

Concepts, Categories and Meaning

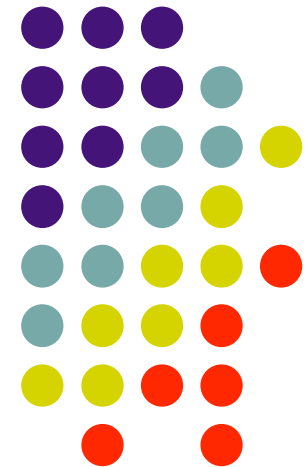
Ontologies and Semantic Representations

Alessandro Lenci

Dipartimento di Linguistica "T. Bolelli"
Università di Pisa



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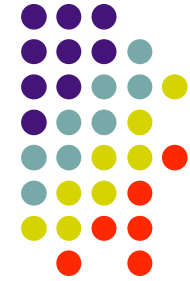
Outline



- What is an ontology?
- Ontology and linguistic analysis
- Ontology and lexical semantics
- Adequacy levels for ontologies
- The limits of ontologies for lexical representations

What is an ontology?

(for computer scientists)



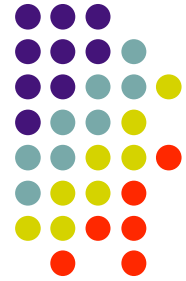
“A body of formally represented knowledge is based on a conceptualization: the objects, concepts, and other entities that are presumed to exist in some area of interest and the relationships that hold them (Genesereth & Nilsson, 1987). A conceptualization is an **abstract, simplified view of the world that we wish to represent for some purpose**. Every knowledge base, knowledge-based system, or knowledge-level agent is committed to some conceptualization, explicitly or implicitly.

An ontology is an explicit specification of a conceptualization. The term is borrowed from philosophy, where an ontology is a systematic account of Existence. For knowledge-based systems, what “exists” is exactly that which can be represented. When the knowledge of a domain is represented in a declarative formalism, the set of objects that can be represented is called the universe of discourse. This set of objects, and the describable relationships among them, are reflected in the representational vocabulary with which a knowledge-based program represents knowledge. **Thus, we can describe the ontology of a program by defining a set of representational terms.** In such an ontology, definitions associate the names of entities in the universe of discourse (e.g., classes, relations, functions, or other objects) with human-readable text describing what the names are meant to denote, and formal axioms that constrain the interpretation and well-formed use of these terms.”

Gruber (1993: 199)

What is an ontology?

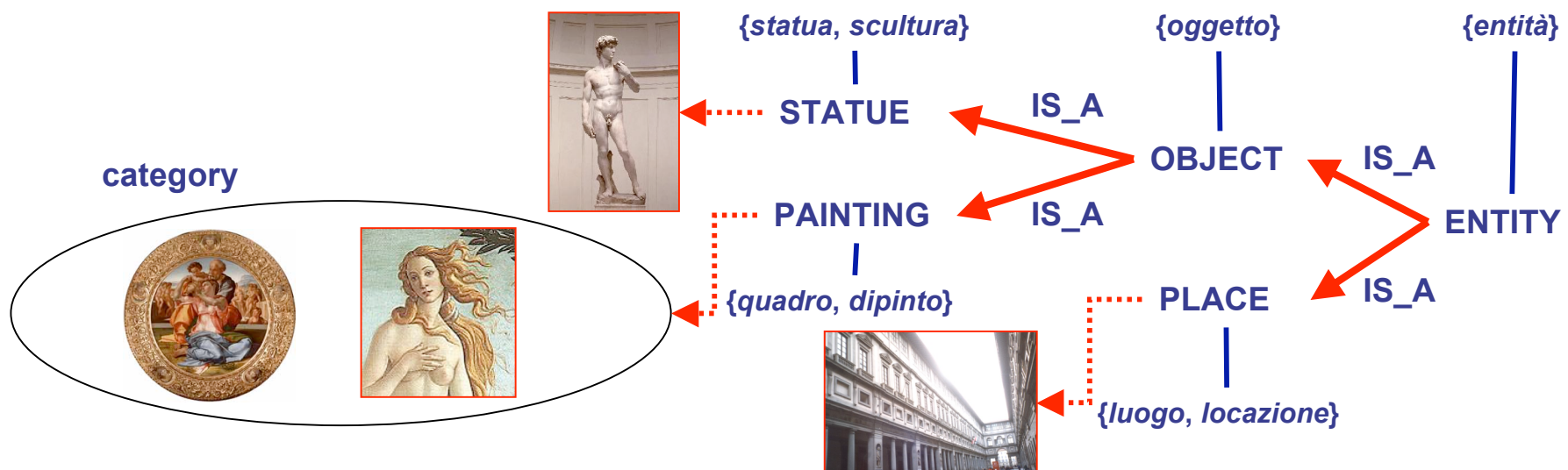
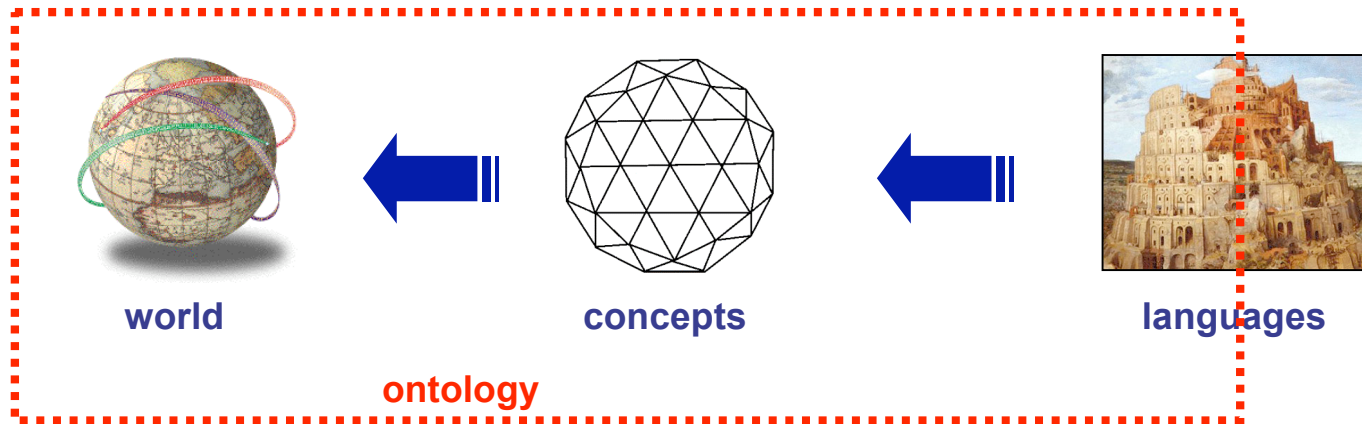
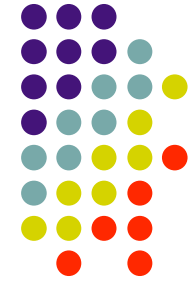
(for computer scientists)



An ontology is a formal specification of a system of concepts representing aspects of reality

- The ingredients of ontologies
 - a **piece of reality** that we want to represent
 - cf. world entities, **categories** of world entities, relations, etc.
 - **concepts** (i.e. abstract, schematic, mental(?) entities) representing the world
 - cf. concepts as representation of categories of entities
 - a **formal language** to express the concepts and the relations between them
 - e.g. 1st order logic, etc.
 - (optional) a **natural language** that expresses the concepts and that “talks about” the reality they represent
 - not necessary, if an ontology is meant only for computer-to-computer interaction (e.g. DB conceptual scheme)

The ingredients of ontologies



What is an ontology? (for linguists)



“These instances of mental universals join other less common concepts to constitute a complex structure in our minds, a **network of cross-connected conceptualizations of the phenomena that make up our world**. Following more and more widespread usage we call such **a system of conceptualizations an ontology**, and we submit that the most reliable basis for any cross-linguistic research lies in the common core of the different individual human ontologies. [...]

Part of knowing French is to know (a sufficient) proportion of the words of French, and part of knowing the French word *canard* is to know that its meaning relates it (among other things) to the concept DUCK, and this is part of its ontological identity. [...] **So to know a language means to have a special kind of ontological knowledge”**

Schalley & Zaefferer (2007:3-10)

“We define an ontology as a **structured inventory of basic, atomic concepts**, as well as complex concepts that are derived via well-formedness rules. [...] We assume that **the ontology is independent of any particular language**, but that it acts as a filter on the possible lexicons of human languages. Only concepts that are sanctioned in the ontology can potentially be lexicalized. We argue that **the lexicon reflects the ontology, which can be “discovered” through the patterns by which existing words are related to one another”**

Fellbaum (2007:419)

What is an ontology?

