Semantic Role Labeling
Outline

• Semantic role theory
• Designing semantic role annotation project
  ▫ Granularity
  ▫ Pros and cons of different role schemas
  ▫ Multi-word expressions
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  ▫ Multi-word expressions
Semantic role theory

- Predicates tie the components of a sentence together
- Call these components arguments
- [John] opened [the door].
Discovering meaning

• Syntax only gets you so far in answering “Who did what to whom?”

John opened the door.

Syntax:

NP_{SUB} V NP_{OBJ}

The door opened.

Syntax:

NP_{SUB} V
Discovering meaning

• Syntax only gets you so far in answering “Who did what to whom?”

Syntax:

Semantic roles:

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John opened the door.

Syntax: \( \text{NP}_{\text{SUB}} \ V \ \text{NP}_{\text{OBJ}} \)

Semantic roles: Opener REL thing opened

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The door opened.

Syntax: \( \text{NP}_{\text{SUB}} \ V \)

Semantic roles: thing opened REL
Can the lexicon account for this?

- Is there a different sense of *open* for each combination of roles and syntax?
  - **Open 1**: to cause something to become open
  - **Open 2**: become open
- Are these all the senses we would need?

1. John opened the door with a crowbar. *Open 1*?
2. They tried the tools in John’s workshop one after the other, and finally the crowbar opened the door. Still *Open 1*?
Fillmore’s deep cases

• Correspondence between syntactic case and semantic role that participant plays
• “Deep cases”: Agentive, Objective, Dative, Instrument, Locative, Factitive
• Loosely associated with syntactic cases; transformations result in the final surface case
The door opened.
Syntax: \[ NP_{\text{SUB}} \quad V \]
Semantic roles:
Objective REL

John opened the door.
Syntax: \[ NP_{\text{SUB}} \quad V \quad NP_{\text{OBJ}} \]
Semantic roles:
Agentive REL Objective

The crowbar opened the door.
Syntax: \[ NP_{\text{SUB}} \quad V \quad NP_{\text{OBJ}} \]
Semantic roles:
Instrumental REL Objective

John opened the door with the crowbar.
Syntax: \[ NP_{\text{SUB}} \quad V \quad NP_{\text{OBJ}} \quad PP \]
Semantic roles:
Agentive REL Objective Instrumental
Fillmore: Theta grids

- Number and type of “deep cases” is determined by the meaning of the verb
- Open: [(Agentitive, ) Objective, (Instrument)]
- Put: [Agentitive, Objective, Location]
  - Carla put the coffee on the table.
  - *Carla put the coffee.
Promotes generalizations across verbs

Grad students like free food.

Syntax:

\[ \text{NP}_{\text{SUB}} \quad \text{V} \quad \text{NP}_{\text{OBJ}} \]

Semantic roles:

Liker (Objective) REL thing liked (Dative)

Free food pleases grad students.

Syntax:

\[ \text{NP}_{\text{SUB}} \quad \text{V} \quad \text{NP}_{\text{OBJ}} \]

Semantic roles:

Thing liked (Dative) REL liker (Objective)
### Some standard semantic roles

<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent</td>
<td>Initiator of action, capable of volition</td>
</tr>
<tr>
<td>Patient</td>
<td>Affected by action, under-goes change of state</td>
</tr>
<tr>
<td>Theme</td>
<td>Entity moving, or being “located”</td>
</tr>
<tr>
<td>Beneficiary</td>
<td>For whose benefit action is performed</td>
</tr>
<tr>
<td>Experiencer</td>
<td>Perceives action but not in control</td>
</tr>
<tr>
<td>Instrument</td>
<td>Intermediary/means used to perform an action</td>
</tr>
<tr>
<td>Location</td>
<td>Place of an object or action</td>
</tr>
<tr>
<td>Source</td>
<td>Starting point</td>
</tr>
<tr>
<td>Goal</td>
<td>Ending point</td>
</tr>
</tbody>
</table>
Exercises from table 1.2 (Palmer et al., 2010)

- [The ball] flew [into the outfield.]
- [Jim] gave [the book] [to the professor.]
- [Laura] talked [to the class] [about the bomb threats.]
- [Laura] scolded [the class.]
- [Bill] cut [his hair] [with a razor.]
- [Gina] crashed [the car] [with a resounding boom.]
Discussion

• Were the role definitions adequate?
• Would you add any roles?
• If so, what would they be?
Other common thematic roles

- **Cause**
  - The wind blew the door open.

