

# Meaning

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- So far, we have focused on the structure of language – not on what things *mean*.
- We have seen that words have different meaning, depending on the context in which they are used.
- Everyday language tasks that require some semantic processing:
  - Answering an essay question on an exam
  - Deciding what to order at a restaurant by reading a menu
  - Realizing that you've been misled
  - ...

# Meaning

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- Meaning representations – representations that link linguistic forms to knowledge of the world
- We are going to cover:
  - What is the meaning of a word
  - How can we represent the meaning
  - What formalisms can be used

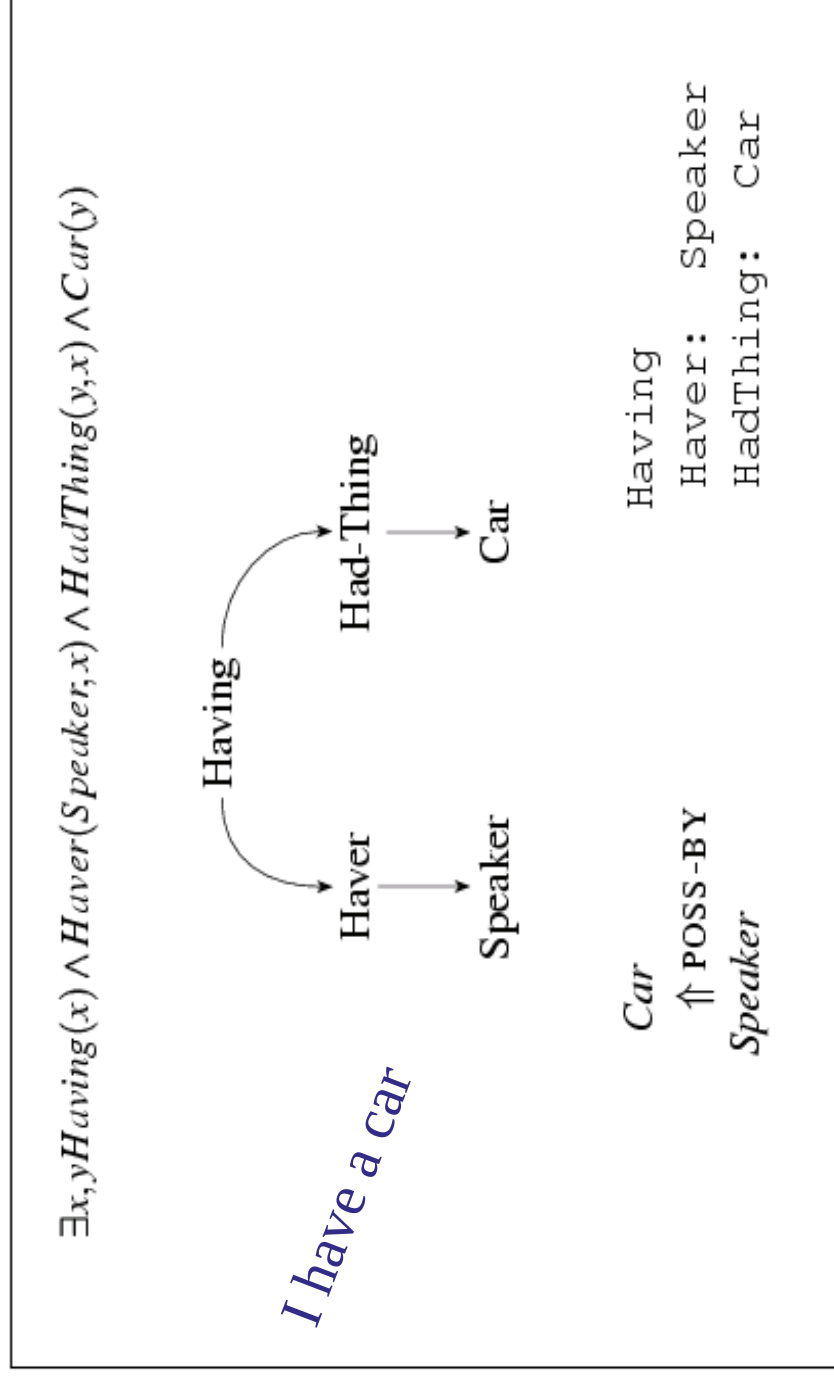
# Meaning Representations

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- Meaning representations
  - The meaning of linguistic utterances can be captured in formal structures
- Meaning representation languages
  - The frameworks that are used to specify the syntax and semantics of these representations
- Language tasks requiring some form of semantic processing
  - Answering an essay question on an exam
  - Deciding what to order at a restaurant by reading a menu
  - Learning to use a new piece of software by reading the manual
  - Following a recipe

