Mechanisms of Meaning
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Raquel Fernández

Institute for Logic, Language & Computation
University of Amsterdam
Plan for Today

- Last week we argued that extensional semantics is not well equipped to represent word meaning.
- Today we will look into componential or decompositional approaches, which dig deeper into word meaning by trying to break down word senses into smaller semantic units.
- We will concentrate on the Generative Lexicon, a framework introduced in the 90’s by Pustejovsky to solve some problems of classic componential approaches and to account for the phenomenon of regular polysemy (among other things).
- We will also discuss Lapata’s (2001) computational model of GL. (seealso next week)

A Cautionary Note about the Lexicon

• Broadly speaking, the lexicon is the vocabulary of a natural language (a speaker’s vocabulary).
• Last week we pointed out that there is not a one-to-one relation between word forms and word senses.
• In compositional theories, the basic expressions are assumed to be word senses not words:
  ∗ ‘bank’₁: the slope of land adjoining a body of water
  ∗ ‘bank’₂: a business establishment in which money is kept
• In its simplest form, the lexicon is thus an inventory of word senses or lexemes, plus a mapping between senses and forms.
• Different theories assume different ways of organising the lexicon.
• Today we will see that Pustejovsky calls into question this simple enumerative view of the lexicon as a list of word senses.
• We will also see (next week) that the very existence of word senses is in fact called into question by some researchers.

Back to our main question: How can word senses be characterised?

• Recall that in principle what seems to be lacking is a way of fleshing out the interpretation function of an extensional semantics theory:

\[
[dolphin] = \{x \mid x \text{ is a dolphin}\} \quad f : D \rightarrow \{1, 0\} \quad \langle e, t \rangle
\]

\[
[envy] = \{\langle x, y \rangle \mid x \text{ envies } y\} \quad f : D \rightarrow (D \rightarrow \{1, 0\}) \quad \langle e, \langle e, t \rangle \rangle
\]

• Classic approaches attempt to define word meaning in terms of necessary and sufficient conditions (\(\approx\) truth conditions).
  * Can we find a set of components/conditions/features that allow us to determine for each entity \(x\), in any possible world, whether \(Dolphin(x)\) is true or not?

• Two well-known approaches of this sort are the following:
  * Axiomatic approaches based on meaning postulates
  * Decompositional theories based on semantic primitives
Axiomatic Theories

Axiomatic theories (often also called relational theories) attempt to capture how lexical items are logically related to each other. The basic strategy consists in:

• translating every item in the lexicon into a logical predicate, and
• formulating meaning postulates (introduced by Carnap (1956)) that describe analytical truths about word senses.

\[
\begin{align*}
\text{raven} & \quad \forall x. \text{Raven}(x) \rightarrow \text{Black}(x) \quad \approx \quad [\text{Raven}] \subset [\text{Black}] \\
\text{dolphin} & \quad \forall x. \text{Dolphin}(x) \leftrightarrow \text{Mammal}(x) \land \text{Can}(x, \text{Swim}(x)) \land \ldots \\
\text{seek} & \quad \forall x \forall y. \text{Seek}(x, y) \leftrightarrow \text{Try}(x, \text{Find}(x, y)) \\
\text{kill} & \quad \forall x \forall y. \text{Kill}(x, y) \leftrightarrow \text{Cause}(x, \text{Become}(y, \neg \text{Alive}(y)))
\end{align*}
\]

Attempt to capture word senses by means of the inferences they license.

Lexical Entailment

This definitional approach in terms of logical relations brings us to the notion of *lexical entailment*.

- The notion of entailment requires truth-bearing expressions (truth is not a property of words).
- The lexical entailments of an expression $E$ in a sentence $S$ are all the entailments of $S$ that are exclusively due to $E$.

