Semantic Theory
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Lexical Semantics III

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A semantically motivated classification of words

Dolphins are mammals, not fish. They are warm blooded like man, and give birth to one baby called a calf at a time. At birth a bottlenose dolphin calf is about 90-130 cms long and will grow to approx. 4 metres, living up to 40 years.They are highly sociable animals, living in pods which are fairly fluid, with dolphins from other pods interacting with each other from time to time.

Thematic roles: Some observations

– *Mary likes John*
– *John pleases Mary*

like(x,y) ↔ please (y,x)

– *Mary gave Peter the book*
– *Peter received the book from Mary*

give (x,y,z) ↔ receive_from (y,x,z)

Some observations [3]:

– *The window broke*
– *A rock broke the window*
– *John broke the window with a rock*

$break_3(x,y,z) \models break_2(z,y) \models break_1(y)$

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.

Examples for Thematic Roles

- Agent
- Theme/ Patient/ Object
- Recipient
- Instrument
- Source
- Goal
- Beneficient
- 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 more abstract/ generic semantic representations
- support the systematic description of selection preferences and constraints
- support the encoding and application of general inference rules
- support the semantic interpretation process (role linking)

Role linking, example

give: SB → Agent
OA → Theme
OD → Recipient

get: SB → Recipient
OA → Theme
OP-from → Agent

The „Role Dilemma“

- In Fillmore's original theory and in early KR research a small, closed, and universally applicable inventory of roles is postulated.
- This assumption is untenable, given the semantic richness of natural languages.

Fillmores Frame-semantic Concept (1976)

- „...first identify the phenomena, experiences, or scenarios represented by the meanings of the *target words ...*“
- „...then identify labels to the parts or aspects of these which are associated with specific means of linguistic expression ...*frame elements ...*“

… implemented in the Berkeley FrameNet Database (since 1996)

- 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

An example [1]

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

An example [2]

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

The Berkeley FrameNet Database

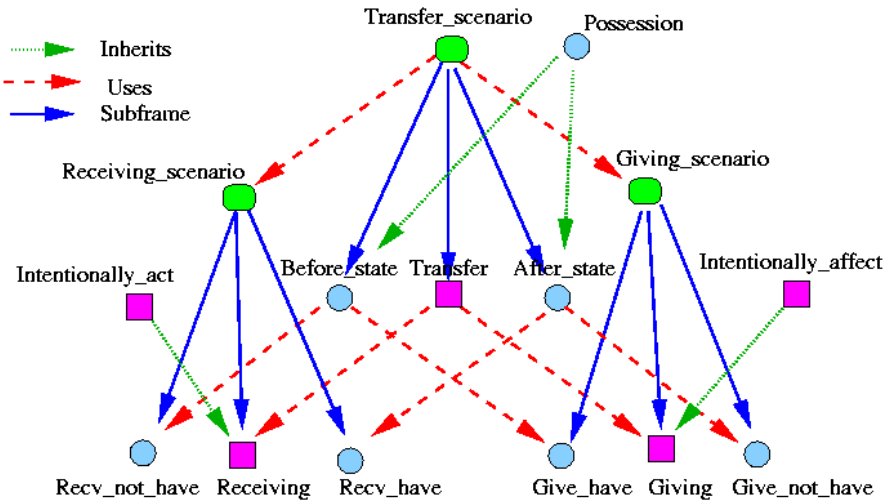
The FrameNet database consists of:

- 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 very 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: Disadvantages

- Lack of coverage (only 40-50% of the English Core Lexicon described, several years required for completion)
- Few and rather unsystematic information about Frame-to-Frame Relations (hierachical relations, causation etc.)
- Some WordNet information is lost (cf. good/bad in MORALITY_EVALUATION frame, believe/know in AWARENESS frame)
- Interfaces for language technology purposes are (still) lacking

FrameNet going multi-lingual

- SALSA: The Saarbrücken Lexical Semantics Annotation and Analysis Project – A corpus-based, large, application-oriented lexical-semantic resource based on FrameNet
- Spanish and Japanese FrameNet under work.

