Stretching the Meaning of Words: Inputs for Lexical Resources and Lexical Semantic Models

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Rome, December 11-13, 2017
Fourth Italian Conference of Computational Linguistics
CLiC-it
Tutorial Outline

- Basics on lexicon, lexical structure and lexical relations.
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- Varieties of linguistic evidence in favour of context-sensitive models of lexical meaning.
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- Varieties of linguistic evidence in favour of context-sensitive models of lexical meaning.
- Lexical information and its interplay with cognition and pragmatic inference.
- The meaning of verbs and its representation in compositional vector space models.
- Concluding observations and lines of research.
How is the structure of the LEXICON?
Questions

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- How does lexical information interact with grammar, PRAGMATICS and the ontological/CONCEPTUAL dimension?
How to approach these questions

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- Merge theoretical accounts with computational analysis.
Lexicalization 1

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![Diagram](image)
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Univerbation (Cruse 2011, 82-91; Booij 2007, 19).
Word forms that acquire the status of autonomous words.
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Fr. *pendant*, originally the present participle of the verb *prendre* ‘to hang’, is used today primarily as a preposition, as in “pendant le diner” ‘during dinner’.
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Engl. *chair* ‘seat’ (“a comfortable chair”) and *chair* ‘position of authority’ (“the department chair”)

It. *penna* ‘feather’ (“una penna d’oca” ‘a goose feather’) and *penna* ‘pen’ (“una penna d’oro” ‘a golden pen’).
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Lexicalization 5

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- Word that **exists** in a language.
- English has **two lexicalizations** to express the state of being able or allowed to do what one wants to do, i.e. *liberty* and *freedom*.
A combination of concepts is expressed by a single word.
Synthetic Lexicalization

- A **combination of concepts** is expressed by a single word.
- MOTION and INSTRUMENT: German *gehen* (feet), *fahren* (vehicles), *reiten* (horses); Dutch *schaatsen* (skate), *fietsen* (bicycles).
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MOTION and INSTRUMENT: German gehen (feet), fahren (vehicles), reiten (horses); Dutch schaatsen (skate), fietsten bike (bicycles).

MOTION, MANNER and INSTRUMENT: Engl. run (feet, high speed), march (feet, with a regular measured tread), limp (feet, with difficulty).
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Engl. *have dinner, make an effort, get ready, get sick, become aware, fall asleep, be late, be ashamed.*
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Both processes present in the same language: *dine/have dinner, stimulate/provide a stimulus, consider/take into consideration, distinguish/make a distinction, exit/go out.*

Descriptive Lexicalization

- The content is described.
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- *stone* ‘that which has become hard’, *basket* ‘that which is woven’ (Cahuilla, Uto-Aztec language of Southern California, Seiler 1975).
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- *table* ‘she (impersonal pronoun) prepares food on it’; *horse* ‘he drags logs’ (Cayuga, Iroquois language of Canada, Sasse 1993).
The content is labeled.
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- palace (vs. building)
The content is labeled.

- palace (vs. building)
- doctor (vs. worker)
Word types

- Simple words.
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- Complex words with morphological structure.
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- Complex words with morphological structure.
- Complex words with syntactic structure.
Word types

Lexicon
- morphologically simple words
- free morphemes (Engl. table)
- bound morphemes and inflection (It. borsa)
- derivations (Engl. printer)
- compounds (Engl. bookstore)

Morphology
- morphologically complex words

Syntax
- phrasal words
- fixed phrases (Engl. part of speech)
## Word types

<table>
<thead>
<tr>
<th>Morphology</th>
<th>Lexicon</th>
<th>Syntax</th>
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<td>incorporated compounds</td>
<td>Engl. <em>breastfeed</em></td>
<td>fixed phrases</td>
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<td>juxtaposed compounds</td>
<td>Engl. <em>love, hate, family love</em></td>
<td>ordinary phrases</td>
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<tr>
<td>Engl. <em>part of speech</em></td>
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- Continuum ranging from lexicon to syntax.
Shared by all words:

- meaning
- sound structure
- morphological structure
- word class

Specific to words which function as predicates:

- argument structure
- Aktionsart
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Why is it difficult to identify subclasses of words on semantic grounds?
The difficulties encountered in classifying verbs in semantic terms derive primarily from the fact that the meaning of verbs consists of a bundle of features with different semantic prominence.