<table>
<thead>
<tr>
<th>$X$ devours $Y$</th>
<th>$X$ eats $Y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e.g. they devoured the cake)</td>
<td>$\rightarrow X$ does something</td>
</tr>
<tr>
<td>$\rightarrow X$ eats $Y$</td>
<td>$\rightarrow Y$ disappears</td>
</tr>
<tr>
<td>$\rightarrow X$ acts quickly</td>
<td>$\rightarrow X$ causes $Y$ to disappear</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

- Under this view, the sense of an expression is considered to be the set of its lexical entailments ($\approx$ its truth conditions).
Some semantic relations can be characterised in terms of lexical entailment.

- **Synonymy**
  - Two expressions A and B are synonymous if and only if they have the same lexical entailments.

- **Hyponymy and Hyperonymy**
  - A is a hyponym of B iff the lexical entailments of B are a proper subset of the lexical entailments of A.
  - B is a hyperonym of A iff A is a hyponym of B.

<table>
<thead>
<tr>
<th>Hyponyms</th>
<th>Hyperonyms</th>
</tr>
</thead>
<tbody>
<tr>
<td>car</td>
<td>vehicle</td>
</tr>
<tr>
<td>devour</td>
<td>eat</td>
</tr>
<tr>
<td>enormous</td>
<td>large</td>
</tr>
</tbody>
</table>
Componential Approaches

- Classic componential approaches break down word meanings into a set of *semantic primitives* or *features*
- Very popular during the 70’s and 80’s within the tradition of Generativist Semantics initiated by Katz & Fodor (1963).

<table>
<thead>
<tr>
<th>Word</th>
<th>Features</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dolphin</td>
<td>$[-\text{HUMAN}, +\text{ANIMATE},...]$</td>
<td>(mammal; can swim...)</td>
</tr>
<tr>
<td>Woman</td>
<td>$[+\text{HUMAN}, +\text{FEMALE}]$</td>
<td></td>
</tr>
<tr>
<td>Bachelor</td>
<td>$[+\text{HUMAN}, -\text{FEMALE}]$</td>
<td>(has never married)</td>
</tr>
</tbody>
</table>

- Features can have different statuses
  - Some play a role in syntagmatic relations such as selectional restrictions: e.g: ‘speak’ selects subjects that are $[+\text{HUMAN}]$, ‘he’ refers to entities that are $[-\text{FEMALE}]$
  - Some do not, but are assumed to be necessarily implied by the word in question: ‘uncles are male’ vs. ‘uncles are generous’
Problems...

Both definitional and componential approaches have problems and by now have been entirely superseded by more recent approaches.

• Is it at all possible to define a set of necessary and sufficient applicability conditions for word senses?
  * This has been fiercely criticised by cognitive psychologists like Rosch, who point to typicality effects
    \( \rightsquigarrow \text{we will discuss this in detail when we cover psychological theories of concepts and word meaning} \)

• Is it at all possible to define a finite, universal set of semantic primitives that can characterise all word senses?
  * What is the ontological status of these primitives?

• These approaches make explicit proposal to represent word senses, but do not address the problems posed by polysemy.

⇒ Pustejovsky’s Generative Lexicon proposes a lexical semantic framework within the componential tradition that aims at addressing this problem.
The Problem of Lexical Ambiguity

Lexical ambiguity: one phonological form, several senses.

- Homonymy or contrastive ambiguity: accidental ambiguity between unrelated senses; one sense invalidates the other:

(1) a. Mary walked along the bank of the river.
   b. ABN-AMRO is the richest bank in the city.

(2) a. Nadia’s plane taxied to the terminal.
   b. The central data storage device is served by multiple terminals.
   c. He disliked the angular planes of his cheeks and jaw.

- Polysemy or complementary ambiguity: ambiguity between semantically related senses that overlap:

(3) a. John crawled through the window.
   b. The window is closed.

(4) a. Mary painted the door.
   b. Mary walked through the door

(5) a. The bank raised its interest rates yesterday.
   b. The store is next to the newly constructed bank.

