

# Natural Language Understanding (NLU) by Machines

See also the lecture notes on NLP

## Relevance to consciousness of an intelligent agent:

- NL allows us to pass on knowledge, to coordinate activities, to explain our beliefs, desires, intentions, plans, perceptions, and thinking; as such NL understanding and communication are a key part of human intelligence.
- We have “inner speech”, and are at times conscious of it, and can externalize it.
- While we presume that monkeys, dogs, etc., are conscious, they clearly don't have the same degree of self-awareness as humans, in the sense of being able to access and make use of a self-model, including episodic (autobiographical) memory, plans for the future, and world knowledge, let alone express such awareness in language.
- So, human-like consciousness in machines seems to require language (as we'll see, this is a rather common view in the philosophy and cognitive science of consciousness)

See my comments (in the lecture notes online) on McDermott's discussion of language.

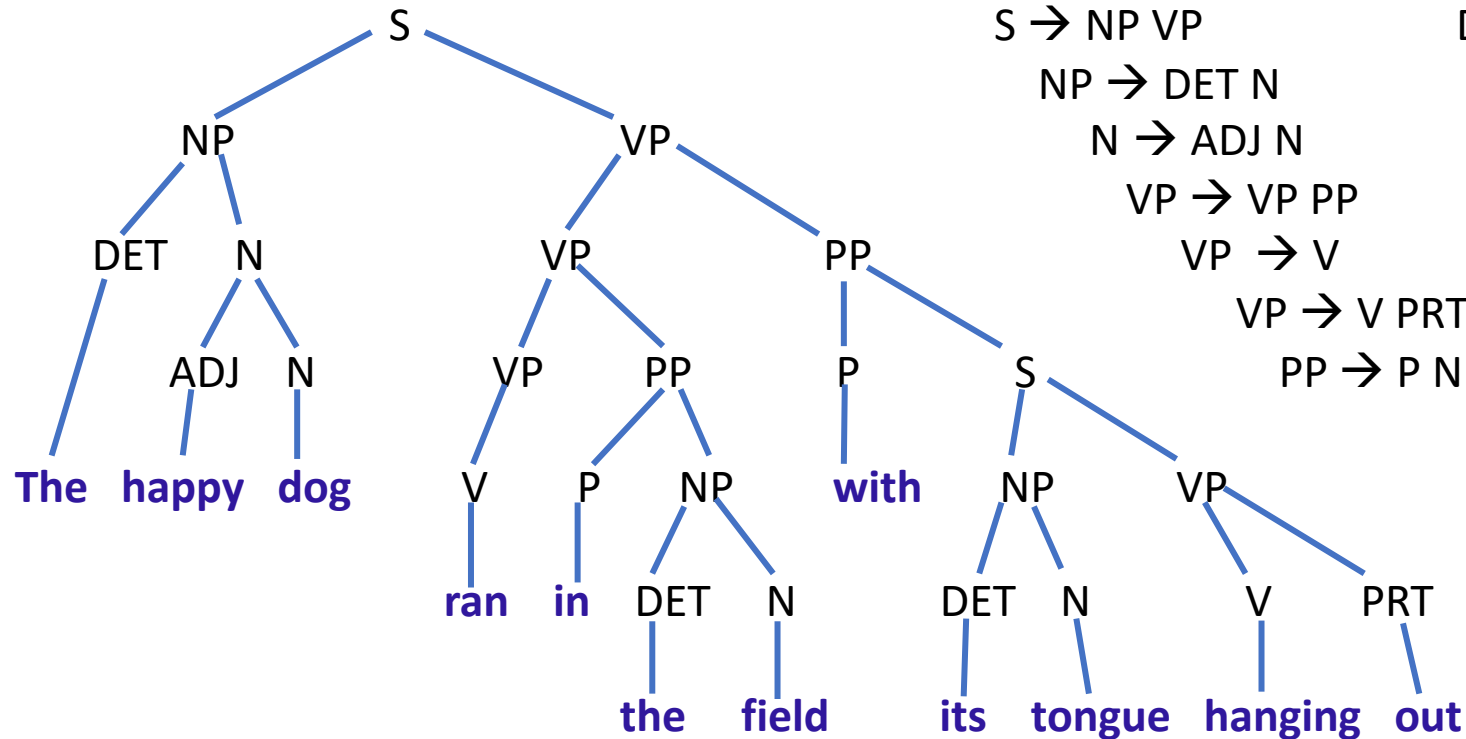
In his Ch. 2 about several subfields of AI.

