Semantic roles

INF5830
Fall 2013
Semantics

- Study of meaning, expressed in language
- Morphemes, words, phrases, sentences
- Lexical semantics
- Sentence semantics
- (Pragmatics: how the context affects meaning)
Semantics

- Linguistic knowledge: **meaning**
  - Meaningful:
    - Word – *flick* vs *blick*
    - Sentence – *John swims* vs *John metaphorically every*
  - Several meanings
    - Words – *fish*
    - Sentence – *John saw the man with the binoculars*
  - Same meaning
    - Word – *sofa* vs *couch*
    - Sentence – *John gave Hannah a gift* vs *John gave a gift to Hannah*
  - Participant roles: *John* is the 'giver', *Hannah* is the 'receiver'
  - Truth conditions
    - *All kings are male*
    - *Molybdenum conducts electricity*
  - Entailment
    - *Alfred murdered the librarian*
    - *The librarian is dead*
Compositional (formal) semantics

- Sentence semantics
- Richard Montague (1974): logic to represent sentence meaning
  - *John is a student* \(\text{student(john)}\)
  - *John is not a student* \(\neg\text{student(john)}\)
  - *Only John is a student* \(\forall x (\text{student}(x) \iff x=\text{John})\)
- the meaning of a sentence = its truth conditions
  - truth value: whether a sentence is true or not
  - truth conditions: the conditions which must be satisfied in the real world in order to make a sentence true
Entailment

- Semantic relation between sentences, irrespective of empirical facts
  - *The anarchist assassinated the emperor*
  - *The emperor died*

- Definition:
  - A sentence $p$ entails another sentence $q$ if it holds that when $p$ is true $q$ is true, and when $q$ is false $p$ is false
Entailment

- The entailment relation is given by linguistic structure
- The source may be lexical (assassinate – die) or syntactic (active – passive)
  - The egyptians built the pyramids
  - The pyramids were built by the egyptians
- **Paraphrase:** two sentences mutually entail each other
- **Contradiction:** two sentences contradict each other if one entails the negation of the other
  - The librarian is dead
  - The librarian is alive
Argument structure

- Verbs differ in their argument structure: number and types of arguments they can take
  - find, hit, chase
  - dance, sleep
- Argument structure of a verb is part of its meaning
- Verbs also limit semantic properties of arguments (selectional restrictions)
  - Colorless green ideas sleep furiously
Argument structure

- Components of verb meaning also influence choice of arguments
  - *John threw/tossed/kicked/flung the boy the ball*
  - *John pushed/pulled/lifted/hailed the boy the ball*
  - *Mary faxed/radioed/emailed/phoned Helen the news*
  - *Mary murmured/mumbled/muttered/shrieked Helen the news*

- verbs of motion: single quick motion vs. extended use of force
- verbs of communications: external apparatus vs. type of voice
"Equivalent" arguments have same semantic properties across syntactic realizations and different predicates

- John punched X with Y
- John punched through X with Y
- John pierced X with Y

All of the above sentences entail that

- X is a physical object
- Y is an instrument
- John is human
Mismatches between syntax and semantics

- Semantic structure does not directly mirror syntactic structure
- Many phenomena affect mapping of syntactic to semantic arguments
  - Passive
    - *The dog chased the cat*
    - *The cat was chased by the dog*
    - *The cat was chased*
  - Impersonal passives
    - *Det ble danset hele natta*
  - Dative shift
    - *John gave the book to Mary*
    - *John gave Mary the book*
Mismatches between syntax and semantics

- Many phenomena affect mapping of syntactic to semantic arguments
  - semantically empty words
    - There are three bikes on your porch
    - Three bikes are on your porch
    - John helped Mary to pack
    - John helped Mary pack
    - John knows that Mary left
    - John knows Mary left
Mismatches between syntax and semantics

- Many phenomena affect mapping of syntactic to semantic arguments
  - expletives can fill syntactic argument positions but no semantic role
    - *It is raining*
    - *It will be sunny tomorrow*
    - *It bothered Sandy that they left*
  - raising verbs have a syntactic argument position with no semantic role and relate it to another predicate
    - *John appears to dance*
    - *It appears to rain*
Mismatches between syntax and semantics

- Goal: to compute the meaning of a sentence
- Regularities in mapping between syntax and semantics
- But not a one-to-one correspondence between syntactic and semantic arguments
- So what are these semantic arguments?
Semantic (thematic) roles

- Introduced in generative grammar mid-1960s and early 70s
  [Fillmore 1968, Jackendoff 1972]
- Classify arguments of predicates into a set of participant *types*
- Describe the semantic relation between the arguments of the verb and the situation described by the verb
  - *The boy threw the red ball to the girl*
  - *The boy* – the participant responsible for the action, the “doer”
  - *the red ball* – the affected entity, “undergoer”
  - *the girl* – endpoint in a change of location
Semantic (thematic) roles