(for linguists)

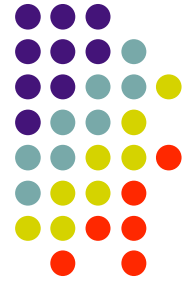


- The ingredients of ontologies (for linguists)
 - **world**, **concepts** (representing the world), and **language** (expressing the concepts)
- A different role for language
 - we are interested only to **language-related conceptualizations**

“The job of the linguist is to find convincing answers to the question: *What kinds of things do people talk as if there are?* [...] It should be clear by now that the subject matter of **Language Ontology** [...] should interest every linguist who subscribes to the view that linguistic signs associate perceivable forms with conceptual contents, because these conceptual contents are never isolated in human language users, but **integrated into the way they conceptualize their world, their individual ontology**”

Nickles et al. (2007:36)

Language-related ontologies



- Three senses of being “**language-related**”
 1. **the ontology is used to provide an explanation of the linguistic generalizations in the grammar**
 - e.g. morphological marking, syntactic distribution, acquisitional patterns, typological universals, etc.
 2. **the ontology is used to represent the meaning (semantics) of lexical items**
 - the meanings of lexical expressions “are” the concepts of the ontology
 3. **the ontology is derived from language**
 - the behavior of linguistic expressions is the (possibly unique) source for the conceptualizations in the ontology

Ontologies and grammar



- The way lexical items behave in grammar is determined by their **ontological status (semantic type)**
- Morphological encoding
 - the ontological type of a noun determines the choice of spatial prepositions (or cases)
 - (1) a. *Gianni è **nella** scuola.* (LOCATION)
b. *Gianni è **dalla** madre.* (HUMAN)
 - the **animacy** of the direct object determines its morphosyntactic encoding (cf. **Differential Object Marking**; Aissen 2003, etc.)
 - (2) a. *Pedro besó **a** Lucía.* (ANIMATE)
b. *Pedro besó el retrato.*
c. *Pedro vio (a) la gata.*

Ontologies and grammar

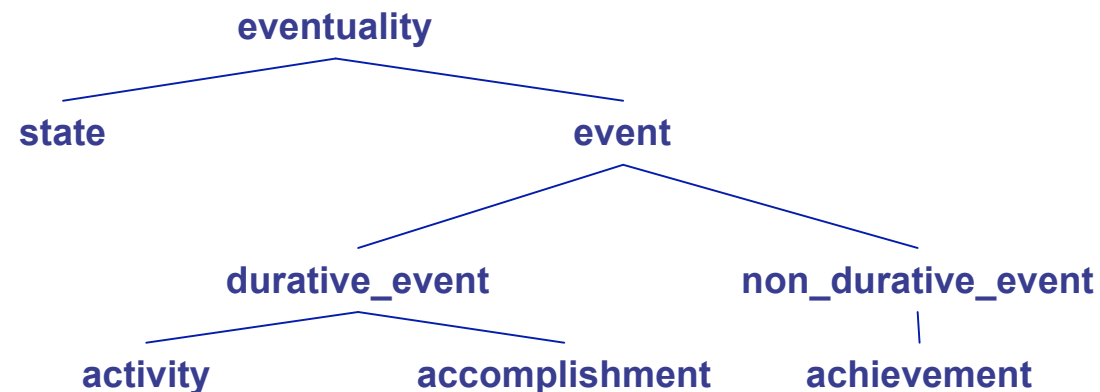
The case of event types



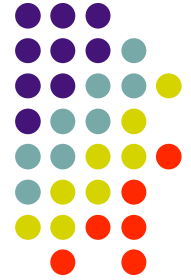
- **Verb event type** (aktionsart, lexical aspect)
 - the standard classification of verbal predicates into **states**, **activities**, **accomplishments** and **achievements** (cf. Vendler 1967, Dowty 1979, Rothstein 2004, etc.)

	telic	durative	dynamic
State (STA)	-	+	-
Activity (ACT)	-	+	+
Accomplishment (ACC)	+	+	+
Achievement (ACH)	+	-	+

An ontology of event types

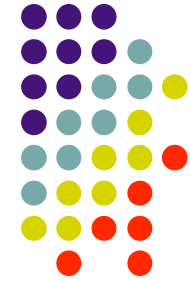


Event types in grammar



- The event type is used to explain many grammatical properties
 - **syntax-semantics interface**
 - telicity conditions the realization of an argument as direct object (cf. Tenny 1994, Beavers 2006)
 - (1) a. John ate (at) the sandwich.
 - b. John wrote (on) his dissertation.
 - cf. partitive vs. accusative case in Finnish
 - **language acquisition**
 - crosslinguistically, perfective morphemes are first produced with telic verbs, and imperfective ones with atelic verbs (cf. Aspect-First Hypothesis; Antinucci & Miller 1976; Bickerton 1984 etc.)
 - tense-aspectual morphological learning would be triggered by event types, as part of the children innate endowment

Event types in grammar



- In many languages, intransitive verbs differ for the type of auxiliary they select (**split intransitivity**)
 - (1) a. *Gianni è arrivato.*
b. *Gianni ha gridato.*
- The choice of the auxiliary is (partially) determined by the **verb event type**
 - **Auxiliary Selection Hierarchy** (Sorace 2000)
 - change of location selects BE (least variation)
 - change of state
 - continuation of state
 - existence of state
 - uncontrolled process
 - controlled process (motional)
 - controlled process (non-motional) selects HAVE (least variation)

Ontologies and meaning representation



- Ontologies are used to represent the meanings of lexical items
 - cf. WordNet, FrameNet, MikroKosmos, Omega Ontology, SIMPLE, etc.
- Ontologies for lexical representations differ for:
 - **type of formal metalanguage**
 - cf. feature lists, semantic networks, frame semantics, etc.
 - **type of meaning representation**
 - cf. holistic (e.g. WordNet) vs. compositional
 - **type of semantic properties they account for**
 - cf. semantic lexical relations (cf. WordNet), argument structure (cf. FrameNet), etc.

Ontologies and semantic representation



- **Adequacy criteria**
 - the ontological representation is adequate iff it can account for the semantic behavior of lexical items
- Some key semantic properties to be explained
 - meaning polymorphism
 - semantic similarity
 - lexical inference
 - lexical combinatorial constraints



Semantic polimorphism

- Words have multiple meanings
 - they change their interpretation depending on the context
- (1) a. *This **bank** denied a new loan to John.* (INSTITUTION)
b. *The **bank** of this river is slippery.* (LOCATION)

The senses of
bank in
WordNet 2.1.

WordNet 2.1 Browser

File History Options Help

Search Word: bank

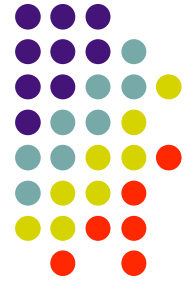
Searches for bank: Noun Verb Senses: []

The noun bank has 10 senses (first 9 from tagged texts)

1. (883) depository financial institution, **bank**, banking concern, banking company -- (a financial institution that accepts deposits and channels the money into lending activities; "he cashed a check at the bank"; "that bank holds the mortgage on my home")
2. (99) **bank** -- (sloping land (especially the slope beside a body of water); "they pulled the canoe up on the bank"; "he sat on the bank of the river and watched the currents")
3. (76) **bank** -- (a supply or stock held in reserve for future use (especially in emergencies))
4. (54) **bank**, bank building -- (a building in which the business of banking transacted; "the bank is on the corner of Nassau and Witherspoon")
5. (7) **bank** -- (an arrangement of similar objects in a row or in tiers; "he operated a bank of switches")
6. (6) savings bank, coin bank, money box, **bank** -- (a container (usually with a slot in the top) for keeping money at home; "the coin bank was empty")
7. (3) **bank** -- (a long ridge or pile; "a huge bank of earth")
8. (1) **bank** -- (the funds held by a gambling house or the dealer in some gambling games; "he tried to break the bank at Monte Carlo")
9. (1) **bank**, cant, camber -- (a slope in the turn of a road or track; the outside is higher than the inside in order to reduce the effects of centrifugal force)
10. **bank** -- (a flight maneuver; aircraft tips laterally about its longitudinal axis (especially in turning); "the plane went into a steep bank")