- good discussion of speech signal processing (though out of date now)
- good discussion of some of the difficulties in processing language (e.g., ambiguity)
- fails to recognize the remarkable *semantic* uniformity of human languages  
( $\Leftrightarrow$  FOL, plus general quantification, modification, reification, temporal reference)

# Language structure: Context-free grammar

What ambiguities/ indexicality  
Can you see here?

Grammar & lexicon: can be used for “chart parsing”



$DET \rightarrow The \mid its$   
 $V \rightarrow ran \mid hanging$   
 $N \rightarrow dog \mid field \mid tongue$   
 etc.

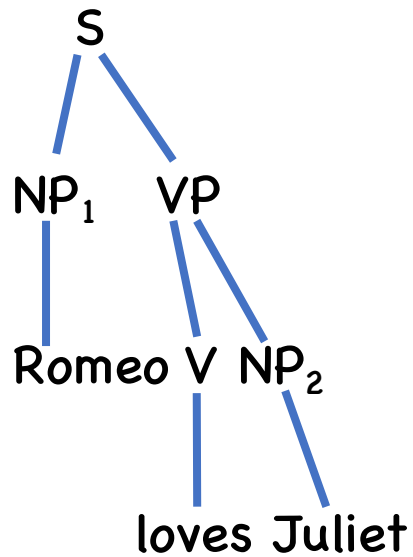


The semantic categories we find here (as in FOL, + some more)

- **entities** (the happy dog, the field, its tongue);
- **predicates** (dog, field, tongue, in, with, ran, hang-out);
- **predicate modifiers** (happy, in the field, with its tongue hanging out)

We could add more, e.g.,  
**General quantifiers**  
 (“very few dogs”),  
**reification** (“happiness”,  
 “dog breeding”, “beauty”)

## Semantic interpretation (very simple example)



### Phrasal rules:

$VP \rightarrow V NP$

$S \rightarrow NP VP$

### Lexicon:

Romeo: NP

Juliet: NP

loves: V

### Semantic (logical form) rules:

$VP' = (V' NP')$  The rules "compose" the parts,

$S' = (VP' NP')$  with lambda-conversion where possible

$NP' = \text{Romeo1}$

$NP' = \text{Juliet1}$

$V' = (\text{lambda } y (\text{lambda } x (\text{love } x y)))$

## Perform "bottom-up" semantic interpretation

- $NP_1' = \text{Romeo1}$
- $V' = (\text{lambda } y (\text{lambda } x (\text{love } x y)))$
- $NP_2' = \text{Juliet1}$
- $VP' = (V' NP_2') = (\text{lambda } y (\text{lambda } x (\text{love } x y)))(\text{Juliet1}) = (\text{lambda } x (\text{love } x \text{Juliet1}))$
- $S' = (VP' NP_1') = (\text{lambda } x (\text{love } x \text{Juliet1}))(\text{Romeo1}) = \text{love Romeo1 Juliet1}$

## These glimpses of syntax, parsing, and semantic interpretation neglect

- Resolving word sense ambiguity
- Resolving phrase structure ambiguity
- Determining referents of pronouns, names, and definite noun phrases
- Adding event or situation variables that are tacitly introduced
- Determining the temporal locations of those events or situations, and their relation to previously introduced events
- Determining the rhetorical role of the sentence in relation to the surrounding text
- Determining the speaker's (or writer's) intention in producing this sentence

Some of these problems can be handled with statistical or deep learning techniques;

but for deep understanding we require large amounts of knowledge about

- the world (physical, behavioral, mental, abstract, ...), and
- how we use language in various communicative genres (story telling, problem solving, teaching, humor, ...).

We won't have any sort of interesting, human-like self-awareness in machines till they, too, acquire all these sorts of knowledge. For a general discussion of the meaning, significance and methods of NLP, see the lecture notes with that heading on the course pages.