

Semantic Theory: Lexical Semantics III

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Thematic Roles (Fillmore 1968)

- **Frames** are the units for the conceptual modelling of the world: structured schemata representing complex situations, events, and actions. The meaning of words in terms of the part which they play in frames.
- **Thematic roles** describe the conceptual participants in a situation in a generic way, independent from their grammatical realization.



An Inventory of Thematic Roles

- Agent
- Theme/ Patient/ Object
- Recipient
- Instrument
- Source
- Goal
- Beneficiary
- Experiencer



Examples Annotated with Thematic Roles

- *[The window]_{pat} broke*
- *[A rock]_{inst} broke [the window]_{pat}*
- *[John]_{ag} broke [the window]_{pat} [with a rock]_{inst}*
- *[Peter]_{ag} gave [Mary]_{rec} [the book]_{pat}*
- *[Mary]_{rec} received [the book]_{pat} [from Peter]_{ag}*



Thematic Roles

- Allow to represent the semantic correspondence between (uses of) relational concepts in a systematic way – thereby supporting basic lexical-semantic inference.
- Support a systematic representation of the mapping between syntactic complements and semantic argument positions (role-linking).
- Support the systematic description of selectional preferences and constraints (e.g.: Agent is animate, Source and Goal are locations)
- Support the encoding and application of additional inference rules.



Role-linking Information

give: SB \diamond Agent
 OA \diamond Theme
 OD \diamond Recipient

get: SB \diamond Recipient
 OA \diamond Theme
 OP-from \diamond Agent

- Linking information is either provided in the lexicon, or modelled in a systematic (but necessary imprecise or incomplete) way.



The „Role Dilemma“

- Originally, a small, closed, and universally applicable inventory of roles was assumed.
- This assumption is untenable: Either you use role names in a more or less arbitrary way, or you have to assume many different roles.



Roles of Commercial transaction verbs?

- Airbus sells five A380 planes to China Southern for 220 million Euro
- China Southern buys five A380 planes from Airbus for 220 million Euro
- Airbus arranged with China Southern for the sale of five A380 planes at a price of 220 million Euro
- Five A380 planes will go for 220 million Euro to China Southern



Proposed solutions

- PropBank: Annotation of Penn TreeBank with predicate-argument structure. Verbs come with individual roles.
- Generalisation over alternation patterns of single verbs (the *break* case).
- No generalisation across lexeme boundaries (the *give/receive* case).
- Good: Efficient annotation process, high inter-annotator agreement
- Bad: The role concept is pretty close to syntax, and rather language-specific.



PropBank Example: *expect*

Roles:

Arg0: *expecter*

Arg1: *thing expected*

Example: Transitive, active:

Portfolio managers *expect* *further declines in interest rates.*

Arg0: *Portfolio managers*

REL: *expect*

Arg1: *further declines in interest rates*



PropBank example: *give*

Roles:

Arg0: giver

Arg1: thing given

Arg2: entity given to

Example: double object

The executives gave the chefs a standing ovation.

Arg0: *The executives*

REL: *gave*

Arg2: *the chefs*

Arg1: *a standing ovation*



Trends in Argument Numbering

- Arg0 = agent
- Arg1 = direct object / theme / patient
- Arg2 = indirect object / benefactive / instrument / attribute / end state
- Arg3 = start point / benefactive / instrument / attribute
- Arg4 = end point

(3 Slides taken over from Baker/Hajic/Palmer/Pinkal, ACL 2004)



Berkeley FrameNet

- **Frames**: an inventory of conceptual structures modelling a prototypical situation like "COMMERCIAL_TRANSACTION", "COMMUNICATION_REQUEST", "SELF_MOTION"
- Semantic roles are **locally valid** only (and accordingly called "Frame Elements" (FE):
 - FEs of the COMMUNICATION_REQUEST frame: SPEAKER, ADDRESSEE, MESSAGE, ...
 - FEs of the COMMERCIAL_TRANSACTION frame: BUYER, SELLER, GOODS, PRICE, ...
- A set of "**target words**" associated with each frame: e.g., for COMMERCIAL_TRANSACTION:
 - buy, sell, pay, spend, cost, charge,
 - price, change, debt, credit, merchant, broker, shop
 - tip, fee, honorarium, tuition