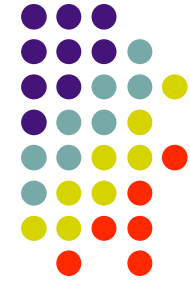
Overview of bank

Semantic similarity

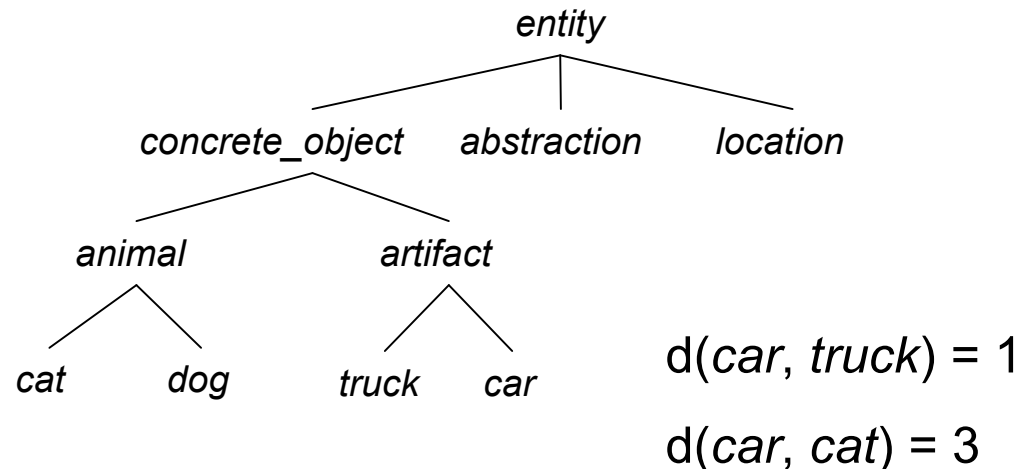


- Understanding the meaning of a word implies understanding which other words it is similar to
 - the degree of semantic similarity between two words has important behavioral effects (cf. **semantic priming**)
- **Semantic similarity**
 - two words sharing a high number of “semantic features”
 - synonymy
 - *car – automobile*
 - co-hyponymy
 - *car – van – truck, etc.*
- **Semantic relatedness** (Budanitsky & Hirst 2006)
 - two words are related without being necessarily similar
 - prototypical event
 - *car – drive*
 - association
 - *car - speed*

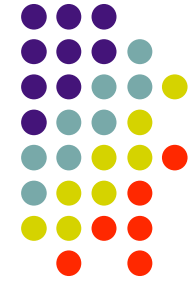
Ontologies to measure semantic similarity



- The semantic similarity between two words can be measured by the **proximity** (distance) of the elements in the ontology that represent their meanings
- Many measures have been proposed to use **WordNet** to estimate the semantic similarity (cf. Budanitsky & Hirst 2006)
 - number of arches (nodes) forming the path connecting two synsets

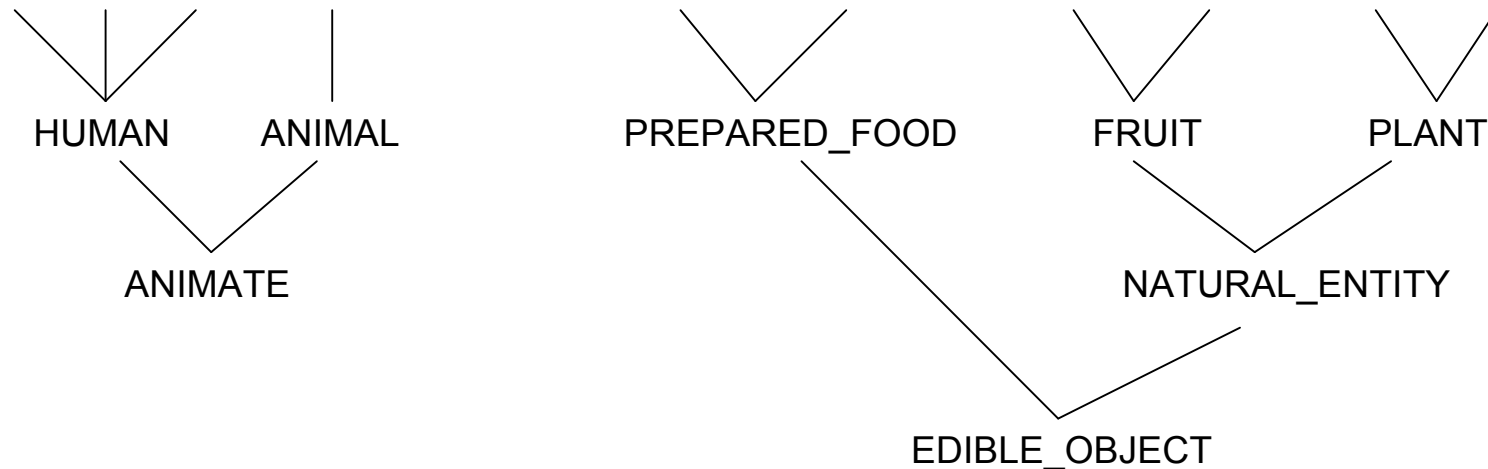


Combinatorial constraints



- The combinatorial properties of lexical items are **semantically constrained**
 - the **semantic type** of an argument (aka selectional preferences) is an **abstraction over a cluster of semantic properties** shared by the linguistic expressions that typically can fill the argument

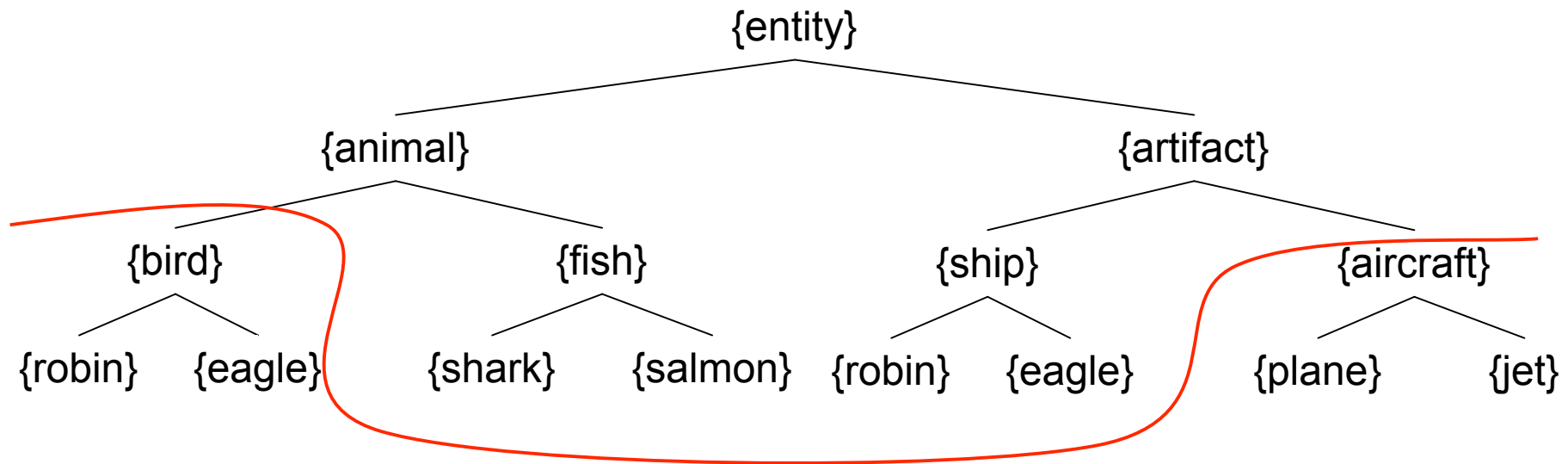
The {*man, boy, girl, giraffe*} eats the {*cake, sandwich, apple, banana, grass, leaf*}



Ontologies and semantic types



- The conceptual atoms of ontologies (e.g. WordNet) can be used to specify the combinatorial constraints of lexical items
 - various methods have been proposed in NLP to map arguments onto WordNet synsets to capture their semantic preferences
 - e.g. *to fly* (x:{BIRD},{AIRCRAFT})



Language-related ontologies

interim summary



- Ontologies *prima facie* are able to provide a satisfactory “characterization” of existing generalizations in grammar
 - cf. the crucial role of event types in current linguistic theories
- Ontologies *prima facie* are able to provide a satisfactory representations of lexical meaning which is able to account for different sorts of semantic phenomena
 - semantic polimorphisms, similarity, inference, combinatorial constraints, etc.

Adequacy levels in grammar (Chomsky 1965)



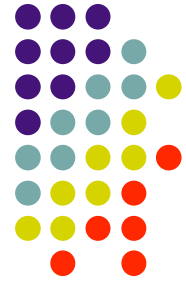
- **Observational adequacy**
 - A grammar of a language L is observationally adequate iff it generates all and only the sentences of L
 - *John reads a newspaper vs. *John a reads newspaper*
- **Descriptive Adequacy**
 - A grammar of a language L is descriptively adequate iff it is an appropriate representation of the linguistic knowledge/intuition of speakers of L
 - e.g. the grammar must account for the structural ambiguity of sentences, the structural differences underlying superficially similar sentences, etc.
 - cf. *È arrivato un uomo* “A man arrived” vs. *Ha gridato un uomo* “A man cried”
- **Explanatory Adequacy**
 - A grammar of a language L meets the condition of explanatory adequacy iff it offers a principled explanation of the competence of speakers of L
 - e.g. the grammar provides an explanation for how it is acquired, for language universals, etc.

