



Ontology in Formal Semantics and Lexical Semantics

ESSLLI 2005 introductory course on
Formal Ontology for Semanticists - Lesson 2

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Outline

- ▶ Introduction
- ▶ Formal Semantics
 - ▶ Basic categories
 - ▶ Time
 - ▶ Mereological structures
- ▶ Lexical Semantics
 - ▶ General structure of the lexicon
- ▶ Formal *and* Lexical Semantics



Referential Semantics and NL Ontological Commitment

- ▶ Referential semantics requires a representation of the world
- ▶ Choice of a descriptive attitude: language-dependent world
 - ▶ for being faithful to linguistic behaviour, for a better semantics
 - ▶ for a cognitive conceptualization of reality
- ▶ Analyzing the ontological commitment of NL, i.e., doing "natural-language metaphysics" [Bach, 1986b]
 - ▶ multiplicationism
 - ▶ relativism vs. universalism?



Interaction between disciplines

► Ontology in NL semantics

- implicit assumptions
- explicit assumptions
- research on adequate theories for a specific domain / phenomenon

► Linguistics in Ontology

- ontological analysis based on linguistically-expressed philosophical arguments (difficult to escape from language)
- ontological analysis based on linguistic intuitions and philosophy of language arguments



The two branches of NL semantics

► Formal semantics

- study of linguistic phenomena affecting truth-values
- semantics of “logical” vocabulary
- essentially grammaticalized phenomena: closed classes
- compositionality principle based on syntactic structure

► Lexical semantics

- semantics of “content words”
- open-class words

► Fuzzy boundary

- grammaticalization is a process
- different languages, different boundaries

► Both formal and lexical semantics reveal NL ontological commitments



Basic categories

- ▶ **Non-logical vocabulary of predicate logic**
 - ▶ distinction between
particulars: variables and individual constants
and
universals: predicates
 - ▶ Focus on domain of quantification implies focus on sub-categories of particulars
- ▶ **Explicit types in Montague Grammar**
 - ▶ basic types *e* (particulars) and *t* (abstract propositions)
 - functional types: $\langle e, t \rangle$, $\langle e, \langle e, t \rangle \rangle$, $\langle t, t \rangle$... (universals, modifiers and logical vocabulary)
 - ▶ type *s* for intensional types (abstract situations)



Time

- ▶ Dealt with in formal semantics, because tense is a grammatical feature in western languages
- ▶ First index added after world in intensional logic [Dowty, 1977], large literature
- ▶ Three domains of temporal referents: *instants*, *intervals* and *events*
- ▶ Technical aspects of the ontology of time treated in more details in lesson 4



Instants

- ▶ Time points, usually assumed to form a linear order isomorphic with the rationals or the reals
- ▶ Not much questioned category (although abstract), often used without making the ontological assumption explicit
- ▶ Classical example: in [Reichenbach, 1947], semantics of tense in terms of time points and relations of precedence and identity
 - ▶ Different tenses exhibit different relational patterns of 3 time points: speech (S), event (E) and reference (R) time
 - ▶ *I saw Mary*: E,R – S
 - ▶ *I had seen Mary*: E – R – S



Instants-2

- ▶ [Dowty, 1977, Dowty, 1979], focussing on progressive tenses, shows that reference to *intervals* can't be avoided
 - ▶ not all assertions that a sentence is true at an interval can be reduced to assertions that this sentence is true at instants of this interval: *I walked for two hours*



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 - ▶ not all assertions that a sentence is true at an interval can be reduced to assertions that this sentence is true at instants of this interval: *I walked for two hours*
 - ▶ Two explicit ontologies of instants are adopted:
 - ▶ dense linear order of time points and
 - ▶ dense future-branching order of time points
- in which intervals are defined as convex sets of instants, distinguishing between open and closed ones



Intervals

Allen [Allen, 1984] proposes an ontology of time taking intervals as *primitive* entities

- ▶ Arguably more commonsensical: nothing happens in punctual, non-extended, time
- ▶ Avoids the use of set theory: expressed in a first-order logic
- ▶ 13 relations, definable in terms of a single primitive one



Events

Much more questioned category, although Davidson's seminal paper [Davidson, 1967] influenced many subsequent work [Kamp, 1979, Kamp, 1981a, Bach, 1986a]

- ▶ How many arguments for a verb?
 - ▶ *Jones buttered the toast*
Butter(Jones, toast)
 - ▶ *Jones buttered the toast with the knife*
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 - ▶ *Jones buttered the toast with the knife*
Butter(Jones, toast, knife)
- ▶ Reify events, implicit arguments of verbs;
distinguish necessary arguments and optional parameters
 - (1) $\exists e \text{ Butter}(e, \text{Jones}, \text{toast})$
 - (2) $\exists e (\text{Butter}(e, \text{Jones}, \text{toast}) \wedge \text{With}(e, \text{knife}))$

(2) logically entails (1)



Events-2

► Further advantages

- Event anaphora: *It happened at midnight*
event nominalization: *The buttering was slow*
- Quantification: *In every burning, oxygen is consumed and Ann burned the wood, therefore Oxygen was consumed.*
- Predication over events: *I enjoyed reading the book, I saw you enter, I heard the explosion*



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- ▶ But: no widely accepted ontologies of events...