Commercial Transaction

- **Airbus** sells **five A380 planes** to **China Southern** for **220 million Euro**
- **China Southern** buys **five A380 planes** from **Airbus** for **220 million Euro**
- **Airbus** arranged with **China Southern** for the sale of **five A380 planes** at a price of **220 million Euro**
- **Five A380 planes** will go for **220 million Euro** to **China Southern**



- COMMERCIAL_TRANSACTION
 - SELLER: Airbus
 - BUYER: China Southern
 - GOODS: five A380 superjumbo planes
 - PRICE: 220 million Euro



The Berkeley FrameNet Database

The FrameNet database consists of:

- A data-base of frames with
 - Descriptions of frames with inventory of Roles/Frame elements and associated lemmas
 - Frame-to-Frame Relations
- A lexicon with
 - Frame information
 - Grammatical realisation patterns (Role Linking)
 - Annotations of example sentences (from BNC) for all use variants of words

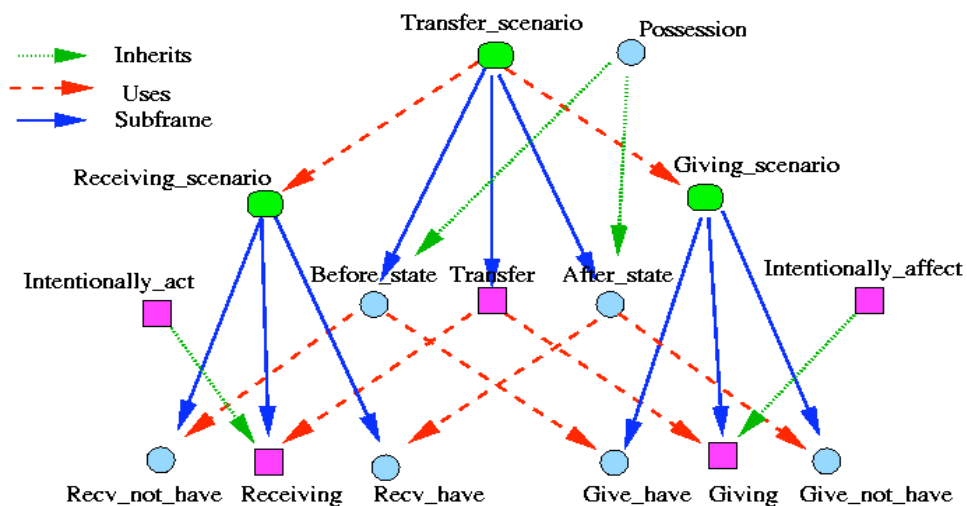


The Berkeley FrameNet Database

- Current release: 700 frames, about 8000 lexical units (mostly verbs)
- Planned: A total of 15000 verb descriptions
- <http://framenet.icsi.berkeley.edu/>



Frame-to-Frame-Relations





FrameNet: Advantages

- A deliberate and careful unified modeling of the core lexicon of English (relational) expressions, mostly verbs, but also deverbal nouns and relational adjectives, which supports
 - semantic representation at an appropriate level of granularity and abstraction
 - semantic construction via grammatical realization patterns
 - inference based on role information
 - An almost ideal platform for cross-lingual lexical-semantic resources (FrameNet for German (SALSA, Saarbrücken), Spanish, Japanese under work, FrameNet for French and Scandinavian languages planned)



FrameNet: Disadvantages

- Few and rather unsystematic information about Frame-to-Frame Relations (hierarchical relations, causation etc.)
- Frame structure tends to be too fine-grained for Information management tasks. E.g., different frames for Giving and Receiving, because of differences in perspective.
- Sometimes, relevant semantic information is missing (cf. good/bad both in MORALITY_EVALUATION frame, believe/know both in AWARENESS frame); this is in particular the case, if semantic features have no impact on the frame/role structure of the respective words.
- Lack of coverage (only 50% of the English Core Lexicon described, several years for completion required)



Thematic Roles in SUMO

- (\Leftrightarrow)
 - (exists (?BUY)
 - (and
 - (instance ?BUY Buying)
 - (agent ?BUY ?AGENT1)
 - (origin ?BUY ?AGENT2)
 - (patient ?BUY ?OBJECT)))
 - (exists (?SELL)
 - (and
 - (instance ?SELL Selling)
 - (agent ?SELL ?AGENT2)
 - (destination ?SELL ?AGENT1)
 - (patient ?SELL ?OBJECT)))