Consider verbs that describe a change in position such as sit. The action of sitting involves the motion of the person performing the action (a motion we may characterize as “internal”). However, this is not the prominent feature in the meaning of the verb, and it would appear odd to classify sit as a verb of motion on a par with enter and exit.
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Verbs appear to encode only some aspects of the event they denote, while presupposing others.

Example: Arrive presupposes motion but it is believed to encode the result/effeクト of such motion, consisting in the fact that the person or thing arrived is located in a place which differs from the one it was located in before the arriving event took place. On this ground, it is reasonable to question whether arrive should be considered a verb of change of location rather than a verb of motion, and which criteria are eligible to distinguish between the two.
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*Sit* is a verb of assuming a position in “He sat in the chair near them” (Levin 1993, 262), while it can be regarded as a verb of spatial configuration in stative uses such as “He sits in the corner near the fire” (Levin 1993, 255).
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Several scholars contend that prominent features are those transparent in the syntax, i.e. those that influence a verb syntactic behavior (Levin and Rappaport Hovav 2005, Ch. 1).

A syntax-informed approach is not driven by syntax but, starting from intuitive groupings identified on a semantic basis, looks for regularities in syntactic behavior of potential members, and divides them into classes based on these regularities.

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Morphological word families, such as book, booking, booklet, bookstore; truly, amply, fortunately, happily.

Sound similarity: big, pig, fig.

Similar syntactic behavior: nouns, verbs, or adjectives.

Semantic.

Semantic networks: buy, acquire, purchase, sell, negotiate, pay, own.


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Book (x), bookstore (y).

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Semantic Relations in the Verbal Lexicon

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“*to v₁* is to *v₂* in a particular/certain manner”: “*to walk* is it to move in a certain manner”, “*to murmur* is it to talk in a certain manner”, etc.
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Kinds of Troponymy

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- intensity (close the door vs. slam the door, whisper vs. shout; eat vs. devour)
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“**The event expressed by** \( v_1 \) **IS SIMULTANEOUS WITH** the event expressed by \( v_2 \).**
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Causation in the Lexicon

The causal relation is **FACTIVE** (according to Lyons’ 1977 terminology) when it applies necessarily, as in the case of *to kill*, which necessarily causes *to die*.
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*He accidentally killed the fly but the fly did not die.*
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- Lexical vs. textual entailment (Dagan, Glickman and Magnini 2006).
Causation in the Lexicon

- Two main types.
Causation in the Lexicon

- Two main types.
- Between lexical entries (necessary, probable or possible).
Causation in the Lexicon

- Two main types.
- Between lexical entries (necessary, probable or possible).
- Inside single entries (polysemy, necessary).
Causative/inchoative verbs

These are verbs which alternate between a transitive variant and an intransitive one, where the first encodes both the *CAUSE* and the *RESULT* and the second only the *RESULT* of the reported event.
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- \textit{To break}, as in “Mary broke the key” vs. “the key broke”.
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Ponti 2016, Identifying Causal Relations between Events with Artificial Neural Networks, MA Thesis, Pavia.
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Purposive constructions: *eat* in order *to nourish oneself*.
Involuntary actions lack a **PURPOSE**, i.e. *break* associates by default with no purpose, as it is typically done unintentionally.
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While many relations of non-factive **CAUSATION** can be analyzed as **PURPOSE** relation, this is not always the case.
While many relations of non-factive **CAUSATION** can be analyzed as **PURPOSE** relation, this is not always the case. For example, *to iron* may cause *to burn* and *to try* may cause *to fail*, but *to burn* is certainly not the ultimate purpose of *ironing* nor is *to fail* the goal of *to try*. 
Fellbaum 2013 contends that next to MANNER, an organizing principle of verb taxonomies distinct from MANNER is PURPOSE.

