Semantic Theory
Lecture 11: Aspectual Classes, Plural and Collectives

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Verbs and Events

- Modeling verb semantics using events provides a natural solution to several hard problems of semantic theory.
- **However …**
  Not all verbs can be appropriately interpreted through implicit event arguments.

Verbs and Events

(1) Mary kicked John

(2) “there is a kicking event, in which Mary and John are involved”

(3) John likes Mary

(4) “there is a liking event, in which John Mary are involved” **(?)**

State- vs. Event-Expressing Verbs

- There are verbs expressing states and verbs expressing events (which we call non-stative for the time being)
  - **Stative verbs:** *know, believe, own, love, resemble*
  - **Non-stative verbs** (event-denoting verbs; verbs expressing "eventualities")**:** *run, walk, kick, kill, build a house*

- Only non-stative verbs come with an implicit event argument:
  - Stative transitives: like'(x, y)
  - Nonstative transitives: kick'(e, x, y)

Statives and Non-Statives: Linguistic Evidence

- **Progressive form**

(1) John is running

(2) John is building a house

*(3) *John is knowing the answer*

Statives and Non-Statives: Linguistic Evidence

- **Simple present**

(1) Mary runs (has the habit of running)

(2) John builds houses (is a professional house builder)

(3) John knows the answer

Statives and Non-Statives: Linguistic Evidence

- **Manner adverbials**

(1) John ran carefully

(2) John carefully built a house

*(3) *John carefully knew the answer*

Verbs and Events

- Modeling verb semantics using events provides a natural solution to several hard problems of semantic theory.
- **However ...**
  Not all verbs can be appropriately interpreted through implicit event arguments.
- **Moreover ...**
  Non-stative verbs do not form a homogeneous semantic class.

Linguistic Evidence: Distribution of Duration Adverbials

(1) a. *John painted a picture in an hour*

b. **John walked in an hour*

c. **It rained in an hour*

(2) a. *?John painted a picture for an hour*

b. *John walked for an hour*

c. *It rained for an hour*

(3) a. *It took John an hour to paint a picture*

b. **It took John an hour to walk*

Linguistic Evidence: Different Entailment Properties

- *John walked from 8. to 11 a.m.*

  $\models$ *John walked from 9 to 10 a.m.*

- *It rained from 8 to 11 a.m.*

  $\models$ *It rained from 9 to 10 a.m.*

- *John painted a picture from 8 to 11 a.m.*

  $\not\models$ *John painted a picture from 9 to 10 a.m.*

Linguistic Evidence: Different Entailment Properties

- *John stopped walking*

  $\models$ *John walked*

- *It stopped raining*

  $\models$ *It rained*

- *John stopped painting a picture*

  $\not\models$ *John painted a picture*

Activities vs. Events

- **Activities** or **Processes**: *run, walk, swim, work, sleep, rain*
- **Proper Events**: *paint a picture, write a paper, build a house, find a solution, reach the summit*

