Semantic Theory

Lexical Semantics II

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Verbs and Events

- Modeling verb semantics using events provides a natural solution to several hard problems of logic-based semantics.

  However:
- Not all verbs can be appropriately interpreted through implicit event arguments.

Verbs Expressing States vs. Events

- *Mary kicked John* : "there is a kicking event, in which Mary and John are involved"
- *John knew the answer:* "there is a knowing event, in which John and the answer are involved" (?)
- There are verbs expressing states and verbs expressing events (which we call non-stative for the time being)
  - Statives: *know, believe, have, desire, love*
  - Non-statives: *run, walk, kick, kill, build a house*
- Only non-stative verbs come with an extra argument:
  - kick(e, x, y)
  - know(x, y)

Aspectual Verb Classes – 1

Verbs expressing:

States
know, believe, own, love, resemble

Events

Linguistic Evidence for State-Event Distinction

- Progressive form
  - *John is running*
  - *John is reciting a poem*
  - **John is knowing the answer*
- Simple present
  - *Mary runs (has the habit of running)*
  - *John recites poems (has the habit of reciting poems)*
  - *John knows the answer*
- Manner adverbials
  - *John ran carefully*
  - *John carefully recited the poem*
  - **John carefully knew the answer*

Verbs and Events

- Modeling verb semantics using events provides a natural solution to several hard problems of logic-based semantics.

  However:
- Not all verbs can be appropriately interpreted through implicit event arguments.

  Moreover:
- Event-expressing verbs do not form a homogeneous semantic class.

Aspectual Verb Classes – 1

Verbs expressing:

States
know, believe, own, love, resemble

Eventualities

Different distribution of duration adverbials

- *John painted a picture in an hour*
- **John walked in an hour*
- **It rained in an hour*

- *John walked for an hour*
- *It rained for an hour*
- *?John painted a picture for an hour*

- *It took John an hour to paint a picture*
- **It took John an hour to walk*

Different inferential properties

- *John walked from 8 a.m. to 11 a.m.* $\models$ *John walked from 9 to 10 a.m.*
- *It rained from 8 a.m. to 11 a.m.* $\models$ *It rained from 9 to 10 a.m.*
- *John painted a picture from 8 a.m. to 11 a.m.* $\not\models$ *John painted a picture from 9 to 10 a.m.*
- *John is working in Saarbrücken* $\models$ *John has worked in Saarbrücken*
- *It is raining in Saarbrücken* $\models$ *It has rained in Saarbrücken*
- *John is painting a picture* $\not\models$ *John has painted a picture*
- *John stopped walking* $\models$ *John walked*
- *It stopped raining* $\models$ *It rained*
- *John stopped painting a picture* $\not\models$ *John painted a picture*

Aspectual Verb Classes – 2

Verbs expressing:

- States
  know, believe, own, love, resemble
- Eventualities
  - Processes/ Activities:
    run, walk, swim, work, sleep, rain
  - (Proper) Events

Verbs and Events

- Modeling verb semantics using events provides a natural solution to several hard problems of logic-based semantics.
  However:
- Not all verbs can be appropriately interpreted through implicit event arguments.
  Moreover:
- Event-expressing verbs (as opposed to statives) do not form a homogeneous semantic class.
- The same holds even for proper event verbs (as apposed to verbs expressing processes or activities).

Accomplishments vs. Achievements

- *John painted a picture*
- *John noticed the picture*
- *John reached the top of the hill*

- *John painted a picture from 9 to 11 a.m.*
- **John noticed the picture from 9 to 11 a.m.*
- **John reached the top of the hill from 9 to 11 a.m.*

- *John stopped painting a picture*
- **John stopped noticing the picture*
- **John stopped reaching the top of the hill*

- *John is painting a picture*
- **John is noticing a picture*

Aspectual Verb Classes – 3

Verbs expressing:

- States
  know, believe, own, love, resemble
- Eventualities
  - Activities:
    run, walk, swim, work, sleep
  - Events
    - Accomplishments:
      paint a picture, write a paper, build a house
    - Achievements:
      recognize, spot, find, lose, reach, die

Vendler's Verb Classification

The taxonomy of aspectual classes was introduced by the linguist Zeno Vendler in the seventies. It is intuitively appealing, but some issues remain open:

- What is the essential ontological difference between the different aspectual classes, and how can it be expressed in a logical framework?
- Vendler talks about "verb classification", but (as he observes himself) it is verb phrases (*paint a picture, walk to the station*) rather than just the verbs (*paint, walk*) that bear aspectual properties. Compositional treatment?