Thematic Roles in SUMO

- SUMO employs thematic roles, and provides rules for role correspondences of different relations. However:
- Thematic role information is unsystematic and sparse, and:
- It excludes role-linking information completely: To make SUMO (thematic) roles usable for NLP tasks, role-linking information must be provided by another resource (e.g., FrameNet)



Event Semantics: Donald Davidson's Problem

- (1) *The gardener killed the baron at midnight in the park*
- (2) *The gardener killed the baron at midnight*
- (3) *The gardener killed the baron in the park*
- (4) *The gardener killed the baron*



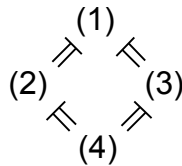
The interpretation of adjunct constructions

- First attempt:
- (1) $\Rightarrow \text{kill}_4(g, b, m, p)$
- (2) $\Rightarrow \text{kill}_3(g, b, m)$
- (3) $\Rightarrow \text{kill}_2(g, b, p)$
- (4) $\Rightarrow \text{kill}_1(g, b)$



The interpretation of adjunct constructions

- A problem: How can the logical entailment relations between the different uses of *kill* be explained?



The interpretation of adjunct constructions

- Naïve FOL interpretation does not solve the problem:
 - $\text{kill}_4(g, b, m, p) \not\models \text{kill}_3(g, b, m)$
 - $\text{kill}_3(g, b, m) \not\models \text{kill}_1(g, b)$
 - etc.



Adjunct Interpretation: Second Attempt

- Fixed arity of the underlying predicate; syntactically not realized predicates are existentially bound:
 - (1) $\Rightarrow \text{kill}(g, b, m, p)$
 - (2) $\Rightarrow \exists y \text{ kill}(g, b, m, y)$
 - (3) $\Rightarrow \exists x \text{ kill}(g, b, x, p)$
 - (4) $\Rightarrow \exists x \exists y \text{ kill}(g, b, x, y)$



Another Problem

- The entailment relations are obtained, but:
- What is the correct arity of an event verb/ its underlying predicate?

The gardener killed the baron at midnight in the park under cover of absolute darkness with a shotgun ...
- Also the order of adjuncts (as compared to complements) (usually) has no impact on the truth conditions of the sentence.



Third Attempt: Higher-order Logic

- Adjuncts are analysed as sentence modifiers (type $\langle t, t \rangle$):
(1) \Rightarrow in the park(at-midnight(kill(g, b)))
- The analysis solves the arity problem, but entailment relations are lost again:
at-midnight(kill(g, b)) $\not\models$ kill(g, b)
- Note also that the order of adjuncts (as compared to complements) (usually) has no impact on the truth conditions of the sentence.



Davidson's Solution

- Verbs expressing events have an additional argument position for an event variable, which is not realised at linguistic surface:

kill $\Rightarrow \lambda x \lambda y \lambda e. \text{kill}(e, x, y)$, where *kill*: $\langle e, \langle e, \langle e, t \rangle \rangle \rangle$

- Adjuncts express two-place relations between events and the respective "circumstantial entities" (a time, a location, ...)
- In finite/tensed clauses, the event variable is existentially bound:

The gardener killed the baron at midnight in the park

$\Rightarrow \exists e [\text{kill}(e, g, b) \wedge \text{time}(e, m) \wedge \text{location}(e, p)]$



Davidson's Solution

- Event verbs are represented by relations of a fixed arity (number of syntactic complements +1)
- Event verbs have an argument position occupied by an event variable.
- Adjuncts are represented by two-place relations.
- Entailments follow straightforwardly, as well as the fact that adjunct semantics is order-independent:
 - $\exists e[\text{kill}(e,g,b) \wedge \text{time}(e, m) \wedge \text{location}(e, p)]$
 - $\models \exists e[\text{kill}(e,g,b) \wedge \text{time}(e, m)]$
 - $\models \exists e[\text{kill}(e,g,b)]$