Linguistic Evidence: Two Sub-Classes of Proper Event Verbs

(1) a. *John painted a picture*

b. *John noticed the picture*

(2) a. *John is painting a picture*

b. **John is noticing a picture*

(3) a. *John painted a picture from 9 to 11 a.m.*

b. **John noticed the picture from 9 to 11 a.m.*

c. **John reached the summit from 9 to 11 a.m.*

(4) a. *John stopped painting a picture*

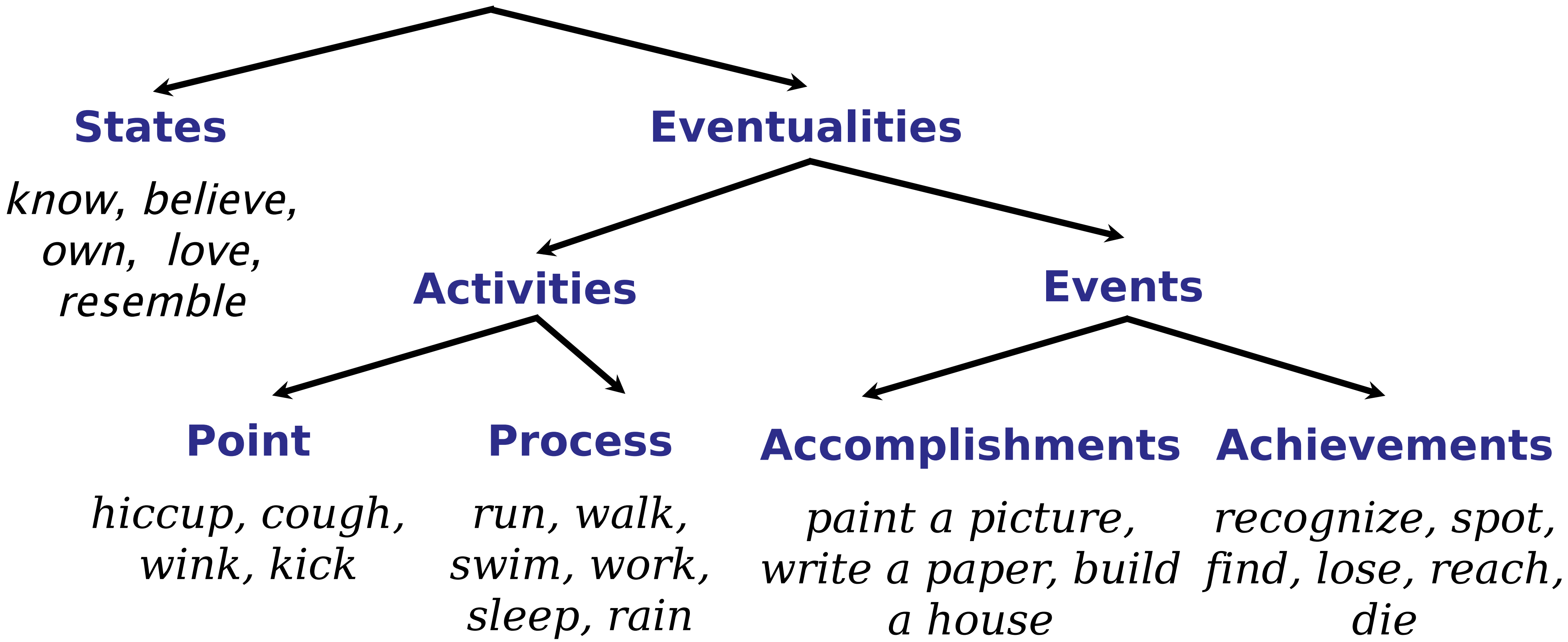
b. **John stopped noticing the picture*

c. **John stopped reaching the summit*

Vendler‘s Aspectual Verb Classes

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

An Extension of Vendler‘s Classification (Moens & Steedman 1988)



Event Categorization accroding to Moens&Steedman

Events are categorize along two dimensions:

- Temporal extension:
  - atomic/ punctual: „Point Activities“ and Achievements
  - extended: Processes and accomplishments
- Specific consequent state implied:
  - consequent state: Accomplishments and Achievements
  - no consequent state: Point Activities and Processes

Open Questions

- Strictly speaking, it is not the verbs (i.e., verb lemmas) lemmas that belong to aspectual classes. Aspect is influenced by:
- Verb Inflection, e.g., simple vs. progressive form
- Verb arguments, compare:
  - *Bill ate :* activity
  - *Bill ate an apple :* accomplishment
  - *Bill ate apples* : acitivity
- Adverbial modifiers:
  - Bill frequently smokes
  - Yesterday, Mary kicked Bill all the time

Open Questions

- The difference in the representation of statives and non-statives is clear: presence/ absence of an event argument.

But:

- How can the difference between activities and proper events be modelled?