To find an answer to these questions, we take a (rather long) detour through the semantics of common nouns.

Plural NPs

Bill and Mary worked $\vDash$ *Bill worked*

Bill and Mary worked $\vDash$ *Mary worked*

$\text{work}(b) \wedge \text{work}(m) \vDash \text{work}(b)$

$\text{work}(b) \wedge \text{work}(m) \vDash \text{work}(m)$

The students worked , John is a student

$\vDash$ *John worked*

$\forall x(\text{student}(x) \rightarrow \text{work}(x)), \text{student}(j) \vDash \text{work}(j)$

Collective predicates

Bill and Mary met $\nvDash$ *Bill met*

The students gathered , John is a student

$\nvDash$ *John gathered*

- "meet" and "gather" are collective predicates.

Collective predicates

- Distributive predicates like *work, sleep, eat, tall* apply to singular and plural nouns. A predication with a plural NP "distributes" over the individual objects covered by the NP.
- Collective predicates are only applicable with plural or group NPs. Their semantics cannot be reduced to atomic statements about single standard individuals.

- Examples for collective predicates:
  - *meet, gather, unite, agree, be similar, compete, disperse, divide, disagree, be numerous, ...*

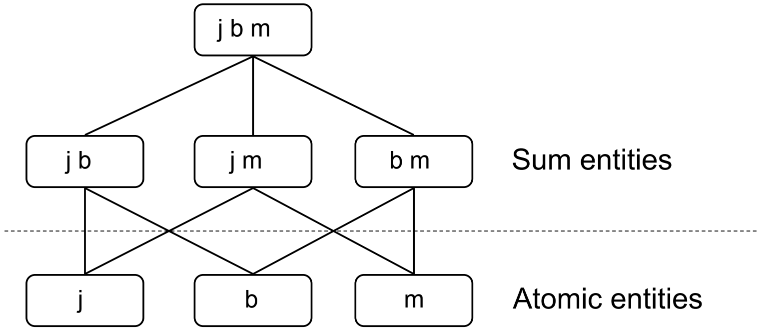
Modeling Plural Terms

- In the face of collective predicates, we cannot model the semantics of plural terms using "atomic" entities of standard FOL. In addition to standard individuals, we add another sort of entities to the model structure universe: "groups" or "sums".

- Singular expressions denote standard "atomic" entities, plural and group expressions denote sums.

- To represent the semantic relations between the group and its members, e.g., in the context of distributive predicates, we add a new relation, the membership or "individual part" relation to the model structure.

Structured Universe – Example



Lattices and Semi-lattices

- A partial ordered set is a structure <A, ≤> with reflexive, transitive, and antisymmetric ≤ .
- Let <A, ≤> be a partial order:

  The join of a and b ∈ A: $a \sqcup b$ is the lowest upper bound for a and b.

  The meet of a and b ∈ A: $a \sqcap b$ is the highest lower bound for a and b.
- A lattice is a partial order <A, ≤> which is closed under meet and join.

Lattices and Semi-lattices

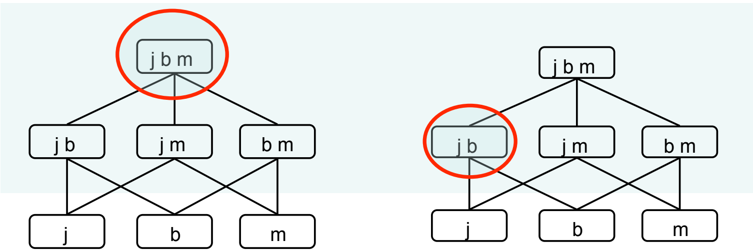
- A lattice may or may not have one maximal and minimal element. If it has such elements, they are named **1** and **0**, respectively, and the lattice is called bounded.
- An $a \in A$ is an atom, if $a \neq \mathbf{0}$ and there is no $b \neq \mathbf{0}$ in A such that $b<a$.
- A lattice $\langle A, \leq \rangle$ is atomic, if for every $a \neq \mathbf{0}$ **there is an atom** $b \leq a$.
- A join semi-lattice is a partial order $\langle A, \leq \rangle$ which is closed under join.