Adequacy levels for ontologies



- **Observational adequacy**
 - An ontology L for a domain D is observationally adequate iff it represents all and only the conceptual relations holding for D
 - cf. LION IS_A ANIMAL vs. * LION IS_A LOCATION
- **Descriptive Adequacy**
 - An ontology for a domain D is descriptively adequate iff it is an appropriate representation of the knowledge/intuition of speakers (experts) about D
 - e.g. the ontology must account for the lexical ambiguity of terms expressing the concepts of D , for the semantic difference underlying superficially similar sentences expressing statements about D , etc.
 - cf. *bank* → *BANK1: INSTITUTION; BANK2: LOCATION*
 - cf. *il ponte di ferro* “the iron bridge” vs. *la ruota della macchina* “the car wheel”
- **Explanatory Adequacy**
 - An ontology of a domain D meets the condition of explanatory adequacy iff it offers a principled explanation of the knowledge of speakers about D
 - e.g. the ontology provides an explanation about crosslinguistic semantic generalizations, about how concepts are acquired, created, etc., and is consistent with cognitive evidence

Adequacy levels for ontologies



- Ontologies differ for the adequacy levels they must reach
- Ontologies for IT and HLT applications don't need to satisfy explanatory adequacy
 - they must offer a **complete and consistent** characterization of a certain domain of knowledge
 - e.g. an ontology for the medical domain must provide an explicit and correct organization of medical knowledge (diseases, organs, etc.)
 - practical requirements are not a secondary issue
 - an ontology is adequate as long as it grants satisfactory operability conditions in a given domain

Descriptive adequacy is not enough for language-related ontologies

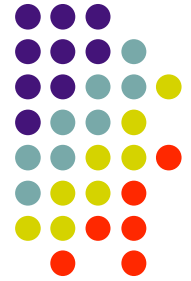
Language-related ontologies must reach explanatory adequacy

Language, ontologies and adequacy



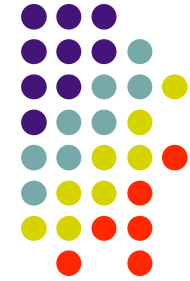
- Many language-related ontologies seem to be happy with (at most) **descriptive adequacy**
 - “We believe that human language **can be meaningfully mapped** to a formal ontology for use in computational understanding of natural language expressions. We have created a formal ontology in a first order logical language called the Suggested Upper Merged Ontology (SUMO) [...] We have created an index linking all [...] synsets from WordNet to terms in SUMO” (Pease 2007 103)
 - “WordNet showed that hyponymy, meronymy, synonymy, antonymy, and a small number of lexical entailment relations are indeed sufficient for organizing the lexicon of English, and WordNets have since been built successfully for a growing number of other languages. Among the most important findings of the WordNet experiment are that [...] there are no words that cannot easily be integrated into the network, i.e., **all words can be linked to others by means of at least one semantic relation**” (Fellbaum 2007: 421)

Language, ontologies and explanatory adequacy



- *To what extent ontologies for grammar characterization are explanatory adequate?*
 - do they provide **satisfactory explanations** of grammatical generalizations?
 - is the ontology supported by **cognitive evidence**?

Event types and TAM acquisition



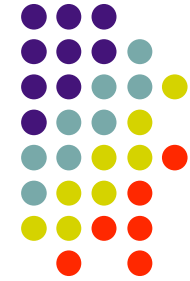
- Li & Shirai (2000) contest the widespread assumption that it is necessary to resort to innate event types to explain acquisition patterns of TAM morphology
 - the strong association between perfective (imperfective) morphology and telic (atelic) verbs is also **present in the adult input**
 - in CDS these associations are even stronger than in ADS
- The pattern can be explained by the children tendency to **mimic adult input**
 - event types are also **inductively acquired**, rather than being part of the child innate endowment
 - cf. also Bertinetto, Lenci, *et al.* (2006) and (2008)

Event types in the mental lexicon



- Bonnotte (2008)
 - stable representations of semantic knowledge about event types available and accessible in long-term memory in normal people
 - experimental study
 - semantic priming (SOA 200ms and 100ms) in French adults with two visual semantic-decision tasks
 - “is the target durative?”
 - “does the target refer to a situation with a directly observable outcome?”
 - **durativity**: facilitation of ACT verbs both with similar and opposite priming, no effect on ACH verbs
 - **resultativity (telicity)**: facilitation of ACH verbs only with similar priming, no effect on ACT verbs

Event types in the mental lexicon



- Lenci & Zarcone (in preparation)
 - ongoing semantic prime and eye-tracking experiments to acquire evidence on event type understanding
 - pilot experiment to test subjects' convergence on the identification of the V(P) event type
 - **graphic coding task**, paper-and-pencil format

▪ states



▪ activities



▪ accomplishments



▪ achievements





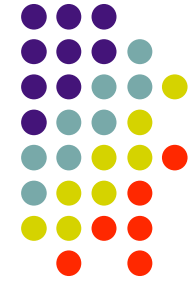
Materials and subjects

- 20 (**non linguistic**) students, native speakers of Italian, aged 18-27 (average age 22.5)
- Stimuli
 - 162 VPs

	ACC	ACH	ACT	STA	ACH/STA
Transitive non polysemous VPs	24	24	24	24	-
Transitive polysemous VPs	-	-	-	-	24
Intransitive non polysemous VPs	-	21	21	-	-

Materials

examples



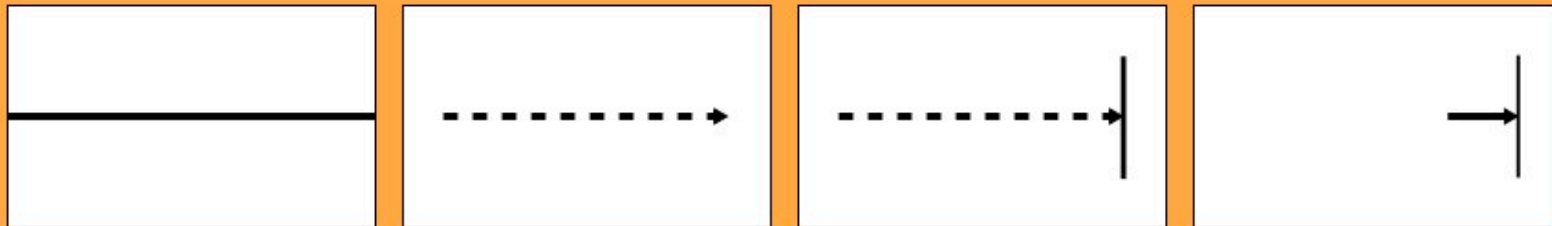
- 24 groups of 4 non polysemous verbs (ACC, ACH, ACT, STA) and 1 polysemous verb (ACH/STA):
 - ACC: *leggere il contratto* “read the contract”
 - ACH: *vincere la scommessa* “win the bet”
 - ACT: *suonare il sassofono* “play the saxophone”
 - STA: *credere all'oroscopo* “believe in horoscopes”
- 21 couples of non polysemous verbs (ACH, ACT)
 - ACH: *entrare* “enter”
 - ACT: *dormire* “sleep”

Interface

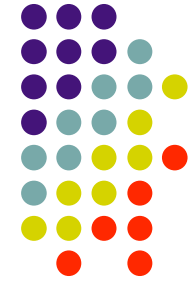


- Training
 - 8 examples in randomized order (2 ACC, 2 ACH, 2 ACT, 2 STA)
- Web experiment, max. 15 sec. per VP

spingere un carrello



Results



Average accuracy	0.61
Inter-subject observed agreement	0.5
Inter-subject expected agreement	0.25
Kappa Mean	0.33

	ACC	ACH	ACT	STA
K Mean	0.49	0.29	0.16	0.25
K St Dev	0.27	0.13	0.14	0.23

- **Inter-subject agreement** is well above chance
 - interesting result, since subjects were NOT trained linguists
- Nevertheless, **lots of disagreement...**
 - variation with respect to event type
 - certain event classes are harder than others
 - event types are highly complex categories intertwined with other grammatical dimensions (cf. aspect, argument structure, etc.)

Language, ontologies and explanatory adequacy



- *To what extent ontologies for lexical semantic representation are explanatory adequate?*
 - do they provide provide satisfactory explanations about **lexical semantic generalizations** and dynamics?
 - are they supported by **cognitive evidence**?