Plural NPs

- *Bill and Mary work* ⊨ *Bill works*
- *Bill and Mary work* ⊨ *Mary works*
  - work’(b) ∧ work’(m) ⊨ work(b)
  - work’(b) ∧ work’(m) ⊨ work(m)
- *The students work , John is a student* ⊨ *John works*
  - ∀x(student’(x) → work’(x)), student’(j) ⊨ work’(j)

Collective Predicates

- *Bill and Mary met*

  $\not\models$ *Bill met*

- *The students met , John is a student*

  $\not\models$ *John met*

- **“meet” is a collective predicate.**

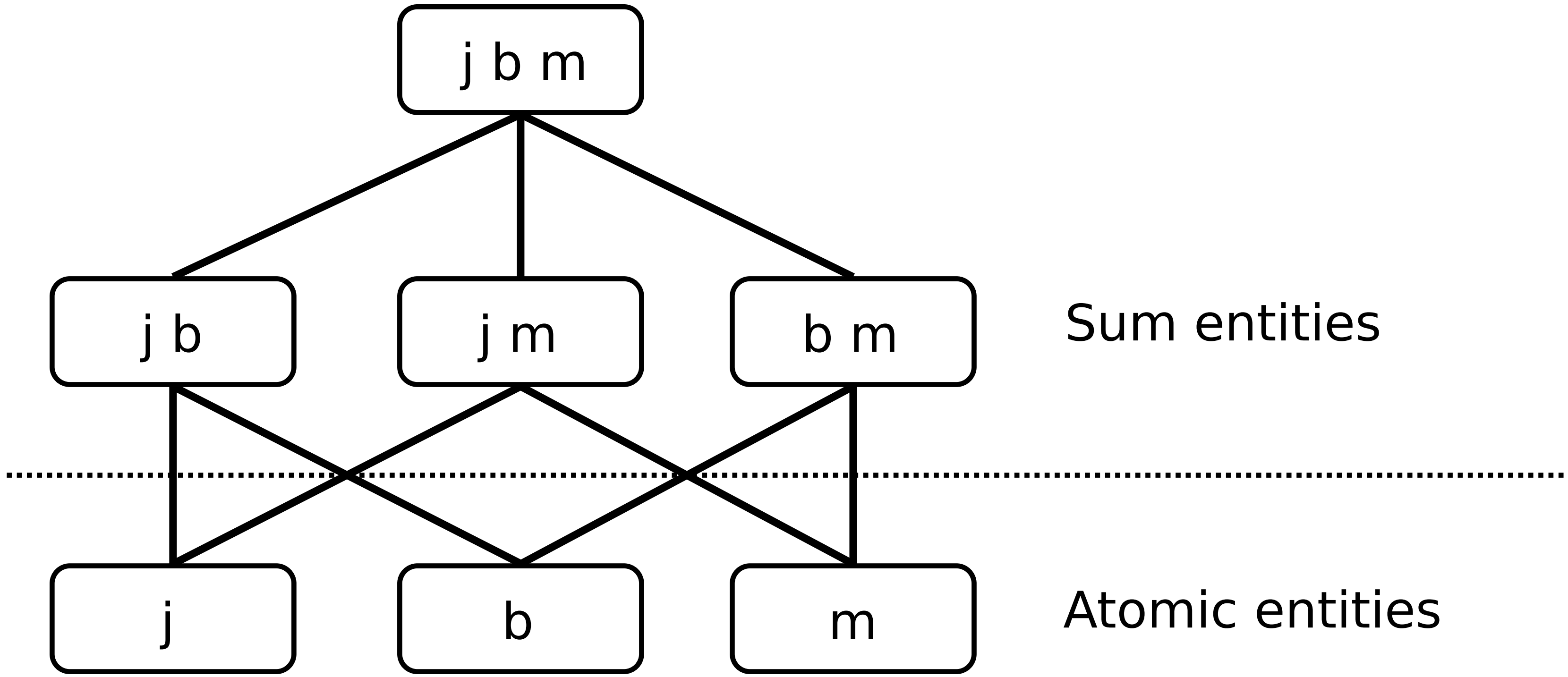
Distributive and Collective Predicates

- **Distributive predicates** like *work, sleep, eat, blond* apply to both singular and plural NPs. When applied to a plural NP, they describe common properties of the set or group of objects denoted by the NP. Therefore, the predicate "distributes" over the individual objects covered by the NP.
- **Collective predicates** only apply to expressions denoting a set or group of objects. They describe a property of the group, not of its individual members.
  - Examples: *meet, gather, unite, agree, be similar, compete, disperse, dissolve, disagree, be numerous, ...*

Sums and Atoms

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

Structured Model Universe with Sum Entities



The edges indicate the (individual) **part-of relation**.