Aspect and Aktionsart

- ▶ Intrusion of lexical semantics into formal semantics
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- ▶ Not all tenses can be applied to all verbs
 - ▶ * *I am knowing the answer*
- ▶ Not all adverbials can modify all VPs
 - ▶ * *I ate in an hour / I ate 3 apples in an hour*
 - ▶ *I ate for an hour / * I ate 3 apples for an hour*
- ▶ Entailment test
 - ▶ *I am pushing a cart* \models *I have pushed a cart*
 - ▶ *I am drawing a circle* $\not\models$ *I have drawn a circle*



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- ▶ Verb categories
 - ▶ States, activities, accomplishments, achievements
- ▶ Complement categories
 - ▶ Singular count nouns, plural nouns, mass nouns



Mereological structures

- ▶ Determiners distinguish mass/count/kind NPs in western languages



Mereological structures

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- ▶ mass terms
 - ▶ *there is some water / water / apple in this bowl*
- ▶ singular count nouns and plurals
 - ▶ *there is an apple in this bowl, there are some apples / two apples / apples in this bowl*
- ▶ generics
 - ▶ *the dodo is extinct, lions have whiskers, water is widespread*



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- ▶ generics
 - ▶ *the dodo is extinct, lions have whiskers, water is widespread*
- ▶ Most analyses make use of mereological or algebraic structures



Mass terms

[Quine, 1960, Parsons, 1970, Pelletier, 1979]

- ▶ Entities
 - ▶ **objects** *the bottle is on the table*
 - ▶ **amounts of matter** *there is water in the bottle*
 - ▶ **substances** (kinds) *water is widespread, this ring is gold*
- ▶ **Amounts of matter form a mereology (GEM assumed)**
 - ▶ Cumulative reference and disjunctive reference
 - ▶ Atomicity?
 - ▶ Substances sometimes identified with the fusion of all amounts of that substance
- ▶ **Substance predication**
 - ▶ *the matter making up this ring is gold*
simply P if substances are maximal sums
- ▶ **Substance abstraction operator for complex substances**
- ▶ **Constitution (see lesson 3)**
 - ▶ *this ring is made of a piece of gold*



Plurals

[Link, 1983]

- ▶ Plurals \neq collections: *the cards, the deck of cards*
 - ▶ Both are *constituted* by the same amount of matter
- ▶ Plural mereological structure (\leq_i) in addition to the mass mereological structure (\leq_m), linked by Const
 - ▶ Domain of \leq_i is **both** objects and amounts of matter
 - ▶ \leq_i is atomic: atoms are singular objects and amounts of matter
 - ▶ $x \leq_i y \rightarrow x \leq_m y$
 - ▶ Only \leq_i provides identity $=$; \leq_m yields only material equivalence $=_m$; $Const(x, y) \rightarrow x =_m y$
- ▶ Cumulative reference applies to plurals
 - ▶ plural predication based on (plural) fusion





Lexical Semantics

- ▶ First account of some lexical semantic constraints in generative grammar and structural semantics through *features* [Katz and Fodor, 1963] (animate/inanimate, gender, ...) and *thematic roles* [Fillmore, 1968] (agent, patient, theme ...)
- ▶ Cognitive semantics has also proposed a variety of semantic primitives [Jackendoff, 1983, Wierzbicka, 1996]
- ▶ Ontological issues more focussed on in approaches to the *general structure* of the lexicon



Structuring relations in the lexicon

- ▶ General studies of the lexicon, e.g. [Cruse, 1986]
 - ▶ mainly stemming from structural semantics
 - ▶ can be exploited from a referential point of view, assuming elements are the predicates lexemes refer to
- ▶ Essentially taxonomies of unary predicates
 - ▶ structured by hyperonymy/hyponymy, i.e., \rightarrow
- ▶ Additional logical relations
 - ▶ synonymy: \leftrightarrow
 - ▶ antonymy: \neg
 - ▶ converse (for binary relations): $R(x, y) \leftrightarrow R'(y, x)$
- ▶ Others structuring relations
 - ▶ meronymy: mereology + varieties of part-of relations
 - ▶ antonymy: opposites wrt some dimension (qualities)
 - ▶ nominalization/verbalization: causation
- ▶ WordNet, most widely used thesaurus (see lesson 5)



The Generative Lexicon

[Pustejovsky, 1991, Pustejovsky, 1995,
Asher and Pustejovsky, 2000]

- ▶ **Accounting for systematic polysemy and coercion patterns**
 - ▶ *John began the book*: reading / writing ambiguity
 - ▶ *John enjoyed the book*
- ▶ **Qualias**
 - ▶ Formal: information contents
 - ▶ Constitutive: physical realization
 - ▶ Agentive: writing event
 - ▶ Telic: reading event
- ▶ **Dot objects**
 - ▶ copredication: *Mary burned the book I had read*
 - ▶ complex types



Discourse and the semantics-pragmatics interface

- ▶ Representational approaches to discourse semantics:
DRT [Kamp, 1981b, Kamp and Reyle, 1993] and SDRT [Asher, 1993, Asher and Lascarides, 2003]
- ▶ Requires reasoning on the discourse contents exploiting
 - ▶ compositional semantics
 - ▶ lexical semantics
 - ▶ commonsense and world knowledge
- ▶ The need for a **coherent and general** ontology is more obvious



Conclusion

Semantics has brought a lot to Ontology Foundational ontology helps doing better semantics

- ▶ Systematic, coherent, global account of ontological assumptions
- ▶ Difficult to study systematic interaction between ontological domains only relying on linguistic data
- ▶ Difficult to study generic categories (top-level) and relations only relying on linguistic data
- ▶ Difficult to tell if language favours one or the other subtle axiomatic options



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