Model structure for plural terms

- A model structure is a pair $M = \langle \langle U, \leq \rangle, V \rangle$, where
  - $\langle U, \leq \rangle$ is an atomic join semi-lattice with universe U and individual part relation $\leq$.
  - V is a value assignment function.
- $A \subseteq U$ is the set of atoms in $\langle U, \leq \rangle$.
- $U \backslash A$ is the set of non-atomic elements, i.e., the proper sums or groups in U.

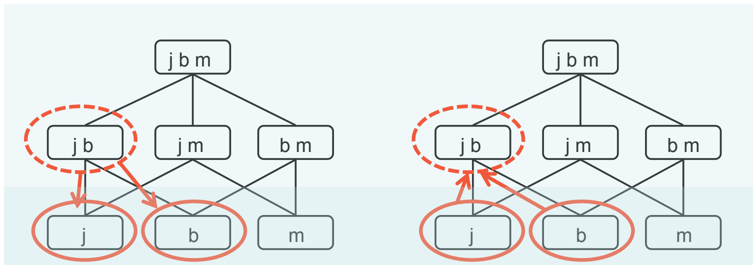
Collective predicates

- Collective predicates F (like *meet, collaborate*): $V_M(F) \subseteq U \backslash A$



Distributive predicates

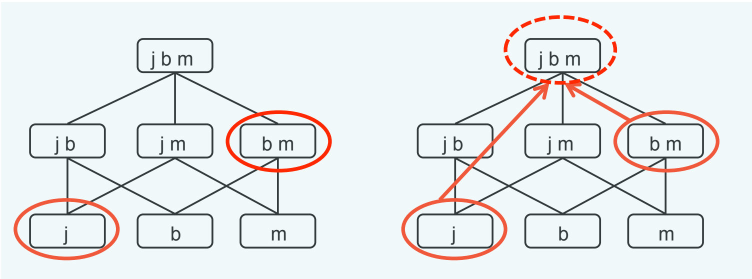
- Distributive predicates F (like *work, tall, student*): $V_M(F) \subseteq U$, such that $a \in V_M(F)$ and $b \in V_M(F)$ iff $a \sqcup b \in V_M(F)$



$\rightarrow$: Distributivity $\leftarrow$: Closure under summation

Interpretation of predicates

- Mixed predicates F (e.g., *carry a piano, solve the exercise*):
  $V_M(F) \subseteq U$



Non-distributive, but closed under summation

Language for plural terms

- Like standard FOL. We add a summation operator ⊕, a one-place predicate At for “atom” and a two-place relation ◃ for “(proper) individual part”, used as in
  - j ⊕ b, “the group consisting of John and Bill”
  - j ◃ j ⊕ b “John is member of the group consisting of John and Bill”
  - j ⊕ b ◃ the_committee: “John and Bill are members of the committee”
- We further introduce variables ranging over proper sums, and write them as X, Y, Z, ...
- Also, we may introduce number-specific individual constants “student_sg”, “student_pl” in addition to the general “student”

Interpretation

Like standard FOL interpretation

- with additional clauses for ⊕ and ◃ :
  $[\![a \oplus b]\!]^{M,g} = [\![a]\!]^{M,g} \sqcup [\![b]\!]^{M,g}$
  $[\![a \lhd b]\!]^{M,g} = 1$ iff $[\![a]\!]^{M,g} < [\![b]\!]^{M,g}$
  $[\![At(a)]\!]^{M,g} = 1$ iff $[\![a]\!]^{M,g} \in A$
- Individual constants denote either atoms ($V_M(a) \in A$) or sums ($V_M(a) \in U \backslash A$)
- Number-specific predicates take their denotations from the respective subsets of U:
  - $V_M(\text{student\_sg}) \subseteq A$
  - $V_M(\text{student\_pl}) \subseteq U \backslash A$

Examples

- *Every student presented a paper*
- *John and Mary presented a paper*
- *Two students presented a paper*
- *Two students presented three papers*