- Role types
  - AGENT: the participant that initiates the action, “volition”, capable of acting with volition
    - David cooked the meat
    - The fox jumped out of the ditch
  - PATIENT: the entity undergoing the effect of some action, often change of state
    - Edna cut back these bushes
    - The sun melted the ice
  - THEME: the entity which is moved by an action, or whose location is described
    - David passed the ball wide
    - The book is in the library
  - EXPERIENCER: the entity which is aware of the action or state described by predicate, but which is not in control
    - Edna felt ill
    - David saw the smoke
    - Fia heard the door shut
Semantic (thematic) roles

- Role types (cont.)
  - **BENEFICIARY**: the entity for whose benefit the action was performed
    - *David filled in the form for his grandmother*
    - *The baked me a cake*
  - **INSTRUMENT**: the means by which an action is performed or something comes about
    - *She cleaned the wound with an antiseptic wipe*
    - *They signed the treaty with the same pen*
  - **GOAL**: the entity towards which something moves (lit./met.)
    - *Edna handed her licence to the policeman*
    - *Fia told the joke to her friends*
  - **SOURCE**: the entity from which something moves (lit./met.)
    - *The plane came back from Kinshasa*
    - *We got the idea from a magazine*
Semantic (thematic) roles

- The initial example:
  
  *The boy*  *threw*  *the red ball*  *to the girl*

  - **AGENT**
  - **THEME**
  - **GOAL**

- Tests for semantic roles
  
  - **AGENT:** add *on purpose*
    
    - *Jon took the book on purpose*
  
  - **THEME/PATIENT**
    
    - *What happened to Y was . . .*
    
    - *What X did to Y was . . .*
Quiz

- Assign semantic roles
  - PATIENT: the entity undergoing the effect of some action
  - AGENT: the participant that initiates the action
  - INSTRUMENT: the means by which an action is performed

- John broke the window
- John broke the window with a rock
- The rock broke the window
- The window broke
- The window was broken by John
Semantic (thematic) roles

- Transformational grammar’s Θ-criterion: in a grammatical sentence every semantic role assigned by the verb must be realized by some argument and each argument may bear only one such role
- Systematic mapping between syntactic realization and semantic interpretation
- Distinction between arguments and adjuncts
Problems for semantic roles

- Assumptions:
  - Small, fixed set of roles
  - Semantic roles are atomic
  - Every argument position is assigned exactly one role
  - Every semantic role is assigned to at most one argument

- Every assumption has been contested
Definition

- Assumption: Small, fixed set of roles
- [Fillmore 1968]: 6 roles and one “default” role
  - “additional cases will surely be needed”
- What counts as evidence for positing semantic roles?
  - semantic properties/entailments?
  - syntactic alternations?
- Problematic phenomenon: symmetric stative verbs
  - *Apples resemble pears*: one or two roles?
Atomicity

- Assumption: roles are atomic
- Importance: if roles are not atomic, can introduce infinitely fine distinctions
  - Problematic phenomenon: RECIPIENT should be subtype of GOAL
    - I sent a package to the boarder/border
    - I sent the boarder/*border a package
- Grammaticality difference signals a distinction, but both cannot appear at the same time
  - I sent the boarder a package to the border
Unique assignment to arguments

- Assumption: every argument is assigned exactly one role
- Importance: consistency and completeness of analysis
  - Problematic phenomenon: predicates of commerce (buy, sell)
    - Buyer and seller are both AGENT’s and RECIPIENT’s
    - Difference: foreground/background of participants
Unique assignment of roles

- Assumption: every role is assigned to at most one argument
- Importance: consistency
  - Problematic phenomenon: complex event predicates
    - *I make laugh you*: both Agent?
Problems for semantic roles

- No real consensus about role inventory
- Difficult to formulate formal definitions of role types
  - $\Rightarrow$ more fine-grained roles, relative to “frames”
    - [Fillmore 1968, Fillmore 1977]
  - $\Rightarrow$ generalized semantic roles [Dowty 1991]
    - PROTO-AGENT, PROTO-PATIENT
Frame Semantics

[Fillmore 1977]

- “Meanings are relativized to scenes”
- “The study of meaning is the study of cognitive scenes that are created or activated by utterances”
- “whenever we understand a linguistic expression of whatever sort, we have simultaneously a background scene and a perspective on that scene”
Frame Semantics

- **Historical roots:**
  - Fillmore’s case grammar
    - case frame: small abstract scene identifying the participants of the scene and thus the arguments of predicates and sentences describing the scene
    - mental access
  - AI (Minsky)
    - frame-based knowledge representations
    - collection of information about objects and events
Frames are intended to bridge semantics and syntax by assigning semantic roles to participants.