Models of the lexicon



- “Naive” model
 - the goal of the lexicon is to represent the different senses of a word
 - the lexicon as a static entity
 - starting from the lexicon, the grammar (and/or pragmatics) must account for the sense-creation processes in context
- Alternative model
 - it is not possible to represent the semantic content of lexemes without considering their creative behavior in context
 - lexicon as an inherently dynamic entity

The Generative Lexicon (GL)

Pustejovsky 1995, 2001, etc.



“...Our aim is to provide an adequate description of how language expressions have content, and how this content appears to undergo continuous modulation and modification in new contexts”

(Pustejovsky 2001)

- GL redefines the boundary between **lexical meaning and (linguistic and extralinguistic) context**
- “**Semantic plasticity**” (lexical creativity, polysemy, etc.) can be explained by
 - **highly structured** semantic representations
 - **compositional operations** between lexical representations

Explanatory adequacy and GL



“Overall, GL is concerned with explaining the **creative use of language**; we consider the lexicon to be the key repository holding much of the information underlying this phenomenon. More specifically, however, it is the notion of a constantly evolving lexicon that GL attempts to emulate; this is in contrast to currently prevalent views of **static lexicon design**, where the set of contexts licensing the use of words is determined in advance, and there are no formal mechanisms offered for expanding this set”

Pustejovsky (2007: 21)

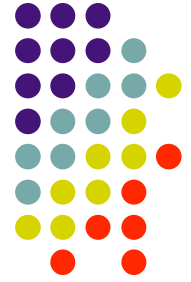
“Sense Enumeration Lexicons”

Pustejovsky (1995)



- In traditional models of the lexicon, the semantic space of a word is organized as a **finite set of distinct senses**
 - senses correspond to associations between the word and conceptual nodes of an ontology
- Linguist context acts as a “**sense selector**”
 - each use context selects the most appropriate sense within the set associated with the word
- **Word Sense Disambiguation**
 - given a fine set of word senses s_1, \dots, s_n , the goal is to select the most appropriate sense s_i for a context C , given some features of C
 - “The BANK₁ **denied a new loan to John.**”
 - “**The river** BANK₂ **is slippery and muddy.**”
- *Ambiguity and logical polysemy are not distinguished!*

Ambiguity vs. polysemy



- **Constrastive ambiguity**

- a lexeme (accidentally) has two or more unrelated senses

- (1)
 - a. *Harborbank is the richest **bank** in the city.*
 - b. *Mary walked along the river **bank**.*

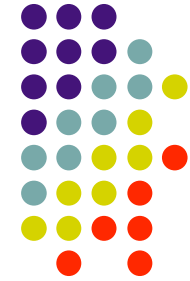
- **Logical polysemy**

- a lexeme has two or more inherently related senses

- (2)
 - a. *John painted the **door**.*
 - b. *John walked through the **door**.*
- (3)
 - a. *The **bank** raised its rate yesterday.*
 - b. *The store is near the new **bank**.*

Logical polysemy

main features



- Intra- and interlinguistic systematicity
 - logical polysemy concerns semantic classes of lexemes
 - e.g. *door, gate, fence, window*, etc.
 - tendential cross-linguistic invariance
- With ambiguous lexemes, the contexts chooses one sense and excludes the others
 - with polysemous lexemes the context simply foregrounds one sense
- Only logical polysemy admits **co-predication**
 - (1) a. *He entered through the freshly painted gate.*
 - b. *The lunch was delicious, but lasted too long.*
 - c. *Boston is a large city, and voted for Obama.*



Types of logical polysemy

- **Object / information**
 - (a) *This book is red.*
 - (b) *I don't believe to this book.*
- **Food / event**
 - (a) *John devoured his lunch.*
 - (b) *Lunch is at 2.*
- **Container / content**
 - (a) *I broke the bottle.*
 - (b) *I drank this bottle at dinner.*
- **Process / result**
 - (a) *The collection was sold.*
 - (b) *The collection of this material required 5 years.*
- **Plant / fruit**
 - (a) *I watered the peach.*
 - (b) *I ate a peach.*

Compositionality



The principle of compositionality

The meaning of a complex linguistic expression is a function of the meaning of its parts

- The principle of compositionality is the cornerstone of any explanation of **semantic creativity**
- Compositionality presupposes that semantic types are “**context free**” entities
 - “compositionality requires that words in isolation have a meaning and that from these meanings, the meaning of a compound can be built” (Janssen 1997)
 - “a lexical item must make approximately the same semantic contribution to each expression in which it occurs” (Fodor & Pylyshin 1988)

Compositionality

the traditional model



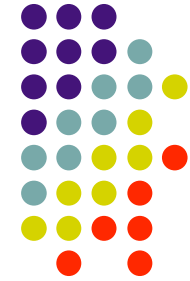
- Each lexeme l is assigned a finite number of senses s_1, \dots, s_n (**sense enumeration lexicons**)
 - polysemy is not distinguished from contrastive ambiguity
 - every new sense of l becomes a new sense s_k
- Meanings are distinguished in **functions** (functional types) and **arguments** (argument type)
 - *eat* $\lambda x \lambda y. \text{eat}(x, y)$
 - *violinist, cake* `violinist, cake`
- Semantic composition is modeled as **function-argument application**
 - *The violinist eats the cake* `eat(violinist, cake)`

The limits of traditional models



- Sense enumeration lexicons fail to reach explanatory adequacy
- They fall short of explaining
 - the creative use of words
 - words can assume new interpretations in contexts
 - the permeability between word senses
 - the boundaries between word senses are “soft”
 - multiple syntactic realizations
 - the same meaning can be realized syntactically in different ways

The creative use of words



- It is hard to establish a priori the number of senses of a word
- The interpretation of *fast* strongly depends on the **meaning of the modified noun**

fast plane

fast path

fast guitarist

fast company

fast cake

fast match

fast tan

fast football

fast web

fast money

fast link

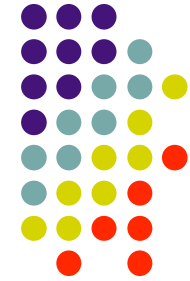
fast business

fast network

fast ground

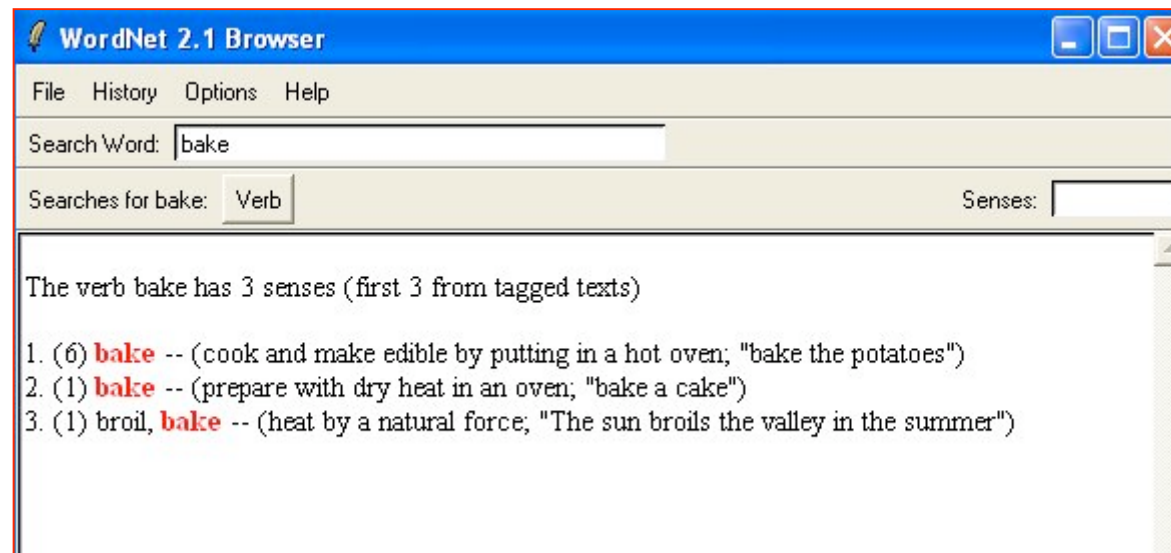
- *fast movie*
 - movie produced (used) in a very short time
 - *Viewlets are small fast movies that run on any platform*
 - movie showing a lot of action
 - *I don't like those Hollywood breathless fast movies*

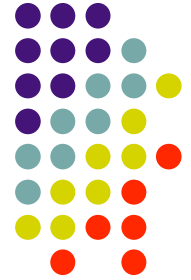
Word sense permeability



- The senses of polysemous words are **closely related**
 - (1)
 - a. *John baked the potatoes.* (change of state)
 - b. *John baked the cake.* (creation)

The senses of
bake in
WordNet 2.1.