Lattices and Semi-Lattices

- A **partially ordered set** is a structure ⟨A, ≤⟩ where ≤ is a reflexive, transitive, and anti-symmetric relation over A.
- Let ⟨A, ≤⟩ be a partial order:
  - The **join** of a and b ∈ A (Notation: **a ⊔ b**) is the lowest upper bound for a and b.
  - The **meet** of a and b ∈ A (Notation: **a ⊓ b**) is the highest lower bound for a and b.
- A **lattice** is a partial order ⟨A, ≤⟩ which is closed under meet and join.
- **A join semi-lattice** is a partial order ⟨A, ≤⟩ which is closed under the join operation.
- An element a ∈ A **is an atom**, there is no b in A (except possibly 0) such that b<a.
- A lattice ⟨A, ≤⟩ **is atomic**, if for every a (≠ 0) there is an atom b ≤ a.

Model Structure for Plural Terms

- A model structure is a pair M = ⟨⟨U, ≤⟩, V⟩, where
  - **⟨U, ≤⟩** is an **atomic join semi-lattice** with universe U and individual part relation ≤.
  - V is a value assignment function.
- A ⊆ U is the set of atoms in ⟨U, ≤⟩.
- U – A is the set of non-atomic elements, i.e., the proper sums or groups in U.

Logic for Plural and Collectives: Syntax

- New logical constants: A binary summation operator ⊕, a one-place predicate for "is an atom", At, 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 part of the group consisting of John and Bill"
  - j ⊕ b ⊲ c "John and Bill are part of the committee"
- A new type of variables, ranging over sums: X, Y, Z, ...
- Specific predicate constants to represent singular and plural of nouns, e.g.: $student^{sg}$, $student^{pl}$, in addition to the general student'.

Logic for Plural and Collecives: Interpretation

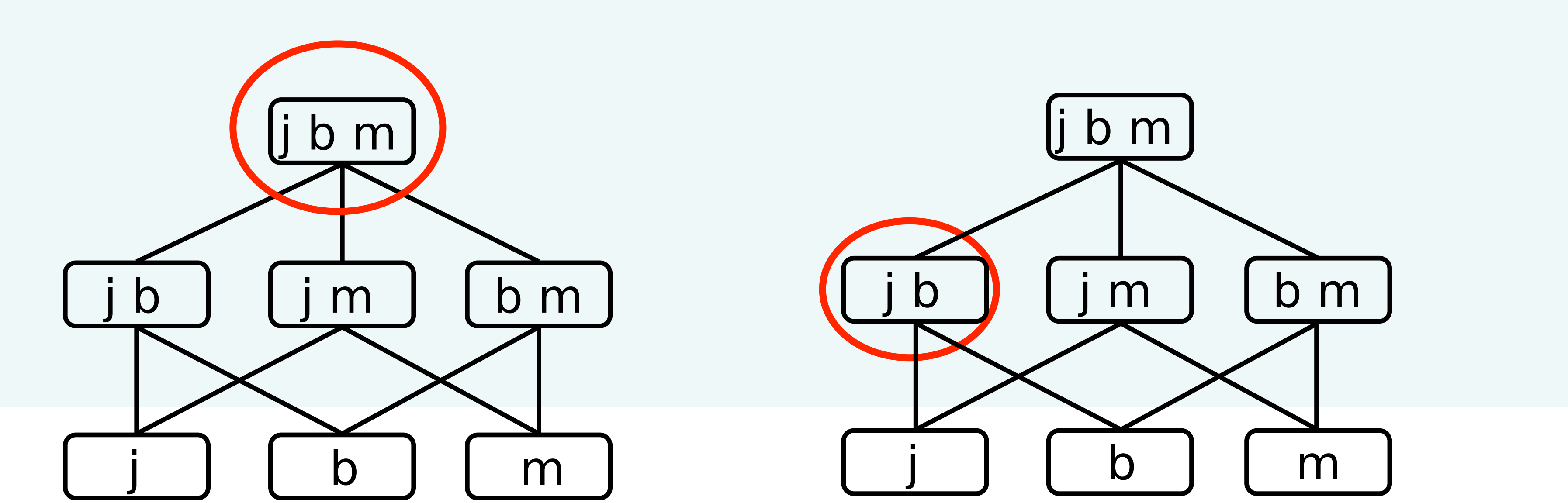
- Like standard interpretation function, with additional clauses for ⊕, ⊲, and At :
  - $[\![a \oplus b]\!]^{M,g} = [\![a]\!]^{M,g} \sqcup [\![b]\!]^{M,g}$
  - $[\![a \lhd b]\!]^{M,g} = 1$ iff $[\![a]\!]^{M,g} < [\![b]\!]^{M,g}$
  - $[\![At(a)]\!]^{M,g} = 1$ iff $[\![a]\!]^{M,g} \in A$