Event Semantics: Donald Davidson's Problem

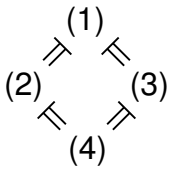
(1) The gardener killed the baron at midnight in the park
(2) The gardener killed the baron at midnight
(3) The gardener killed the baron in the park
(4) The gardener killed the baron

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:
  - $kill_4(g, b, m, p) \not\models kill_3(g, b, m)$
  - $kill_3(g, b, m) \not\models kill_1(g, b)$
  - etc.

Adjunct Interpretation: Second Attempt

- Fixed arity of the underlying predicate; syntactically not realized predicates are existentially bound:

  (1) $\Rightarrow$ kill(g, b, m, p)

  (2) $\Rightarrow \exists$y kill(g, b, m, y)

  (3) $\Rightarrow \exists$x kill(g, b, x, p)

  (4) $\Rightarrow \exists$x$\exists$y 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 <t,t>):
  (1) $\Rightarrow$ in the park(at-midight(kill(g, b)))
- The analysis solves the arity problem, but entailment relations arelost 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 $\Rightarrow$ $\lambda x \lambda y \lambda e$.kill(e,x,y), where kill: <e,<e,<e,t>>>
- Adjuncts express two-place relations between events and the respective "cirumstantial 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
  $\Rightarrow \exists e[$ kill(e,g,b) $\wedge$ time(e, m) $\wedge$ 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:
- $\exists e[\ kill(e,g,b) \wedge time(e, m) \wedge location(e, p)\ ]$
  $\models \exists e[\ kill(e,g,b) \wedge time(e, m)\ ]$
  $\models \exists e[\ kill(e,g,b)\ ]$

Compositional Semantics for Adjunct constructions

- Adjuncts are analysed as intersective modifiers for event predicates (type: <<e,t>,<e,t>>), in full analogy to intersective noun modifiers (adjectiveds, PPs):
  red $\Rightarrow \lambda F \lambda x[F(x) \wedge red(x)]$
  at midnight $\Rightarrow \lambda E \lambda e[E(e) \wedge time(e, m)]$
  The gardener killed the baron at midnight
  $\Rightarrow \lambda E \lambda e[E(e) \wedge time(e, m)](\lambda e.kill(e, g, b))$
  $\Leftrightarrow \lambda e.kill(e, g, b) \wedge time(e, m)$
  If clause is finite, the event variable is eventually bound:
  $\Rightarrow \exists e.kill(e, g, b) \wedge time(e, m)$

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 an standard common noun:
  The [[pavillon] in the park]
  Note: Event semantics provides a natural interpretation for deverbal common nouns.

„Neo-Davisonian“ 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
  $\Rightarrow \exists e$ [kill(e) $\wedge$ ag(e,g) $\wedge$ pat(e,b) $\wedge$ time(e,m) $\wedge$ location(e,p)]
- Neo-Davidsonian semantics allows the partioning of semantic information into minimal pieces, but:
- Proper interpretation of the role relations anticipates knowledge of the event predicate, to some extent.

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 = <U,V>, 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 an 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 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'

leave(e,j)
$e < e_u$

arrive(e',p)
$e' < e$

Events, activities, states

- Davidsonian event semantics works well for verbs expressing individual events that can be temporally located (like in *The gardener killed the baron* or *John left*).
- Verbs expressing activities (*John is walking, sleeping*), usually expressed by progressive form in English, are not temporally delimitable.
- Events and activities are usually subsumed under the common concept of "eventualities", in contrast to states (*John lives in Saarbrücken*, *John likes Mary*).

What else?

- Semantics of tense and aspect is a large and important research area in natural language semantics.
- Unfortunately, we had no opportunity to look into it, as well as into many other interesting questions of NL Semantics, e.g. the semantics of
  - spatial prepositions
  - adjectives, comparatives, superlatives
  - vague expressions
  - propositional attitudes
  - modal verbs
  - support verb constructions
  - ellipsis
  - etc.