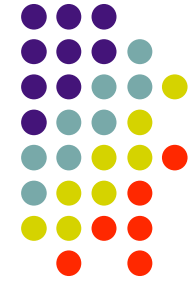


The Generative Lexicon

- GL semantic representations \neq senses
- Lexical creativity (polysemy, etc.) as constrained generation of senses in context through
 - richer modes of composition (e.g. co-compositionality, type coercion, etc.)
 - highly structured lexical entries

$$\left[\begin{array}{l} \alpha \\ \text{ARGUMENT_STRUCTURE} = [\dots] \\ \text{EVENT_STRUCTURE} = [\dots] \\ \text{QUALIA} = \left[\begin{array}{l} \text{CONSTITUTIVE} = \text{what } x \text{ is made of} \\ \text{FORMAL} = \text{what } x \text{ is} \\ \text{TELIC} = \text{function of } x \\ \text{AGENTIVE} = \text{how } x \text{ came into being} \end{array} \right] \end{array} \right]$$

The Qualia Structure (QS)



- **Formal** - that which distinguishes the object within a larger domain
 - Is-a, ...
- **Constitutive** – information about an entity’s structural attributes
 - sensory attributes: dimensionality, shape, size, color, texture, weight, taste, ...
 - the material composing the entity
 - parts and composing elements
- **Agentive** – information concerning how the entity comes into existence
- **Telic** – purpose and function of an entity

What is the QS?

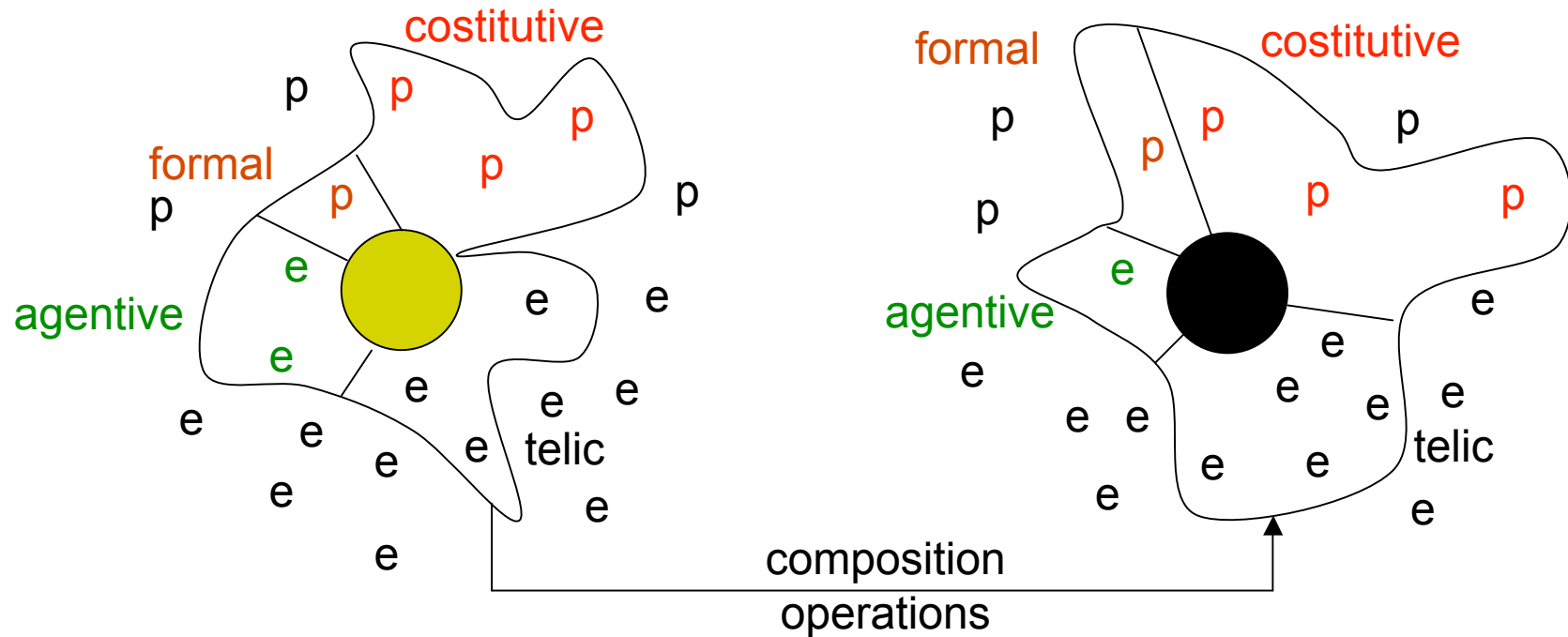
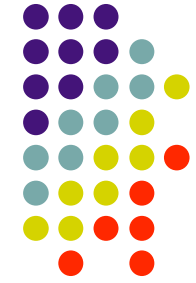


“We can think of qualia as that set of properties or events associated with a lexical item which best explain what that word mean”

(Pustejovsky 1995)

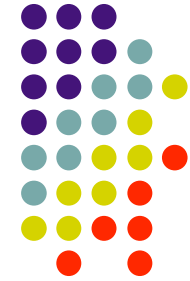
- The qualia represent an **interface between lexicon and context**
 - context does not only select senses, **but becomes a constitutive ingredient of their structure**
 - “...our point here is that by distinguishing metaphysics from the lexicon, we can both maintain that something like a door or a bathroom has a proper function without being required that that function is part of the lexical entry. It is **just such functions that sometimes don't make it over to the lexicon from the metaphysical scheme**” (*Asher & Pustejovsky 2000*)

Qualia and context



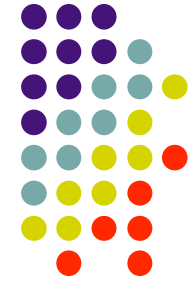
Semantic composition becomes “**context-sensitive**” relatively to the context subset lexicalized in the QS

The composition operations

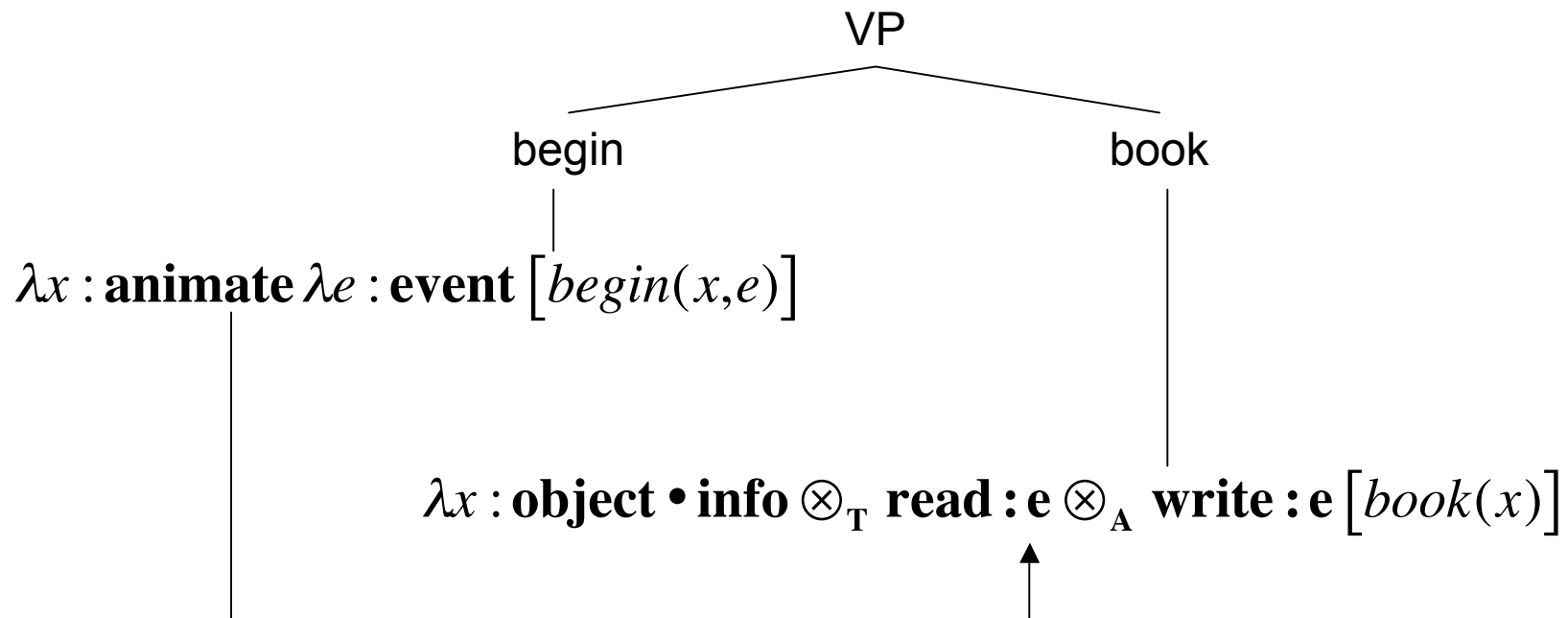


- Pustejovsky (1995)
 - type coercion, selective binding, co-composition
 - these operations act on the QS of the function as well as of the argument
- Type coercion
 - the type of the argument is changed into the one required by the function selectional preferences, provided that this change is allowed by the argument QS