- The interpretation function of non-logical constants must satisfy specific constraints. See next slides.

Interpretation of Collective Predicates

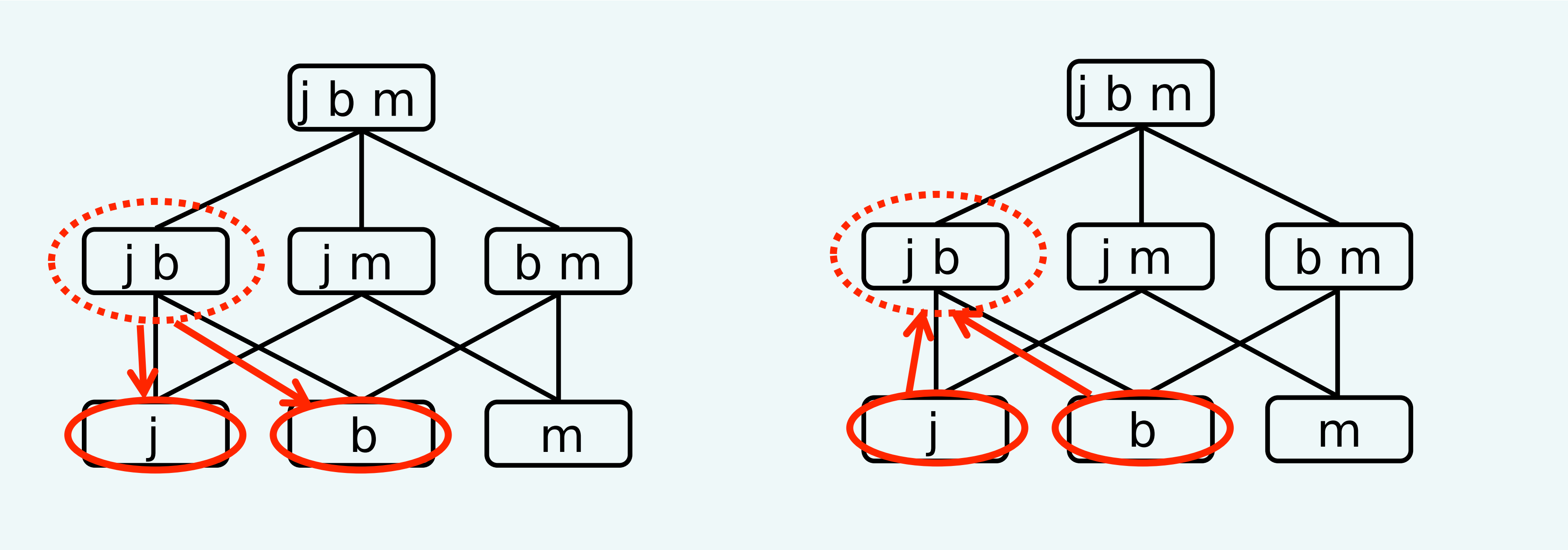
- Collective predicates F (like *meet'*, *collaborate'*, also *student^s*):

  $V_M(F) \subseteq U - A$



Interpretation of Distributive Predicates

- Distributive predicates F (like work', blond', student'):
  - $V_M(F)$ is a subset of U satisfying the following conditions:
  - If a ∈ $V_M(F)$ and b<a, then b ∈ $V_M(F)$ (**Distributivity**)
  - iff a, b ∈ $V_M(F)$, then a⊔b ∈ $V_M(F)$ (**Closure under Summation**)



