Semantic Theory

Lexical Semantics I

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Problems with verb and noun denotations

- *John loves Mary*
- *Mary kicked John*
- *Bill is coughing*

- *Bill travelled to Paris*
- *Bill's travel ended in Paris*

- *Bill saw an elephant*
- *Bill saw an accident*

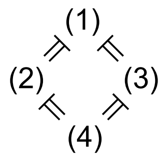
Davidson's problem

Interpretation of adjunct constructions:

(1) The gardener killed the baron at midnight in the park
$\Rightarrow$ $kill_4(g, b, m, p)$
(2) The gardener killed the baron at midnight
$\Rightarrow$ $kill_3(g, b, m)$
(3) The gardener killed the baron in the park
$\Rightarrow$ $kill_2(g, b, p)$
(4) The gardener killed the baron
$\Rightarrow$ $kill_1(g, b)$

Davidson's Problem

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



- 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

- Determine the maximum arity n of the predicate.
- Take n to be the arity of the predicate.
- Bind syntactically empty argument positions with existential quantifier.

  (1) ⇒ kill(g, b, m, p)

  (2) ⇒ ∃y kill(g, b, m, y)

  (3) ⇒ ∃x kill(g, b, x, p)

  (4) ⇒ ∃x∃y kill(g, b, x, y)

- Problem: What is the maximum arity of a predicate?

  The gardener killed the baron at midnight in the park under cover of absolute darkness with a gun …

Davidson's Proposal

- Standard FOL-Semantics: two-place verbs denote sets of pairs of individuals.
- Davidson: Verbs denote events.
- Verbs expressing events have an additional event argument, which is not realised at linguistic surface:

  λyλxλe. kill(e,x,y)

- In general, n-place event verbs are represented by relations of arity n+1.
- Adjuncts express two-place relations between events and the respective "circumstantial information" (a time, a location, ...)
- The event variable is existentially bound:

  The gardener killed the baron at midnight in the park

  ⇒ ∃e[kill(e,g,b) ∧ time(e, m) ∧ location(e, p)]

Davidson's Proposal

- Semantic representation of verbs using events allows an arbitrary number of adjuncts.
- Since adjunct information is attached through conjunction, entailment the entailment problem is trivially solved:

∃e[kill(e,g,b) ∧ time(e, m) ∧ location(e, p)]

|= ∃e[kill(e,g,b) ∧ time(e, m)]

|= ∃e[kill(e,g,b)]

Extending model structure

- We assume two disjoint classes, or kinds, or sorts of individuals:
  - A set of “standard individuals” or “objects” U
  - A set of events E
- A model structure is defined as

  M = (U, E, V),

  with U∩E = ∅,

  V interpretation function like in standard FOL

Variables in sorted logic

- We assume a separate inventory of variables for each sort of individuals:
  - (Standard) Object variables: Var_U = x, y, z, ... a , x_1, x_2, ...
  - Event variables: Var_E = e, e', e'', ..., , e_1, e_2, ...
- Variable assignment functions g assign object and event variables individuals of the respective sort-specific domain:
  - g(x) ∈ U for x ∈ Var_U
  - g(e) ∈ E for x ∈ Var_E
- Quantification ranges over sort-specific domains:
  - $[[\exists x\ \Phi\ ]]^{M,g} = 1$ iff there is an a ∈ U s.t. $[[\ \Phi\ ]]^{M,g[x/a]} = 1$
  - $[[\exists e\ \Phi\ ]]^{M,g} = 1$ iff there is an a ∈ E s.t. $[[\ \Phi\ ]]^{M,g[x/a]} = 1$

Events as individuals

- Events as individuals: Technical trick or appropriate extension of semantics?
- Conceiving of a coughing (killing, selling, ...) as an entity in its own right is intuitive: Interpreting the predicate *cough* as a class of events with a certain property is much more natural than defining it as the set of all coughing persons (in a given world and time).
  Bill is coughing ⇒ ∃e.cough(e, b)
- Also, it provides a natural basis for the interpretation of (deverbal or genuine) event nouns*: the cough, the murder, the purchase, the sale* refer to event individuals, like *student, tree, table* refer to standard individuals.