How is PURPOSE relate to MANNER?

To exercise is defined by subordinates like to swim, to bike, to jog that are shared with another superordinate, i.e. to move.

But to move has any subordinates that are not shared with to exercize, such as to fly and to drive.
According to Fellbaum, the relation of **PURPOSE** is always *defeasible*, i.e. **PURPOSE** is not a necessary meaning component of the verbs in question: *expectation* that a biking event is an exercising event, event though biking is not necessarily exercising.

She compares it to the notion of role in the nominal domain (Cruse 1986).

- *animal* vs. *pet*: “That’s a dog but it is not a pet.”
- *to bike* vs. *to exercise*: ?We biked but we did not exercise.
Verbs form troponymy chains that are **shallow** (four levels at most) and **tend to extend horizontally rather than vertically**.
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Nouns tend to organize themselves along the hypernymy and hyponymy axis and generate **deep hyponymy chains** (up to 12 levels).

Adjectives rarely form hyperonymy chains and tend to organize themselves along the axis of **opposition** (polar/scalar or binary).
Semantic Relations in the Lexicon

- Paradigmatic (in absentia, same POS, share nearest neighbors): hyponymy (event/lecture), meronymy (brain/body), synonymy and near synonymy (enough/sufficient, serious/no laughing matter), antonymy (raise/fall).

- Syntagmatic (in praesentia, different POS, co-occur): role (pedestrian, walk, paint, portrait), attribution (blond, hair).

- Both = manner (damage, severely; to move/to walk) Others?
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- We have now understood that the two traditional Hjelmslev’s structuring axes (vertical, either or vs. horizontal, both and) are useful but not mutually exclusive wrt specific dimensions.

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Ambiguity in Language

- Ambiguity is **pervasive** and plays a communicative role in the language (Piantadosi et al 2012).
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- Ambiguity results from **a pressure** for efficiency in communication.
Ambiguity is pervasive and plays a communicative role in the language (Piantadosi et al 2012).

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Any efficient communication system will necessarily be ambiguous when context is informative about what is being communicated.
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- Ambiguity results from **a pressure** for efficiency in communication.

- Any efficient communication system will necessarily be ambiguous when context is informative about what is being communicated.

- The units of an efficient communication system will not convey and redundantly specify information **already provided by the context**.
Polysemy in language

What is the meaning of an individual word, out of context?
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- Do words carry different meanings in a manner similar to the multiple interpretations that utterance may assume?
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- Evidence-based approach.
Words are able to take on a different meaning *depending on the context* in which they are used.
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The couple at the next table was laughing.
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The couple at the next table was laughing.

The next train is delayed.
Context and lexical meaning

- Words are able to take on a different meaning depending on the context in which they are used.
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- The next train is delayed.
- The next costumer, the next slide ...
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- **checklist theory** of lexical meaning.
- **sense enumeration** lexicon.

This is the standard way dictionaries and **resources** used for NLP tasks (i.e. WordNet for word sense detection etc.) are put together.
Types of contextual variation

Properties of objects coming into the foreground in the context.
Types of contextual variation

Properties of objects coming into the foreground in the context.

- This *car* *weighs* over 2,000 lbs.
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Pustejovsky and Jezek 2012 *Introducing Qualia Structure*
Types of contextual variation

Contextual coercions

The flight lasted three hours.
The flight landed safely at about 9 a.m.
I bought the flight for Christmas.
You reached the house.
Do you want the whole house waken up?
The rest of the house was sleeping.

Pustejovsky and Jezek 2008, Jezek and Quochi 2010, Pustejovsky et al. 2010

SemEval-2010 Task 7 Argument Selection and Coercion.

Elisabetta Ježek

Streching the Meaning of Words
Types of contextual variation

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Types of contextual variations

Hidden Events

We canceled the taxi.
From the house I heard the bell.
We took a break before dessert.
They finished the beer.
They finished their cake.
Any chocolate? Not after that cake!
I refer to biscuits.
We skipped the cake and settled for another co-

Pustejovsky and Anick 1988 (later “Qualia roles”; data from Pustejovsky and Jezek 2012)

Elisabetta Ježek

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Typed Predicate-Argument Structure (T-PAS)
Jezek, Magnini, Feltracco, Bianchini, Popescu 2014

Mismatch classification

- Verb classes (Levin 1993, VerbNet).

