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Readings:

- Portner, P. (2005). What is meaning: Fundamentals of formal semantics. (Ch. 1.3)
- Winter, Y. (2016). Elements of formal semantics: An introduction to the mathematical theory of meaning in natural language. Edinburgh University Press. (Ch. 1)

Credits to:

- Masha Esipova, Nadine Theiler & Lucas Champollion (NYU) and Ivano Ciardelli (LMU, Munich)

1 What is Meaning? Fundamentals of Formal Semantics

SEMANTICS is the study of MEANING in LANGUAGE

- Phonetics and phonology study linguistic sounds.
- Morphology studies words and their structure.
- Syntax studies the structure of sentences.
- Lexical semantics studies the meaning of and relationships between individual words
- **Truth-conditional semantics** (a.k.a. formal semantics) studies the meaning of sentences.
- **Pragmatics** studies the way in which context influences meaning.

The central question of semantics: what is the meaning and how does a sentence end up associated with meaning?

1.1 Examples

(1) The two-man U.S.-Russian crew of a Soyuz spacecraft en route to the International Space Station survived a dramatic emergency landing in Kazakhstan on Thursday when their rocket failed in mid-air.(from Reuters, 11 Oct 2018)

- This piece does not just cause you to think of a spacecraft. It leads you to think of a complex and very specific series of events involving various participants.
- If you trust the source of the sentence, and thus accept (1) as a true description of the world, the content of (1) will be integrated into your worldview. This can then be used to interpret further information, make predictions, and guide action.

- E.g., it may cause you to buy SpaceX stocks in the expectation that SpaceX will become a competitor in transporting astronauts to the ISS.

Language can be used to cause humans to think ideas that they have never thought before. It can be used not just to convey information, as in (1) but also:

- request information
  (2) Where did the spacecraft land?
- to impart instructions
  (3) Bring water and salt to boil in a large saucepan; pour polenta slowly into boiling water, whisking constantly until all polenta is stirred in [. . .]
- bring new concepts into existence
  (4) I have called this principle, by which each slight variation, if useful, is preserved, by the term of Natural Selection. (Darwin, On the origin of species)
- suggest ideas
  (5) The keys might be in the car.
- make proposals
  (6) Shall we go for a walk?
- and much more (express feelings or opinions, make threats and promises, praise, insult, congratulate, . . .).

How is this achieved? How is it that we can encode thoughts into sentences, and decode sentences produced by others?

Frege was the first to fully realize the importance of the question, and suggest the core of (what we think must be) the answer:

> It is astonishing what language accomplishes. With a few syllables it expresses a countless number of thoughts, and even for a thought grasped for the first time by a human it provides a clothing in which it can be recognized by another to whom it is entirely new. This would not be possible if we could not distinguish parts in the thought that correspond to parts of the sentence, so that the construction of the sentence can be taken to mirror the construction of the thought [. . .]
>
> If we thus view thoughts as composed of simple parts and take these, in turn, to correspond to simple sentence-parts, we can understand how a few sentence-parts can go to make up a great multitude of sentences to which, in turn, there correspond a great multitude of thoughts. The question now arises how the construction of the thought proceeds, and by what means the parts are put together [. . .] (Frege, Logical Investigations)

Summary so far:

- meanings are composed from parts which correspond to sentence parts;
- the construction of the sentence mirrors the construction of its meaning;
- by combining sentence parts in infinitely many different ways we can thus build an infinite number of corresponding meanings.

Compositionality principle: the meaning of a complex expression is determined by the meanings of its parts (constituent expressions) and the rules used to combine them.

We understand the spacecraft sentence in (1) because we understand the words that occur in it, and we understand the grammar of the sentence.

A natural language comes with:

- a lexicon, specifying words and corresponding meanings;
- a grammar, specifying syntactic rules to assemble words into sentences, and corresponding semantic rules to combine the meanings of words to yield the meaning of the sentence.

Human language is a discrete combinatorial system: infinitely many signals are obtained by combining a finite number of basic blocks in infinitely many different ways. This discrete combinatorial structure seems to be the key feature of human language.

The gist of compositional semantics

- How do we get to a sentence's truth conditions from the meanings of its parts? This is the main question of compositional semantics.
- For example, we know what it takes for (7a) and (7b) to be true. But how do we know it?

  (7) a. Neil giggles.
      b. Marilyn giggles.

- Both (7a) and (7b) consist of an NP (Neil and Marilyn, respectively) and a VP giggles. What do these parts mean and how do we combine them?
- Neil and Marilyn are *names*, which simply refer to the individuals thus named.
- We can think of a VP giggles as an incomplete, or an unsaturated, proposition, which we call a *predicate*. A predicate needs to combine with an *argument* (or multiple arguments) to become a *proposition*.
- In (7a) giggles is saturated by Neil, and in (7b) it is saturated by Marilyn. Depending on what the actual world is like, the sentences might be true or false, but we don't need to know if they are true or false to know their *truth conditions*.