Uniform treatment of various complements

- *Bill saw an elephant.*
  ∃e∃x [see(e, b, x) ∧ elephant(x)]
- *Bill saw an accident.*
  ∃e∃e' [see(e, b, e') ∧ accident(e')]
- *Bill saw the children play*
  ∃e∃e' [see(e, b, e') ∧ play(e', the-children)]

Compositional derivation of event-semantic representations

- Compositional derivation of event-semantic representations
- In analogy to intersective adjectives:
  - Adjectives in attributive use are common noun modifiers (type: <<e,t>,<e,t>>)
  - Representation of the adjective *red:*
    red ⇒ λFλx[F(x) ∧ red*(x)]
- Adjuncts are analysed as modifiers for event predicates:
  - *at midnight* ⇒ λEλe[E(e) ∧ time(e, midnight)]

Compositional derivation of event-semantic representations

- *kill* ⇒ λyλxλe.kill(e,x,y)
- *The gardener killed the baron* ⇒ λyλxλe.kill(e,x,y)(b)(g)
  ⇔ λe.kill(e, g, b)
- *The gardener killed the baron at midnight*
  ⇒ λEλe[E(e) ∧ time(e, midnight)](λe.kill(e, g, b))
  ⇔ λe[kill(e, g, b) ∧ time(e, midnight)]
- As a last step in the derivation process, the event variable is existentially bound.
  ⇒ ∃e[kill(e, g, b) ∧ time(e, midnight)]

Uniform treatment of modifiers

- Uniform semantic representation for adjuncts and post-nominal modifiers:
  in the park ⇒ λFλx[F(x) ∧ location(x, park)]
- Local adjunct:
  [[The gardener killed the baron] in the park]
  ⇒ λEλe[E(e) ∧ location(e, park)](λe.kill(e, g, b))
  ⇔ λe[kill(e, g, b) ∧ location(e, park)]
- Post-nominal modifier of event noun:
  The [[murder] in the park]
  ⇒ λEλe[E(e) ∧ location(e, park)](λe.murder(e))
  ⇔ λe[murder(e) ∧ location(e, park)]
- Post-nominal modifier of standard noun:
  The [[pavillon] in the park]
  ⇒ λFλx[E(x) ∧ location(x, park)](λy.pavillon(y))
  ⇔ λx[pavillon(x) ∧ location(x, park)]

Tense

- Tensed sentences:
  John walked
  John is walking
  John will walk
- Representation in conventional tense logic:
  walk(john)
  F*walk(john)*
  P*walk(john)*
- Interpretation of tense operators in tense logic
  $\vDash_{M,t}$ FA iff $\vDash_{M,t'}$ A is true for all t' > t
  $\vDash_{M,t}$ PA iff $\vDash_{M,t'}$ A is true for all t' < t

Temporal Precedence

- A model structure with events and temporal precedence is defined as
  M = (U, E , <, e_0, V),
  with U∩E = ∅,
  < ⊆ E×E an asymmetric relation (temporal precedence)
  e_0∈E the utterance event
  V an interpretation function like in standard FOL, with
  D_e = U∪E
- Overlapping events:
  e o e' iff neither *e < e' nor e' < e*

Temporal Precedence II

- An alternative model structure with points and intervals of time:

  $M = (U, E, T, <, t_0, tl, V)$,
  with U, E, and T mutually disjoint,
  $<$ a linear ordering on T
  $t_0 \in T$
  tl a function from E to intervals of T
  V an interpretation function like in standard FOL
- Precedence of events:

  $e < e'$ iff for all $t \in tl(e)$, $t' \in tl(e')$: $t < t'$
- Overlapping events:

  $e \circ e'$ iff $tl(e) \cap tl(e') \neq \varnothing$

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Tense in Event Semantics

- As a last step in the derivation process, the event variable is existentially bound.

  $\lambda e.kill(e, g, b) \Rightarrow \exists e.kill(e, g, b)$

- As a last step in the derivation process, the event variable is existentially bound and located w.r.to the utterance event

  $\lambda e.kill(e, g, b) \Rightarrow \exists e[\, e < e_u \wedge kill(e, g, b)]$

John is walking $\Rightarrow \exists e[\, e \circ e_u \wedge walk(e, john)]$

- Event Semantics allows the explicit representation of temporal relations

John left, after Peter had arrived

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

Events and event anaphora in DRT

- *The gardener killed the baron . It happened at midnight.*
- *Yesterday, I travelled by train from Munich to Saarbrücken. That trip was boring.*

- We extend DRT representations by a new kind of discourse referent (which are mapped by the embedding functions to individuals of sort "event").
- NPs containing event nouns introduce event DRs.
- Pronouns/ definite NPs expressing events are linked to event DRs.

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