- **Topic**
  - They discussed the merger.

- **Stimulus**
  - She smelled the tang in the air.

- **Recipient**
  - She sent the president an angry letter.

- **Co-agent**
  - Peter met Tom in the conference room.
Real world examples

- [Some of Tuesday night's rioters] bragged [of booze-fueled rampages.]
Real world examples

- Police ranks have been depleted by summer vacations, and social media sites - coupled with dramatic video of the rioting - have bolstered a mob mentality and spread disobedience.
Real world examples

• [Police ranks] **have been depleted** by [summer vacations,] and

• [social media sites - coupled with dramatic video of the rioting -] **have bolstered** [a mob mentality] and

• **spread** [disobedience].
Dowty’s proto-agent and proto-patient

- Simplify the proliferating roles.
- Concentrate on mapping roles to syntax.
- The most important being subject and object.
- Subject often agent, cause, instrument, patient
Prototype theory

- Account of category membership
- No “necessary and sufficient” conditions of membership in a category
- Prototypical members, fuzzy boundaries
- Semantic roles are categories
- Prototypical agents: sentient, volitional, causes a change of state in another participant
- Not all agents fit every property
Proto-Agents

1. Volitional involvement in event or state
2. Sentience (and/or perception)
3. Causing an event or change of state in another participant
4. Movement (relative to position of another participant) (exists independently of event named)

Agent, Experiencer, Instrument, Causer, etc.
Proto-Patient

- Undergoes a change of state
- Incremental theme
- Causally affected by another participant
- Stationary relative to movement of another participant, or
- does not exist independently of the event, or at all
  - [She] said [a few words about proto-patients.]

- Patient, Theme, Percepts, etc.
Argument selection principle

• In predicates with subject and object, the argument with the most proto-agent entailments is lexicalized as the subject; the argument with the most proto-agent entailments is lexicalized as the direct object.
Groups semantic roles

- Agent, Experiencer, Cause, Instrument
- Patient, Theme, Recipient
- Many verbs take more than 2 roles
- Oblique, Source, Goal
Two participants with similar properties

- Kevin loaded the cart with mangoes.
- Proto- patient properties for
- Cart
  - Causally affected by another participant
  - Undergoes change of state
- Mangoes
  - Causally affected by another participant
  - Undergoes change of state
Incremental theme

- The one that is the undergoing a change of state
- AND the completion of that change of state signals the end of the event.
- Predicts alternations.
- Kevin loaded [the cart] [with mangoes.]
- Kevin loaded [the mangoes] [onto the cart.]
Assign Dowty’s roles

- [The ball] flew [into the outfield.]
- [Jim] gave [the book] [to the professor.]
- [Laura] talked [to the class] [about the bomb threats.]
- [Laura] scolded [the class.]
- [Bill] cut [his hair] [with a razor.]
- [Gina] crashed [the car] [with a resounding boom.]
Assign Dowty’s roles

- [Police ranks] have been depleted by [summer vacations,] and

- [social media sites - coupled with dramatic video of the rioting -] have bolstered [a mob mentality] and

- spread [disobedience].
Levin’s verb classes


• “Behavior of a verb . . . is to a large extent determined by its meaning” (p. 1)
  
  Amanda *hacked* the wood with an ax.
  Amanda *hacked* at the wood with an ax.
  Craig *notched* the wood with an ax.
  *Craig notched* at the wood with an ax.

• Can we move from syntactic behavior back to semantics?
Syntactic alternations

• Levin created classes of verbs based on semantic similarity and similar syntactic behavior
• Allowing the same alternations
• Hack is part of the cut class, along with cut, chop, saw, and snip
• Levin does not supply a list of semantic roles, but the alternations depend on the idea of roles consistent across different syntactic realizations.
• VerbNet
Filmore’s Frame Semantics

- Semantic representations of common scenarios
- Lexical items are related in these frames with more detailed, specific roles
- Classes of verbs (and eventive nouns)
- Concerned with semantic coherency of the frames, not syntactic coherency like Levin
- Instantiated in FrameNet
Closure frame

- An Agent manipulates a Fastener to open or close a Containing_object (e.g. coat, jar). Sometimes an Enclosed_region or a Container_portal may be expressed.