What is formal semantics?

It is a discipline that uses the scientific method, and many formal tools from logic, to study the phenomenon of meaning composition in natural language.

We want to build mathematical models of how composition happens, capable of making predictions that can be tested.

For this we will use tools from logic, in particular:

- a formal notion of models
- a recursive definition of expressions
- a recursive definition of semantic value of expressions in a model

Showing that such an approach is possible was the ground-breaking contribution of Richard Montague (1970, 1973). After him, a logical semantics of this kind for a fragment of natural language is called a Montague grammar.

Two styles of doing formal semantics:

- **Direct interpretation**: natural language expressions are mapped directly to semantic objects in the model.
- **Indirect interpretation**: natural language expressions are translated to expressions in a formal logical language, which are then mapped to semantic objects in the model.

We will do the latter, we use an artificial logical language with a clearly defined semantics (an extension of first-order logic). We will then interpret natural language by giving:

- translations of natural language words into logical language
- rules for deriving the translation of a complex expression given the translations of its constituents and a syntactic analysis of the expression

In the end, given a sentence and a specific syntactic analysis of it, the theory will output a formula encoding the meaning of the sentence. For instance, to anticipate, we will want our step-by-step process to generate the usual translations for the following sentences:

(8) a. Alice loves Bob $\rightsquigarrow L(a, b)$
b. every professor snores $\rightsquigarrow \forall x.[P(x) \to S(x)]$
c. some professor snores $\rightsquigarrow \exists x.[P(x) \to S(x)]$

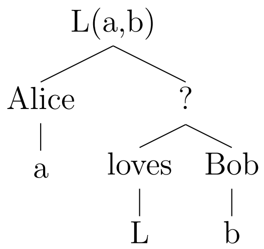
Usually, in a first-order logic course, these translations are done by hand. Now we want them to be derived in a systematic, predictable way given the meanings of the constituents and the composition rules. It is natural to assume that, in these sentences:

(9) Alice $\rightsquigarrow a$
Professor $\rightsquigarrow P$
Snores $\rightsquigarrow S$

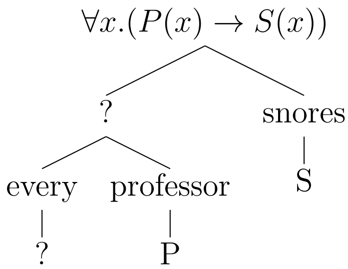
But what about every? And what about the compound predicate loves Bob? And by what rules are the meanings assembled?

In the next few classes we will be concerned with filling in the question marks in structures such as:

a.



b.



What notion of sentence meaning?

The standard answer in semantics is to follow logic: what we want to obtain are the sentence's **truth conditions**. –More explicitly: semantics should determine what things have to be like in order for the sentence to be true.

For some purposes, this view is to narrow:

- First, language contains not only declarative sentences, but also interrogative sentences and imperatives, to which the notion of truth does not naturally apply.

  (10) a. Alice went to Paris.
  b. Where did Alice go?
  c. Go to Paris!

  We thus need a separate view about the semantics of interrogatives and imperatives.

- Second, even for declaratives, we seem to need something more fine-grained for some purposes. For instance, consider:

  (11) a. Every dog is a dog.
  b. Either it rains or it doesn't rain.

  They have the same truth-conditions (always true) but intuitively different meanings (the former is about dogs, the latter about rain).

Nevertheless, truth-conditions capture important aspects of the meaning of a (declarative) sentence.

- They determine the sentence's **informative content**: by asserting a sentence, a speaker conveys the information that the state of affairs is one of those where the sentence is true.
- They allow us to characterize the relation of **entailment**: α entails β if in all circumstances where α is true, β is true as well

The truth-conditional perspective on meaning naturally suggests two ways to assess the predictions of a theory.

- **Truth-value judgments**: check whether speakers of the language judge the sentence as true/false in the circumstances predicted by the theory.

  (12) Most cats are sleeping.

  (12) is intuitively false in a situation where one cat out of ten is sleeping. We want the theory to predict this.

- **Entailment judgments**: check whether speakers judge a sentence as following from another in accordance with the theory's entailment predictions.

  (13) Many cats are sleeping.

  (13) intuitively entails that *some animals are sleeping*. We want the theory to predict this.

- However, the picture is complicated by two important linguistic phenomena which need to be factored in: (i) implicatures and ii) presuppositions $-- >$ Lecture 2