	quickly, well, alone
P	Preposition	in, to, of, after, in spite of
D	Determiner	a, the, all, some
Pron	Pronoun	I, you, she, theirs, our
PropN	Proper Noun	John, IBM, University of Haifa

Constituents

- Phrases are projections of word categories:
- Noun phrases are headed by nouns:
  table → round table → the round table → the round table in the corner
  → the round table in the corner that we sat at yesterday
- Verb phrases are headed by verbs:
  climbed → climbed a tree → climbed a tree yesterday
  → recklessly climbed a tree yesterday
- Adjectival phrases are headed by adjectives:
  high → rather high / higher than me / high as a tree

Constituents

- Phrases consist of a *head* and additional *complements* and *adjuncts*. The phrase is a *projection* of its head.
- Complements are required by the head, and are mandatory. Adjuncts are optional, and can be iterated.
- Example: John drinks a cup of milk every morning

Syntactic phenomena

- Agreement
- Subcategorization
- Case assignment
- Unbounded dependencies
- Subject/object control
- Coordination

A gradual description of language fragments

- E_0 is a small fragment of English consisting of very simple sentences, constructed with only intransitive and transitive (but no ditransitive) verbs, common nouns, proper names, pronouns and determiners.
- Typical sentences are:

  A sheep drinks
  Rachel herds the sheep
  Jacob loves her

A gradual description of language fragments

- Similar strings are not E_0- (and, hence, English-) sentences:

  $*$*Rachel feed the sheep*
  $*$*Rachel feeds herds the sheep*
  $*$*The shepherds feeds the sheep*
  $*$*Rachel feeds*
  $*$*Jacob loves she*
  $*$*Jacob loves Rachel she*
  $*$*Them herd the sheep*

A gradual description of language fragments

There are constraints on the combination of phrases in E_0:

- The subject and the predicate must *agree* on number and person: if the subject is a third person singular, so must the verb be.
- Objects complement only – and all – the *transitive* verbs.
- When a pronoun is used, it is in the *nominative* case if it is in the subject position, and in the *accusative* case if it is an object.

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Subcategorization

- E_1 is a fragment of English, based on E_0, in which verbs are classified to subclasses according to the complements they "require":

  Laban gave Jacob his daughter
  Jacob promised Laban to marry Leah
  Laban persuaded Jacob to promise him to marry Leah

- Similar strings that violate this constraint are:

  $*$*Rachel feeds Jacob the sheep*
  $*$*Jacob saw to marry Leah*

Control

- With the addition of infinitival complements in E_1, E_2 can capture constraints of argument *control* in English:

  Jacob promised Laban to work seven years
  Laban persuaded Jacob to work seven years

Long distance dependencies

- Another extension of E_1 is E_3, typical sentences of which are:

  The shepherd wondered whom Jacob loved $\smile$.
  The shepherd wondered whom Laban thought Jacob loved $\smile$.
  The shepherd wondered whom Laban thought Rachel claimed Jacob loved $\smile$.

- An attempt to replace the gap with an explicit noun phrase results in ungrammaticality:

  $*$*The shepherd wondered who Jacob loved Rachel.*

Long distance dependencies

- The gap need not be in the object position:

  Jacob wondered who ◡ loved Leah
  Jacob wondered who Laban believed ◡ loved Leah

- Again, an explicit noun phrase filling the gap results in ungrammaticality:

  Jacob wondered who the shepherd loved Leah

Long distance dependencies

- More than one gap may be present in a sentence (and, hence, more than one filler):

  This is the well which Jacob is likely to ◡ draw water from ◡
  It was Leah that Jacob worked for ◡ without loving ◡

- In some languages (e.g., Norwegian) there is no (principled) bound on the number of gaps that can occur in a single clause.

Long distance dependencies

- There are other fragments of English in which long distance dependencies are manifested in other forms.
- *Topicalization*:

  Rachel, Jacob loved ◡

  Rachel, every shepherd knew Jacob loved ◡

- Another example is *interrogative sentences*:

  Who did Jacob love ◡*?*
  Who did Laban believe Jacob loved ◡*?*

Coordination

- *Coordination* is accounted for in the language fragment E_4:

  No man lift up his [hand] or [foot] in all the land of Egypt
  Jacob saw [Rachel] and [the sheep of Laban]
  Jacob [went on his journey] and [came to the land of the people of the east]
  Jacob [went near], and [rolled the stone from the well's mouth], and [watered the flock of Laban his mother's brother].
  every [speckled] and [spotted] sheep
  Leah was [tender eyed] but [not beautiful]
  [Leah had four sons], but [Rachel was barren]
  She said to Jacob, "[Give me children], or [I shall die]!"

The goals of syntactic analysis

- Given a natural language sentence, syntactic analysis provides a structural description of the sentence.
- To do so, one must have a *model* of the structure of the language.
- Syntax is concerned with a formulation of the structure of natural languages. An example of a syntactic formalism is *context-free grammars*.
- In CFGs, the structure of sentences is modeled by *derivation trees*.