Semantic roles

INF5830
Fall 2015
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*
Sentence analysis in NLP

- Want to get at the meaning expressed by these sentences
  - IBM bought Spark
  - IBM acquired Spark
  - Spark was acquired by IBM
  - The owners of Spark sold to IBM
- Parsing will give us relations between verbs and arguments, e.g. dependency triples
  - (buy, subj, IBM), (buy, obj, Spark)
  - (acquire, subj, IBM), (acquire, obj, Spark)
  - (was, subj, Spark), (acquired, vmod, by), (by, pcomp, IBM)
  - (sold, subj, owners), (owners, nmod, of), (of, pcomp, Spark), ...
- Not quite what we need?
Semantic roles

- Alternative sentence-level representation of semantic content
- Characterization of events: who did what to whom, where when and how?
- **Predicate** of a clause determines the main event, e.g. ‘eat’, ‘break’, ‘kiss’
- Semantic roles describe participants in the event
- Closely related to a verb’s **argument structure**
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/hauled 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 the 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
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:
  \[ \text{The boy} \quad \text{threw} \quad \text{the red ball} \quad \text{to the girl} \]
  AGENT \quad THEME \quad GOAL

- Tests for semantic roles
  - AGENT: add \textit{on purpose}
    - Jon took the book \textit{on purpose}
  - THEME/PATIENT
    - \textit{What happened to Y was} \ldots
    - \textit{What X did to Y was} \ldots
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
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
- Two “responses”:
  - more fine-grained roles, relative to “frames”
    [Fillmore 1968, Fillmore 1977]
  - 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
Frame Semantics

- Frames are intended to bridge semantics and syntax by assigning semantic roles to participants
- Subject selection principles
  - AGENT $\rightarrow$ (deep) subject
  - word-specific
    - *I regard John as pompous*
    - *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 (frame): 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>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>

Alfred bought the book from Olivia for 10 dollars.
Alfred bought them for 1 dollar.
Alfred bought a bicycle from Sarah.
## Frame Semantics

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>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agent</strong></td>
<td>person cutting the Item</td>
</tr>
<tr>
<td><strong>Item</strong></td>
<td>item being cut</td>
</tr>
<tr>
<td><strong>Pieces</strong></td>
<td>parts of the original Item</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frame Elements (non-core):</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instrument</strong></td>
<td>instrument with which the Item is cut</td>
</tr>
<tr>
<td><strong>Manner</strong></td>
<td>manner in which Item is cut</td>
</tr>
<tr>
<td><strong>Place</strong></td>
<td>where cutting takes place</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>purpose for cutting</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)
Proto-roles

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)
  - Experiencer is sentient/perceiving
  - Stimulus causes emotional reaction
  - \( x \) likes \( y \) / \( y \) pleases \( x \)
  - \( x \) fears \( y \) / \( y \) 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