Type coercion



- *John began the book.*
 - the event required by the selectional preference of *begin* is “reconstructed” from the QS of *book*



Selective binding



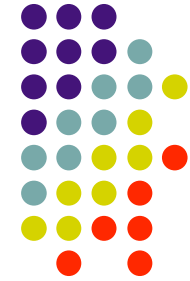
- An adjective can modify a particular aspect of the noun QS
- Adjectival polysemy
 - *fast car*
 - *fast pianist*
 - the adjective selects for an event, which is provided by the noun QS

$\lambda y : e [fast(y)]$

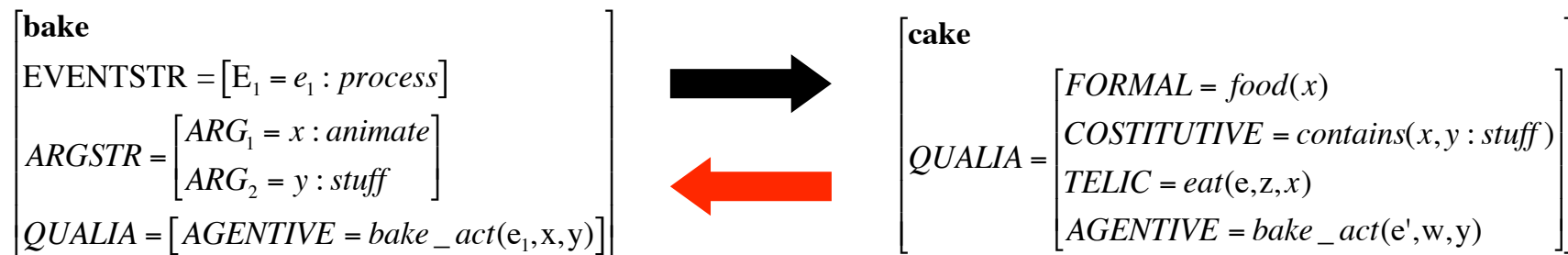
$\lambda x : animate \otimes_T play : e [pianist(x)]$



Co-composition

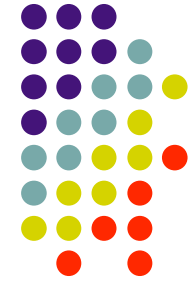


- The argument QS can modify the semantic type of the predicate
 - (1) a. *John baked the potatoes.*
b. *John baked the cake.*
- “there is only one sense for *bake*, and any other readings are derived through generative mechanisms in composition with its arguments” (Pustejovsky 1995: 123)
 - the argument “**co-specifies**” the predicate



Composition operations

(Pustejovsky 2007)



- **Pure Selection** – the type required by a predicate matches the type of the argument
 - *read a book*
- **Accomodation** – the type required by a predicate is inherited by the argument position in the type ontology
 - *read an essay*
- **Type Coercion**
 - **Exploitation** – the type required by a predicate is extracted from the argument QS
 - *understand the book*
 - *burn the book*
 - **Introduction** – the argument is extended with the type required by the predicate
 - *The boys are reading the metro wall.*

$\lambda x : \mathbf{animate} \lambda y : \mathbf{concrete} \bullet \mathbf{info}[read(x)(y)]$ $\lambda z : \mathbf{concrete} [wall(z)]$

Where do the problems lie?



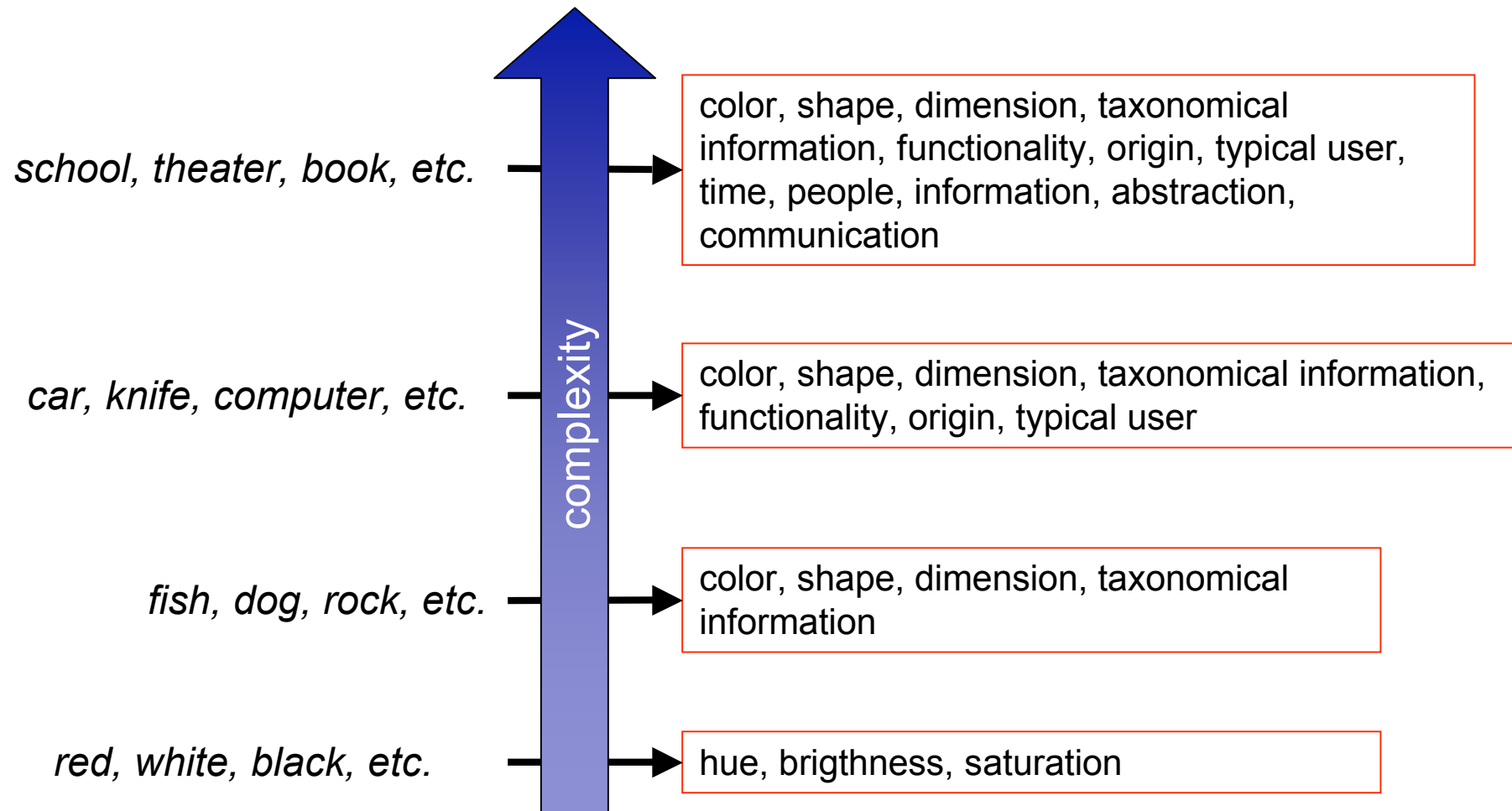
- Why (most) language-related ontologies fail to satisfy **explanatory adequacy** in representing lexical meaning?
 - (1) **ontology conceptual nodes are poorly structured**
 - (2) **the lexicon-ontology interface is too naive**
 - (3) **there is too much emphasis on the paradigmatic organization of the lexicon**

The structure of concepts



- Concepts are **multidimensional structures** organizing different types of information (properties)
 - lots of evidence for this in cognitive research (cf. Vigliocco *et al.* 2004, etc.)
 - an important share of these properties refer to the typical situations or contexts in which entities are used
 - concepts as “**contextually situated**” representations (cf. Wu & Barsalou in press)
- GL attempts to import this view into lexical representations
 - **simple types** - only formal and constitutive information
 - cf. natural kinds (*cat*, *water*, etc.)
 - **unified types** - simple types + telic and/or agentive
 - cf. artifacts (*car*, *knife*, etc.) and roles (*violinist*, *student*, etc.)
 - **complex types (dot types)**
 - cf. logical polysemy (*book*, *lunch*, etc.)