- Buckle, button, cap, close, fasten, lace, open, seal, tie, unbutton, uncap, unfasten, unscrew, unzip, zip
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Generality/Granularity of the Roles

- PropBank
  - Most general
- VerbNet
  - General, broad
- FrameNet
  - More specific, narrow
- PropBank
  - Most specific
# VerbNet

<table>
<thead>
<tr>
<th>Agent</th>
<th>Source</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>Destination</td>
<td>Extent</td>
</tr>
<tr>
<td>Theme</td>
<td>Topic</td>
<td>Asset</td>
</tr>
<tr>
<td>Location</td>
<td>Predicate</td>
<td>Value</td>
</tr>
<tr>
<td>Instrument</td>
<td>Beneficiary</td>
<td>Attribute</td>
</tr>
<tr>
<td>Experiencer</td>
<td>Stimulus</td>
<td></td>
</tr>
<tr>
<td>Recipient</td>
<td>Material</td>
<td></td>
</tr>
<tr>
<td>Cause</td>
<td>Product</td>
<td></td>
</tr>
</tbody>
</table>
2,500 frame elements (semantic roles) and growing

Create_representation

A Creator produces a physical object, which is to serve as a Representation of an actual or imagined entity or event, the Represented.

[Picasso] drew [some violent looking birds].

Creator Represented

carve.v, cast.v, draw.v, paint.v, photograph.v, sketch.v
PropBank

- Uses numbered arguments: Arg0, Arg1, Arg2 . . .
- Defined differently for each sense of a verb
- Open.01 “open”
  - **Arg0**: opener
  - **Arg1**: thing opening
  - **Arg2**: instrument
  - **Arg3**: benefactive
Draw.01

- **Arg0**: artist
- **Arg1**: art
- **Arg2**: benefactive

- [Picasso] drew [some violent looking birds].

These roles only apply to *draw*. 
Why numbered arguments?

• Avoids lack of consensus concerning a specific set of semantic role labels
• Numbers correspond to labels that are verb-sense-specific
• Arg0 and Arg1 correspond to Dowty’s (1991) proto-agent and proto-patient
Argument number assignment

- **Arg0** is reserved for the agent role
- **Seem.01**
  - **Arg1**: thing seeming
  - **Arg2**: perceiver

- All others assigned in order
- Args 2-5 are highly variable
Typical correspondences

• Arg0 = agent
• Arg1 = patient
• Arg2 = benefactive / instrument / attribute / end state
• Arg3 = start point / benefactive / instrument / attribute
• Arg4 = end point
Increase: 5 roles

Roles:

Arg0: causer of increase
Arg1: thing increasing
Arg2: amount increased by
Arg3: starting point
Arg4: end point

Example: Net income increased to $274 million from $130 million.

Arg1: net income
REL: increase
ARG4: to $274 million
ARG3: from $130 million
Use the Unified Verb Index to find FrameNet and PropBank roles

- [The ball] flew [into the outfield.]
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- [Bill] cut [his hair] [with a razor.]
- [Gina] crashed [the car] [with a resounding boom.]

http://verbs.colorado.edu/verb-index/index.php
• [Police ranks] **have been depleted** by [summer vacations,] and

• [social media sites - coupled with dramatic video of the rioting -] **have bolstered** [a mob mentality] and

• **spread** [disobedience].
Discussion

• What pros and cons do you see with the different role sets?
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VerbNet

• **Pros:**
  ▫ This level of generality produces many examples of each role.
  ▫ Connection to predicate-logic type semantic representations

• **Cons:**
  ▫ Needs better coverage of verbs and verb senses
  ▫ Clearer definitions of thematic roles
FrameNet

- **Pros:**
  - Clear definitions of roles

- **Cons:**
  - Needs better coverage of verbs and verb senses
  - Narrow roles can result in a sparse data problem
PropBank

**Pros:**
- Very easy to apply argument labels
- Arg0 and arg1 consist across verbs

**Cons:**
- Verb-specific numbered arguments make it difficult to make generalizations across verbs

Most practical applications of PB have converted numbered args to consistent thematic roles
- Arg0/ Arg1 constitute 85% of arguments, have consistent correspondences
- Arg2-5 performance drops significantly
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Light verbs

• Labeling arguments in the usual way with light verbs is misleading
• [He] took [a walk.] (??)
• Walk is really the predicating element
• [She] made [a comment about his hair]. (??)
Argument structure

• The predicating noun projects the argument structure
• She made a comment about his hair.
• [She] commented [about his hair.]
  Agent      Topic

• *She made to buy the company.