(6) a. The farm will fail unless we receive the subsidy promised.
   b. To farm this land would be both foolish and without reward.
The Problem of Lexical Ambiguity

- **Axiomatic** and classic *decompositional* approaches based on necessary and sufficient conditions do not offer the means to distinguish between contrastive and complementary ambiguity:
  * they see the lexicon as an enumeration of senses, where all ambiguities are equally contrastive.

- The main aim of Pustejovsky’s *Generative Lexicon* is to propose a lexical semantics framework that explains complementary ambiguity.

- His focus is on **Logical Polysemy**, which he defines as:
  * complementary ambiguity with overlapping and dependent senses where there is no change in lexical category.

---

(7) a. The **bank** raised its interest rates yesterday. ✓
    b. The store is next to the newly constructed **bank**.

(8) a. The **farm** will fail unless we receive the subsidy promised. ×
    b. To **farm** this land would be both foolish and without reward.
Pustejovsky observes that senses related by logical polysemy exhibit *systematic alternations*:

(9) Count/Mass alternations:  *lamb, dear, rabbit, chicken*
   
   a. The *lamb* is running in the field.
   b. John ate *lamb* for dinner.

(10) Container/Content:  *bottle, glass, box*

   a. Mary broke the *bottle*.
   b. The baby finished the *bottle*.

(11) Figure/Ground:  *door, window, fireplace*

   a. The *window* is rotting.
   b. Alex crawled through the *window*.

(12) Product/Producer:  *newspaper, Honda*

   a. The *newspaper* fired its editor.
   b. John spilled coffee on the *newspaper*.

The different senses of logically polysemous expressions seem to be somehow present simultaneously, with one of them being *focused* in a particular context.
Polysemy and the Lexicon

- How can we adequately describe contrastive and complementary sense distinctions within the lexicon?
- An option is to group polysemous senses within one lexical entry and to include a different lexical entry for each contrastive sense.
  * This is indeed the approach typically taken in dictionaries:

* But this approach is still *enumerative*...
Polysemy and the Lexicon

Polysemy raises a serious problem for the structure of the lexicon:
• ambiguity seems to be an inherent feature of word meaning
• the number of senses increases with the frequency of a word
• there is no clear upper boundary for the possible set of senses

Pustejovsky points out that words can take an infinite number of meanings in novel contexts ⇝ the creative use of words
• particularly apparent with adjectives such as ‘good’ or ‘fast’, which take novel senses depending on the nominal they modify.

...plus 36 other senses
The Inadequacy of Sense Enumeration Lexicons

• Summing up – what are the main problems faced by an enumerative view of the lexicon?

  ∗ the **systematic alternations** exhibited by logical polysemous expressions are not accounted for;
  
  ∗ even if we group the senses of polysemous expressions within a single entry, the **open-ended** and **creative** nature of the set of possible senses is not accounted for;
  
  ∗ the **permeability** of senses is not accounted for: senses may **overlap**, with a single use being able to denote two senses:

(13) John crawled through the broken *window*.

![](window.png)
The Generative Lexicon

• New lexical semantics framework within the tradition of decompositional approaches, developed by James Pustejovsky.
• It reacts against enumerative models of the lexicon to propose a generative theory of lexical meaning.
• GL attempts to propose a method for the decomposition of semantic categories that can explain the generation of interpretations in particular contexts.
• Rather than assuming a fixed set of semantic primitives and defining senses with sets of features, GL assumes:
  * structured forms or templates common to all lexical items, and
  * a set of compositional devices.
Levels of Semantic Representation in GL

1. **Argument Structure**: Information about arity and type of arguments for a predicate.

2. **Event Structure**: Information about event types for a predicate, e.g. *state*, *process*, *transition*

3. **Qualia Structure**: A representation of the defining attributes of an entity, e.g. its constitutive parts, purpose and function, mode of creation, etc.
   * constitutive / formal / telic / agentive

4. **Inheritance Structure**: Information about how a word is related to other items in the lexicon. Interface with conceptual structure.
   * fixed inheritance relations
   * projective inheritance relations

⇒ *You can find more details in Pustejovsky (1995).*
Qualia Structure

• The set of properties or events that best describes what words mean \(\rightsquigarrow\) inspired by Aristotle’s *modes of explanation or aitiae*.