Dimensions in concepts

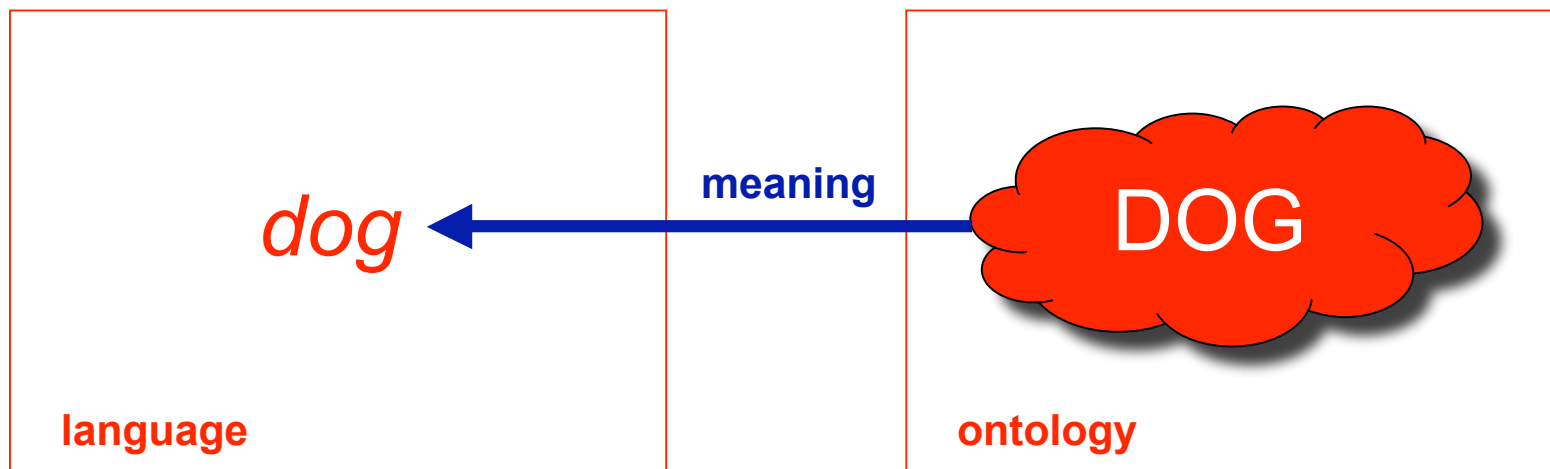


Lexicon-ontology interface

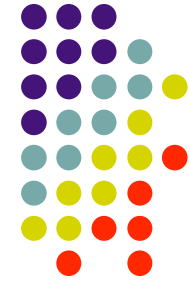


“If meanings are just concepts that happen to be coded by a given meaning-bearing entity of a given language, for instance a word, then of course meaning relations are just ontological relations. But linguists are rarely aware of the fact that relations of this kind hold irrespectively of how the related concepts are coded and irrespectively of whether they are coded (and therefore meanings) at all”

(Nickles et al. 2007:40)



Lexicon-ontology interface



- Meanings **ARE** concepts
 - the subset of lexically encoded concepts
 - indeed, these terms are often used interchangeably, especially in cognitive psychology
 - cf. Vigliocco & Vinson (2007) for arguments against this simple equation
- Concepts (and the ontology they belong to) are assumed to be (strongly) independent from language
 - concepts are the “entities” on which linguistic expressions are interpreted, thereby getting their semantic content
 - in principle, **this would require the ontology to be designed only by using “language-independent” criteria**

Ontology and its sources



- Typically, ontology are designed by using a mixture of language independent and language dependent criteria
 - cf. arguments againts “mixed ontologies” in Bateman (2007)
- Actually, the same ambiguity exists in GL to define the QS
 - QS as interesting properties about an entity that explain its concept (**ontological criteria**)
 - QS as those contextual properties that are necessary to explain the semantic creativity of lexical expression (**linguistic criteria**)

The
hyperonyms of
horse in
WordNet 2.1.

5 senses of horse

Sense 1

horse, *Equus caballus* -- (solid-hoofed herbivorous quadruped domesticated since prehistoric times)

=> equine, equid -- (hoofed mammals having slender legs and a flat coat with a narrow mane along the back of the neck)

=> odd-toed ungulate, perissodactyl, perissodactyl mammal -- (placental mammals having hooves with an odd number of toes on each foot)

=> ungulate, hoofed mammal -- (any of a number of mammals with hooves that are superficially similar but not necessarily closely related taxonomically)

=> placental, placental mammal, eutherian, eutherian mammal -- (mammals having a placenta; all mammals except monotremes and marsupials)

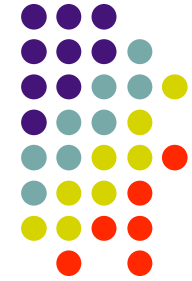
=> mammal, mammalian -- (any warm-blooded vertebrate having the skin more or less covered with hair; young are born alive except for the small subclass of monotremes and nourished with milk)

=> vertebrate, craniate -- (animals having a bony or cartilaginous skeleton with a segmented spinal column and a large brain enclosed in a skull or cranium)

=> chordate -- (any animal of the phylum Chordata having a notochord or spinal column)

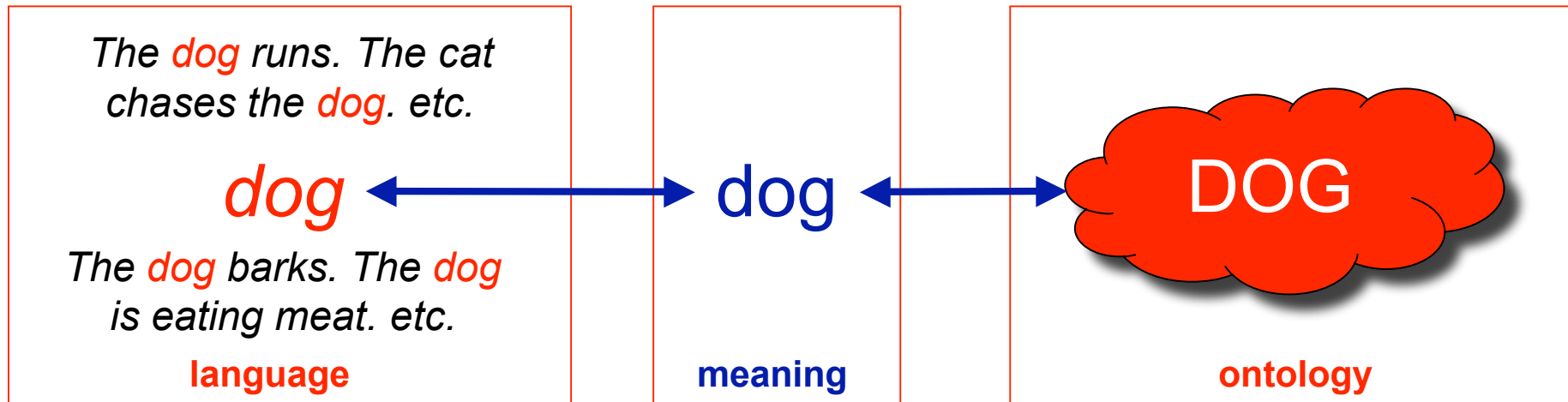
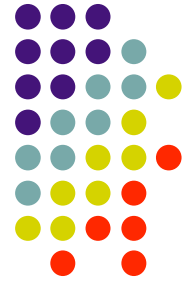
=> animal, animate being, beast, brute, creature, fauna -- (a living organism characterized by voluntary movement)

Paradigmatic vs. syntagmatic



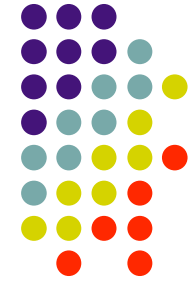
- A great bulk of the semantic content of lexical items arises in **syntagmatic contexts**
 - i.e. **by the fact that words co-occur with other words**
- Ontologies are **static snapshots** of a conceptual space that typically encode the **paradigmatic organization** of the lexicon
 - FrameNet could be regarded as a possible exception
- The **behavior of words in syntagmatic contexts** lies outside the aims of ontological representation
 - consequently, the aspect of meanings that arise in context are reified within the ontology (**representational overloading**)

A three-layer model of the lexicon-ontology interface



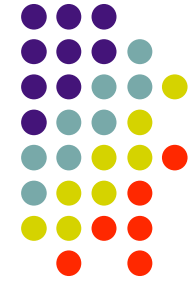
- The **behaviour of words in the linguistic contexts** is a crucial source of their semantic content
 - the **relation between meanings and concepts** can not be stipulated a priori as an identity, but it is itself an *explanandum*

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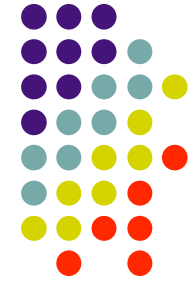
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