Subject selection principles:
- AGENT → (deep) subject
- word-specific
  - \textit{I regard John as pompous}
  - \textit{John strikes me as pompous}
Frame Semantics

- Roles are relative to a frame
- Claim: meaning of a verb can be modeled by reference to its frame
- Claim: the arguments of a verb can be described by reference to relevant participants and objects
  - frame elements = semantic roles
  - NB! semantic roles are frame-specific
- Perspective
  - commercial event: buyer, seller, money, goods
    - buyer, goods: sell
    - buyer, money: spend
    - etc.
Frame Semantics

<table>
<thead>
<tr>
<th>BUYER</th>
<th>buy</th>
<th>GOODS</th>
<th>(SELLER)</th>
<th>(PRICE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>subject</td>
<td></td>
<td>object</td>
<td>from</td>
<td>for</td>
</tr>
<tr>
<td>Alfred</td>
<td>bought</td>
<td>the book</td>
<td>from Olivia</td>
<td>for 10 dollars</td>
</tr>
<tr>
<td>Alfred</td>
<td>bought</td>
<td>them</td>
<td></td>
<td>for 1 dollar</td>
</tr>
<tr>
<td>Alfred</td>
<td>bought</td>
<td>a bicycle</td>
<td>from Sarah</td>
<td></td>
</tr>
</tbody>
</table>
### Commercial transaction frame (partial):

<table>
<thead>
<tr>
<th>VERB</th>
<th>BUYER</th>
<th>GOODS</th>
<th>SELLER</th>
<th>MONEY</th>
<th>PLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>buy</td>
<td>subject</td>
<td>object</td>
<td>from</td>
<td>for</td>
<td>at</td>
</tr>
<tr>
<td>sell</td>
<td>to</td>
<td>object</td>
<td>subject</td>
<td>for</td>
<td>at</td>
</tr>
<tr>
<td>cost</td>
<td>ind.obj</td>
<td>subject</td>
<td></td>
<td>object</td>
<td>at</td>
</tr>
<tr>
<td>spend</td>
<td>subject</td>
<td>on</td>
<td></td>
<td>object</td>
<td>at</td>
</tr>
</tbody>
</table>
Frame Semantics (FrameNet)

Example: cutting frame

**Definition:**
An Agent cuts an Item into Pieces using an Instrument:

<table>
<thead>
<tr>
<th>Frame Elements (core):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent</td>
</tr>
<tr>
<td>Item</td>
</tr>
<tr>
<td>Pieces</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frame Elements (non-core):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument</td>
</tr>
<tr>
<td>Manner</td>
</tr>
<tr>
<td>Place</td>
</tr>
<tr>
<td>Purpose</td>
</tr>
</tbody>
</table>

**Lexical Units:**
carve, chop, cube, cut, dice
fillet, mince, pare, slice
Dowty’s Proto-roles

- Influential theoretical approach
- Semantic role: “set of entailments of a group of predicates with respect to one of the arguments of each”
  - $x$ murders $y$, $x$ nominates $y$, $x$ interrogates $y$
  - $\rightarrow x$ does a volitional act ($\neg$ kills)
  - $\rightarrow x$ intends it to be this kind of act ($\neg$ convince)
  - $\rightarrow x$ causes an event involving $y$ ($\neg$ looks at)
  - $\rightarrow x$ moves or changes externally ($\neg$ understands)
Prototype theory

- General theory of natural categories
- Departure from Aristotelian theory on categorization (definition)
  - necessary and sufficient conditions
  - bird: [+feathers], [+beak], [+ability to fly]
- Developed by Eleanor Rosch and colleagues in the 70’s (psychology)
  - graded notion of categories: chair more prototypical ‘furniture’ than lamp
  - showed experimental effects of prototypes
- Applied to linguistics: cognitive linguistics (Lakoff)
- Inspired Dowty’s proto-roles
Dowty’s Proto-roles

- Dowty: only two ‘thematic-role-like concepts’ for verbal predicates: the **proto-agent** and **proto-patient** role.
- Proto-roles are cluster-concepts determined for each predicate wrt a set of semantic properties
  - **Proto-agent:**
    - volition
    - sentience (and/or perception)
    - causes event
    - movement
  - **Proto-patient:**
    - change of state
    - incremental theme
    - causally affected by event
    - stationary (relative to movement by agent)
Dowty’s Proto-roles

- Focus on argument selection (linking): assignment of grammatical function to subcategorised arguments (subject, object, oblique object)
  - only semantic distinctions relevant to argument selection (in some language) are relevant
  - any semantic distinction relevant to argument selection can count toward defining a role
- Individual arguments have different “degrees of membership” in PROTO-AGENT and PROTO-PATIENT
Dowty’s Proto-roles

- Proto-roles and linking: **Argument Selection Principle (ASP)**
  - The argument with the most PROTO-AGENT properties becomes subject
  - The argument with the most PROTO-PATIENT properties becomes object
- If two compete, both will be possible (psych verbs)
  - Expriencer is sentient/perceiving
  - Stimulus causes emotional reaction
  - $x \text{ likes } y / y \text{ pleases } x$
  - $x \text{ fears } y / y \text{ frightens } x$
Quiz

▶ How does the ASP select subject/object?
▶ Properties
  ▶ Proto-agent:
    ▶ volition
    ▶ sentience (and/or perception)
    ▶ causes event
    ▶ movement
  ▶ Proto-patient:
    ▶ change of state
    ▶ incremental theme
    ▶ causally affected by event
    ▶ stationary (relative to movement by agent)

▶ John broke the window
▶ John broke the window with a rock
▶ The rock broke the window
▶ The window broke

Charles Fillmore. 1968.

Charles Fillmore. 1977.
The case for case reopened. In *Syntax and Semantics*, volume 8.