  Targeted grammatical relation: SUBJ OF, OBJ OF, COMPL.

  Shift types: Artifact as Event, Artifact as Human, Artifact as Sound, Event as Location, Vehicle as Human.

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Arriva Mirko e interrompe la conversazione.
‘Mirko arrives and interrupts the conversation’ (matching)
Aspectual Verbs (Jezek, Magnini, Feltracco, Bianchini, Popescu 2014)

[[Human]-subj] interrompe [[Event]-obj]

- Arriva Mirko e interrompe la conversazione. ‘Mirko arrives and interrupts the conversation’ (matching)
- Il presidente interrompe l’oratore. ‘The president interrupts the speaker’ (Human as Event)
|[[Human]-subj] annuncia [[Event]-obj]|

- Lo speaker annuncia la partenza.
  ‘The speaker announces the departure’ (matching)
Communication Verbs

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- Il maggiordomo annuncia gli invitati.
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- Una telefonata anonima avvisa la polizia.
  ‘An anonymous telephone call alerted the police’ (Event as Human)
Avoid Verbs

[[Human]-subj] evita [[Event]-obj]

- Abbiamo evitato l’incontro.
  ‘We avoided the meeting’ (matching)
Avoid Verbs

[[Human]-subj] evita [[Event]-obj]

- Abbiamo evitato l’incontro.
  ‘We avoided the meeting’ (matching)
- Meglio evitare i cibi fritti.
  ‘It is best to avoid fried food’ (Artifact as Event)
Forbid Verbs

[[Human]-subj] vieta [[Event]-obj]

- Nell’Italia di allora la legge vietava l’aborto.
  ‘At that time in Italy law prohibited abortion’ (matching)

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La Francia vieta il velo a scuola.
‘France bans the headscarf in schools’ (Artifact as Event)
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Verbs of Desire (Bos 2009)

[[Human]-subj] preferire [[Event]-obj]

- Preferisco bere piuttosto che mangiare.  
  ‘I prefer drinking to eating’ (matching)
[[Human]-subj] preferire [[Event]-obj]

- Preferisco *bere* piuttosto che *mangiare*.
  ‘I prefer drinking to eating’ (matching)
- Preferisco *la birra* al *vino*.
  ‘I prefer beer to wine’ (*Artifact* as *Event*).
<table>
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<th>Perception Verbs</th>
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  ‘I stayed for a long while listening to his breath’ (Event as SOUND)
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  ‘I stayed for a long while listening to his breath’ (Event as Sound)

- Non ho potuto ascoltare tutti i colleghi
  ‘I could not listen to all colleagues’ (Human as Sound)
[Human]-subj raggiunge [Location]-obj

- Abbiamo raggiunto l’isola alle 5.
  ‘We reached the island at 5’ (matching)
[Human]-subj raggiunge [Location]-obj

- Abbiamo raggiunto l’isola alle 5.
  ‘We reached the island at 5’ (matching)
- Ho raggiunto il semaforo e ho svoltato a destra.
  ‘I reached the traffic light and turned right’ (Artifact as Location).
Directed Motion Verbs 2/3

[[Human]-subj] arriva (Adv [[Location]])

- Alla fine, ormai col buio, sono arrivata a una radura.
  ‘Finally in the dark I came upon a clearing.’ (matching)
Alla fine, ormai col buio, sono arrivata a una radura. ‘Finally in the dark I came upon a clearing.’ (matching)

Gli invitati arrivano al concerto in ritardo. ‘The guests arrived late at the concert’ (EVENT as LOCATION).
[[Flying Vehicle]-subj] atterra ([Adv [Location]])

- Il nostro aereo atterra alle 21.
  ‘Our plane lands at 9pm’ (matching)
Motion using a Vehicle