Interpetation of Number

- Standard common nouns are distributive predicates. The grammatical number feature provides a distinction between atom-denoting and group-denoting uses.
- $V^M(student^{sg}) \subseteq A$
- $V^M(student^{pl}) \subseteq U - A$
- $V^M(student') = V^M(student^{sg}) \cup V^M(student^{pl})$

Examples

- *John and Mary worked*
- *John and Mary met*
- *Two students worked*
- *Two students met*
- *Two students presented a paper*

Mass Nouns and Plurals

- *water, gold, wood, money, soup, ...*
- Mass nouns and plurals are **closed under summation:**
  - students + students = students
  - water + water = water
- Mass nouns and plurals **combine with cardinalities:**
  - 5 students — 5 liters of water
- Mass nouns and plurals **share grammatical patterns:**
  - for instance, indefinite plural NPs and indefinite mass term NPs don’t take an article in English and German

Mass Nouns and Plurals

- Unlike plurals, mass nouns are **divisive**: An amount of water can always be subdivided into proper parts, which are water again.
- Mass nouns are a challenge for model theoretic semantics: Their denotations cannot be reduced to atomic individuals.

Model Structure for Mass Nouns (1)

- We add another sort of entities, the **"portions of matter"** M, to the model structure, and distinguish an individual part and a material part relation, writing $\leq_i$ for the former, and $\leq_m$ for the latter:

- $M = \langle\langle U, \leq_i\rangle, \langle M, \leq_m\rangle, V\rangle$
  - $U \cap M = \emptyset$
  - $\langle U, \leq_i\rangle$ is an atomic join semi-lattice
  - **$\langle M, \leq_m\rangle$ is a non-atomic** (and dense) **join semi-lattice**
  - V is a value assignment function

Model Structure for Mass Nouns (2)

- There is close relationship between the domain of (atomic and sum) individuals and material entities: Each individual consists of a specific portion of matter.
- To model the object-matter relation, we extend the model structure with a “materialization” function h:
- $M = \langle\langle U, \leq_i\rangle, \langle M, \leq_m\rangle, h, V\rangle$,

  where h is a homomorphism that maps (atomic and sum) individuals to the matter they consist of.
- Because h is a homomorphism, the following holds:
  - $a \leq_i b$ iff $h(a) \leq_m h(b)$
  - $h(a \sqcup_i b) = h(a) \sqcup_m h(b)$

Logic for Plurals and Mass Nouns: Syntax

- We add a material fusion operation and a material part relation, and distinguish $\oplus_i$, $\oplus_m$, $\lhd_i$, and $\lhd_m$. (summation and individual part relation are indexed with "i").
- We express the materialization function with a new logical operator m (type ⟨e, e⟩, takes a type e argument of sort "individual" and returns a type e constant of sort "matter".
- We use $\boldsymbol{x}$, $\boldsymbol{y}$, $\boldsymbol{z}$, ... as variables referring to matters.

Logic for Plurals and Mass Nouns: Interpretation

- $M = \langle\langle U, \leq_i\rangle, \langle M, \leq_m\rangle, h, V\rangle$

Interpretation of new logical constants:

- $[\![a \oplus_i b]\!]^{M,g} = [\![a]\!]^{M,g} \sqcup_i [\![b]\!]^{M,g}$
- $[\![a \lhd_i b]\!]^{M,g} = 1$ iff $[\![a]\!]^{M,g} <_i [\![b]\!]^{M,g}$
- $[\![At(a)]\!]^{M,g} = 1$ iff $[\![a]\!]^{M,g} \in A$

- $[\![a \oplus_m b]\!]^{M,g} = [\![a]\!]^{M,g} \sqcup_m [\![b]\!]^{M,g}$
- $[\![a \lhd_m b]\!]^{M,g} = 1$ iff $[\![a]\!]^{M,g} <_m [\![b]\!]^{M,g}$
- $[\![m(a)]\!]^{M, g} = h([\![a]\!]^{M, g})$

Examples

(1) a. The/A ring is made of gold

b. $\exists y$ [ring(y) $\wedge$ gold(m(y))]

(2) a. The/A ring contains gold

b. $\exists y \ \exists \boldsymbol{x}$ [ring(y) $\wedge$ $\boldsymbol{x} \lhd_m$ m(y) $\wedge$ gold($\boldsymbol{x}$)]