# Meaning Representations

- Semantic analysis
  - Take linguistic inputs and construct meaning representations that are made up of the *same kind stuff* that is used to represent this kind of everyday common sense knowledge of the world



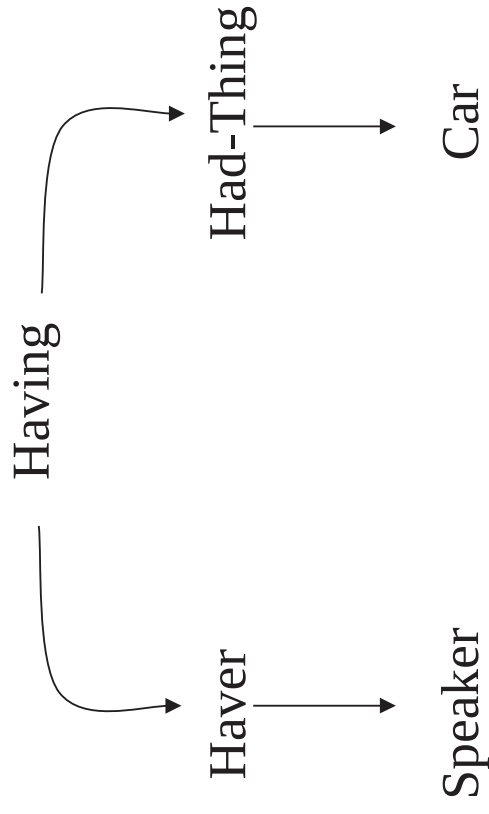
# Common Meaning Representations

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- First Order Predicate Calculus (FOPC):

$$\exists x,y \text{ Having}(x) \wedge \text{Haver}(\text{Speaker},x) \wedge \text{HadThing}(y,x) \wedge \text{Car}(y)$$

- Semantic Net:



# Common Meaning Representations

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- Conceptual Dependency Diagram:

Car  
↑ Poss-By  
Speaker

- Frame-based Representations:

Having  
Haver: Speaker  
HadThing: Car

# Common Meaning Representations

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- They all share a common foundation:
  - Meaning representation consists of structures composed of sets of symbols
  - These symbols structures correspond to objects, relations among objects, in some world being represented

# What Can Serve as a Meaning Representation?

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- Anything that serves the core practical purposes of a program that is doing semantic processing ...
  - Answer questions
    - *What is the tallest building in the world?*
  - Determining truth
    - *Is the blue block on the red block?*
  - Drawing inferences
    - *If the blue block is on the red block and the red block is on the tallest building in the world, then*
      - *the blue block is on the tallest building in the world*
- What are basic requirements of meaning representation?



# Computational Desiderata for Representations

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- Considering the issue of *why* meaning representations are needed and

*what* they should do for us

- Verifiability
- Unambiguous representations
- Canonical form
- Inference and variables
- Expressiveness

# Computational Desiderata for Representations

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- Verifiability
  - It must be possible to use the representation to determine the relationship between the meaning of a sentence and the world we know it.
  - The most straightforward way:
    - Compare, or match the representation of the meaning of an input against the representation in its **KB**, its store of information about its world.

(14.1) Does *Maharani* serve vegetarian food?  
*Serves (Maharani, VegetarianFood)*

# Computational Desiderata for Representations

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- Unambiguous representations
  - Single linguistic input can legitimately have different meaning representations assigned to them.
  - (14.2) *I wanna eat someplace that's close to ICSI.*
    - Ordinary interpretation – eat *at* nearby location
    - Godzilla's interpretation
  - Regardless of any ambiguity in the raw input, it is critical that a meaning representation language support representations that have a single unambiguous interpretation.
  - **Vagueness**, a concept closely related to ambiguity
    - (14.3) *I want to eat Italian food. (pasta? spaghetti? lasagna?)*