Compositional Semantics for Adjunct constructions

- Adjuncts are analysed as intersective modifiers for event predicates (type: $\langle\langle e,t\rangle, \langle e,t\rangle\rangle$), in full analogy to intersective noun modifiers (adjectiveds, PPs):
 - *red* $\Rightarrow \lambda F \lambda x [F(x) \wedge \text{red}(x)]$
 - *at midnight* $\Rightarrow \lambda E \lambda e [E(e) \wedge \text{time}(e, \text{midnight})]$

The gardener killed the baron at midnight

$\Rightarrow \lambda E \lambda e [E(e) \wedge \text{time}(e, \text{midnight})](\lambda e. \text{kill}(e, g, b))$

$\Leftrightarrow \lambda e. \text{kill}(e, g, b) \wedge \text{time}(e, \text{midnight})$

In finite clauses, the event variable is eventually bound:

$\Rightarrow \exists e. \text{kill}(e, g, b) \wedge \text{time}(e, \text{midnight})$



Uniform treatment of modifiers

- One semantic representation for the use of PPs as adjuncts and postnominal modifiers:
in the park $\Rightarrow \lambda F \lambda x [F(x) \wedge \text{location}(x, p)]$
 - Local adjunct /event modifier
[[The gardener killed the baron] in the park]
 - Post-nominal modifier of an event-denoting deverbal noun:
The [[murder] in the park]
 - Post-nominal modifier of a standard common noun:
The [[pavillon] in the park]
- Note: Event semantics provides a natural interpretation for deverbal common nouns.



Thematic Roles in Event Semantics

- Complements can be treated analogously to adjuncts: Event verbs are represented as one-place event predicates. Thematic roles are two-place relations linking arguments to the event denoted by the verb:
The gardener killed the baron at midnight in the park
 $\Rightarrow \exists e [\text{kill}(e) \wedge \text{ag}(e,g) \wedge \text{pat}(e,b) \wedge \text{time}(e,m) \wedge \text{location}(e,p)]$
- „Neo-Davidsonian“ semantics allows the partitioning of semantic information into minimal pieces:



Event anaphora in DRT

- *The gardener killed the baron . It happened at midnight.*
- *Yesterday, I went by train from Hamburg to Saarbrücken. That was a boring trip.*
- Event referents
 - a new kind of discourse referents
 - are introduced (e.g.) by finite clauses
 - and can be referred to by nominal anaphoric expressions



Event anaphora in DRT

- *The gardener killed the baron . It happened at midnight.*

e, g, b

gardener(g)
baron(b)
kill(e,g,b)

e, g, b, e'

gardener(g)
baron(b)
kill(e,g,b)
midnight(m)
time(e',m)
e'=e



FOL Model Structure with Events

- Like standard FOL Model Structure $M = \langle U, V \rangle$, except that the universe is subdivided into
 - a set of standard individuals U_S , and
 - a set of events U_E , which is partially ordered by a "temporally precedes" relation.



Temporal relations in Event Semantics

- Event Semantics allows the explicit representation of tense and temporal relations in FOL/DRT

John left $\Rightarrow \exists e [\text{leave}(e, j^*) \wedge e < e_u]$

where $<$ is interpreted as temporal precedence, and e_u is the utterance event.

John left, after Peter had arrived

$\Rightarrow \exists e_1 \exists e_2 [\text{leave}(e_1, j^*) \wedge e_1 < e_u \wedge \text{arrive}(e_2, p) \wedge e_2 < e_1]$



Temporal relations in an Event Semantics

John left, after Peter had arrived

j, e, p, e'

$\text{leave}(e, j)$

$e < e_u$

$\text{arrive}(e', p)$

$e' < e$



Events, activities, states

- Davidsonian event semantics works well for verbs expressing **individual events** that have a specific temporal location (like in *The gardener killed the baron* or *John left*).
- **Activities** (*John is walking, working*), usually expressed by the progressive form in English, lack a precise temporal location: If I am working during a time interval, I am also working during all sub-intervals – representation via discourse referents is problematic.
- Events and activities are usually subsumed under the common concept of "**eventualities**", in contrast to **states** (*John lives in Saarbrücken, John likes Mary*).
- Event-denoting expressions resemble ordinary "countable" common nouns. Activities and states are semantically similar to plurals and mass nouns.