• All categories express a qualia structure, but not all lexical items carry a value for each qualia role. Very important for nominals.

  * **Constitutive:** information about the constituent parts of an object.
    ‘*house*’ [\texttt{CONST} = windows, rooms...] ‘*hand*’ [\texttt{CONST} = part-of-body...]
  * **Formal:** distinctive features of objects
    ‘*house*’ [\texttt{FORMAL} = building, size \(x\), shape \(y\)...]
  * **Telic:** purpose and function
    ‘*house*’ [\texttt{TELIC} = living-in] ‘*novel*’ = [\texttt{TELIC} = reading]
  * **Agentive:** factors involved in the origin or creation of entities
    ‘*house*’ [\texttt{AGENT} = building] ‘*novel*’ = [\texttt{AGENT} = writing]
Qualia Structure and Composition

- Critical for explaining how words enter into compositional processes that generate creative senses.

(14) *arrow*
    - wooden(CONST) / large(FORMAL) / useful(TELIC) / carved(AGENT)

(15) a. Can you **shine** the **lamp** over here?  (TELIC)
    b. Mary **hung** the **lamp** in the kitchen.  (FORMAL)
    c. John **assembled** the **lamp**.  (AGENTIVE)
Generative Devices

GL aims at capturing the means by which words can assume a potentially infinite number of senses in context.

- **Type Coercion**: a predicate converts its argument to the right type, exploiting the qualia structure of its argument.

(16) a. John began **to read a book**.
    b. John began **a book**.

$\Rightarrow$ the type of ‘book’ is coerce into an event type by exploiting its **TELIC** (reading) and **AGENTIVE** (writing) roles.

- **Co-composition**: the complement co-specifies the verb; the composition of qualia structures results in a derived sense of the verb.

(17) a. John baked **the potato** / **the cake**.
    b. Mary painted **the wall** / **a picture**.

$\Rightarrow$ **change of state vs. creation** sense due to the **AGENTIVE** role of ‘cake’ (baking-act) and ‘picture’ (painting-act).
• **Selective Binding:** a predicate (typically an adjective) selects a particular quale within the noun it modifies. The composition results in a new sense for the predicate.

(18) a. a fast boat / a fast train / a fast typist
    b. a good knife / a good teacher / a good child

⇝ very productive and apparently non-compositional.
Summary

• We have briefly reviewed axiomatic (relational) and primitive-based theories of word meaning.

• A problem with these theories (pointed out by Pustejovsky) is that they have a sense enumeration view of the lexicon.

• The Generative Lexicon proposes that accounts for regular polysemy by adopting a generative view of the lexicon:
  ∗ Lexical items are decomposed into feature structures;
  ∗ A set of generative devices operates on elements of these structures to generate a potentially infinite number of word senses.

• Some problems of the framework pointed out in class:
  ∗ GL also seems to include an enumerative component, e.g. in the values taken by the qualia roles of nominals (can we determine these values a priori independently of context?)
  ∗ the role within the GL theory of “projective inheritance relations” as introduced in Pustejovsky (1991) is not clear – in fact this element is not present in later version of the theory.

⇒ If you want to learn more about GL, you should read the original literature (beyond Pustejovsky 1991). Ask me for references.
Next Week

We will discuss the following papers. Please read them before class!

  * what’s the topic under investigation?
  * what’s the approach adopted and motivation for it?
  * what’s the main proposal/contribution of the paper?
  * how is it evaluated and what are the results?

  * what are the main issues the paper addresses?
  * what are the main proposals the paper makes to address these issues?

You can find links to these papers on the course website: http://staff.science.uva.nl/~raquel/teaching/mom2010/