[[Flying Vehicle]-subj] atterra ([Adv [Location]])

- Il nostro aereo atterra alle 21.
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- Il pilota e’ regolarmente atterrato senza problemi.
  ‘The pilot landed regularly with no problems’ (HUMAN as VEHICLE).
Motion using a Vehicle

[[Flying Vehicle]-subj] atterra ([Adv [Location]])

- **Il nostro aereo** atterra alle 21.
  ‘Our plane lands at 9pm’ (matching)

- **Il pilota** e’ regolarmente atterrato senza problemi.
  ‘The pilot landed regularly with no problems’ (**Human** as **Vehicle**).

- **Tutti i voli civili** sono atterrati.
  ‘All civilian flights landed’ (**Event** as **Vehicle**).
Vehicle Verbs

[[Human]-subj] parcheggiare ([[Vehicle]-obj])

- **Luca** ha parcheggiato sotto casa.
  ‘Luca parked near the house’ (matching)
Vehicle Verbs

[[Human]-subj] parcheggiare ([[Vehicle]-obj])

- **Luca** ha parcheggiato sotto casa.
  ‘Luca parked near the house’ (matching)
- **L’ambulanza** ha parcheggiato lontano.
  ‘The ambulance parked far away’ (**Vehicle** as **Human**)
Detecting Mismatches

We have recently performed a distributional analysis and developed a geometric method for detecting mismatches in corpora.

Figure 2: Spectrum of Coercion: Verb-object pairs deemed most selectional, ambiguous, and coercive are projected into subspaces using the INDY technique, with key geometric features preserved here.

Detecting Mismatches

The work is based on the projection in space of context sensitive distributional semantic subspaces generated through selection techniques of the set of co-occurrence features that are salient for the input terms (model originally developed in McGregor et al 2015).

Figure 1: Semantics in Space: Verb-object pairs are projected into a subspace in which the geometric features of the relationship between the word-vectors, the origin, and salient points in the subspace are expected to collectively indicate semantic relationships such as coerciveness.

Types of contextual variations

Systematic polysemies (Apresjan 1973)
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- container/content

I broke two glasses.
I drank two glasses.
The university hired a new professor.
The university is close to the station.
This is a friendly university.
The building was beginning to take place.
The building was burned down.

Elisabetta Ježek
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Inherent polysemies (Pustejovský 1995)

Jess almost dropped the book, then hastily replaced it on the shelf.
The author will be discussing her new book.
This is a bulky and demanding book. (copredication)

It was a long lunch.
It was a heavy lunch.
We had a quick and tasty lunch on the terrace. (copredication)

Cruse 1995's nouns with facets, and Asher's 2011 dual aspect nouns.
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- **event and food**
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What counts as a copredication?

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Jacquey 2001, 155
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    Jacquy 2001, 155
  - It. Una volta completata, la traduzione si può caricare in una
    sezione apposita del sito.
    ‘Once completed, the translation may be uploaded in a special
    section of the site’.
    Jezek and Melloni 2011, 27
Experimental setting

- We conduct a research to automatically extract copredication contexts from corpora and identify a list of candidate inherently polysemous nouns for each pattern (Jezek and Vieu 2014).

- We use the tagged Italian ItTenTen10 (2.5 Gigawords) corpus queried through Sketch Engine and its API.

- We focus on the copredication pattern 
  \[
  \text{\texttt{\textbf{V}\text{\textbf{Det}\textbf{N}\textbf{Adj}}}}
  \]
  and the inherent polysemy scheme
  \[
  \text{physical} \hspace{1cm} \text{object} \hspace{1cm} \text{information}
  \]

  - It. Consultare un libro voluminoso.
    'Consult a bulky book'
  - It. ...bruciavano i libri controversi.
    '...they burned the controversial books'.