# Computational Desiderata for Representations

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- Canonical Form

- Inputs that mean the same thing should have the same meaning representation
  - (14.4) *Does Maharani have vegetarian food?*
  - (14.5) *Do they have vegetarian food at Maharani?*
  - (14.6) *Are vegetarian dishes served at Maharani?*
  - (14.7) *Does Maharani serve vegetarian fare?*
- Food, dish and fare – all have various word senses and some of the senses are synonymous with one another
- The process of choosing the right sense in context is called word sense disambiguation (WSD)

# Computational Desiderata for Representations

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- If a system has the ability to choose that shared sense, then an identical meaning representation can be assigned to the phrases.

# Computational Desiderata for Representations

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- Inference and Variables

- (14.10) *Can vegetarians eat at Maharani?*
- There is a common sense connection between what vegetarians eat and what vegetarian restaurants serve
- This is a fact about the world and **not fact about any particular kind of linguistic regularity**
- **Inference:** refer generically to a system's ability to draw valid conclusions based on the meaning representation of inputs and its store of background knowledge
  - *I'd like to find a restaurant where I can get vegetarian food*
  - *Serves( $x$ , VegetarianFood)*

# Computational Desiderata for Representations

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- Expressiveness

- To be useful, a meaning representation scheme must be expressive enough to handle an extremely wide range of subject matter
- Ideal situation: having a single meaning representation language that could adequately represent the meaning of any sensible natural language utterance

# Meaning Structure of Language

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- Various methods by which human language convey meaning:
  - Form-meaning associations,
  - Word-order regularities,
  - Tense systems,
  - Conjunction and quantifiers, and
  - A fundamental predicate-argument structure
- The last one has great practical influence on the nature of meaning representation languages.



# Meaning Structure of Language

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- All human language have a form of predicate-argument arrangement at the core of their semantic structure
- This predicate-argument structure asserts
  - The specific relationships hold among the various concepts underlying the constituent words and phrases that make up sentences
- This underlying structure permits the creation of a single composite meaning representation from the meanings of the various parts of an input
- One of the most important jobs of a grammar is to help organize this predicate-argument structure

# Predicate-Argument Structure

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- (14.12) I want Italian food. *NP want NP*  
(14.13) I want to spend less than five dollars. *NP want Inf-VP*  
(14.14) I want it to be close by here. *NP want NP Inf-VP*
- The syntactic frames specify the number, position, and syntactic category of the arguments that are expected to accompany a verb  
*want* in (14.12) specifies the following facts:
  - # There are two arguments to this predicate.
  - # Both arguments must be NPs.
  - # The first argument is pre-verbal and plays the role of the subject.
  - # The second argument is post-verbal and plays the role of the direct object.
- Two extensions of these frames into the semantic realm:
  - Semantic roles
  - Semantic restrictions on these roles

# Predicate-Argument Structure

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- Notion of semantic role
  - By looking at (14.12) through (14.14)
    - The pre-verbal argument plays the role of the entity doing the *wanting*, while
    - The post-verbal argument plays the role of concept that is *wanted*.
  - By noticing these regularities and labeling them accordingly, we can associate *the surface arguments of a verb* with a set of *discrete roles in its underlying semantics*
    - Verb subcategorization allows **linking** of arguments in the surface structure with the semantic roles
  - The study of roles associated with specific verbs and across classes of verbs is referred to as **thematic role** or **case role** analysis

# Predicate-Argument Structure

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- Notion of semantic restrictions
  - Only certain kinds, or *categories*, of concepts can play the role of *wanter*
  - *want* restricts the constituents appearing as first argument to, that can partake in a *wanting* role – **selection restriction**
- Predicate-argument structures other than verbs:
  - (14.15) an Italian restaurant *under* fifteen dollars  
*Under(ItalianRestaurant, \$15)*
  - (14.16) Make a *reservation* for this evening for a table for two person at 8.  
*Reservation(Hearer, Today, 8PM, 2)*

# Predicate-Argument Structure

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- Useful meaning representation language must support:
  - Variable arity predicate-argument structures.
  - The semantic labeling of arguments to predicates.
  - The statement of semantic constraints on the fillers of argument roles.

# References

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- Slides were adapted from:  
Speech and Language Processing, *Jurafsky and Martin*