Distributional analysis of copredication in Jezek and Vieu 2014, Vieu, Jezek and VanDeCruys 2015.
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Effective copredication contexts extraction require identification of predicates that select the different aspects of the noun (i.e. adjective and verbs selecting for either the \textit{information} or the \textit{physical\_object} aspect to be tested).
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Manual extraction of predicates is costly and time-consuming.
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We use a model that relies on latent dimensions computed by non-negative matrix factorization.
Semi-automatic predicate extraction

- Latent semantic distributional model to semi-automatically extract predicates from corpus.
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  - NMF: Non-negative matrix $A$ is factorized into two other non-negative matrices:
    \[ A_{i \times j} \approx W_{i \times k} H_{k \times j} \] (1)
    where $k$ is much smaller than $i, j$ (Lee, 2001)
Semi-automatic predicate extraction

Extension of NMF to jointly induce latent factors for 3 modes (N, V, Adj) in the co-predication pattern [V [Det N Adj]] by interleaved factorizations.

Exploits syntactic constraints to obtain semantic similarity, not just topic similarity.

Elisabetta Ježek

Streching the Meaning of Words
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![Diagram](image)
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  **Diagram:**

  ![Diagram](image)

- Exploits syntactic constraints to obtain semantic similarity, not just topic similarity.
Extracting the latent dimensions

- Extract co-occurrence frequencies from freely available ItWaC corpus (Baroni et al, 2009), using most frequently occurring 1K verbs, 4K nouns and 2K adjectives.

- Set the number of latent dimensions to $k = 100$.
- Select dimensions and take their first 20 items. Yields 4 lists of predicates $V_{\text{Phys}}$, $A_{\text{Info}}$, $V_{\text{Info}}$, and $A_{\text{Phys}}$.

- Two alternative methods:
  - Manually review the 15 dimensions most associated with the 10 Info●Phys seed nouns to pick between 2 and 5 dimensions for each list ($\text{DimsN}$).
  - Automatically pick the 5 dimensions most associated with 10 seed predicates (manually chosen) for each list ($\text{DimspP}$).
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<thead>
<tr>
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<th>Adjectives</th>
<th>Nouns</th>
</tr>
</thead>
<tbody>
<tr>
<td>narrare</td>
<td>antico</td>
<td>leggenda</td>
</tr>
<tr>
<td>raccontare</td>
<td>greco</td>
<td>favola</td>
</tr>
<tr>
<td>imparare</td>
<td>volgare</td>
<td>fiaba</td>
</tr>
<tr>
<td>conoscere</td>
<td>latino</td>
<td>storia</td>
</tr>
<tr>
<td>inventare</td>
<td>crudele</td>
<td>latino</td>
</tr>
<tr>
<td>evocare</td>
<td>medievale</td>
<td>greco</td>
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<td>apprendere</td>
<td>saggio</td>
<td>dialetto</td>
</tr>
<tr>
<td>credere</td>
<td>triste</td>
<td>mito</td>
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<td>sognare</td>
<td>medioevale</td>
<td>antico</td>
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<td>insegnare</td>
<td>romantico</td>
<td>mito</td>
</tr>
<tr>
<td>recitare</td>
<td>napoletano</td>
<td>mestiere</td>
</tr>
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<td>sapere</td>
<td>italico</td>
<td>eroe</td>
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<td>tradurre</td>
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<td>poesia</td>
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<td>nobile</td>
<td>lingua</td>
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<td>parlato</td>
<td>poeta</td>
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<td>ispirare</td>
<td>indiano</td>
<td>danza</td>
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<td>dipingere</td>
<td>popolare</td>
<td>arabo</td>
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<td>orientale</td>
<td>comico</td>
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<td>moderno</td>
<td>accento</td>
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<td>vivere</td>
<td>cinese</td>
<td>spagnolo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>drama</td>
</tr>
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</table>

A dimension picked for both VInfo and AdjInfo
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<th>Nouns</th>
</tr>
</thead>
<tbody>
<tr>
<td>compilare (compile)</td>
<td>cartaceo (of paper)</td>
<td>fotocopia (photocopy)</td>
</tr>
<tr>
<td>allegare (attach)</td>
<td>elettronico (electronic)</td>
<td>copia (copy)</td>
</tr>
<tr>
<td>spedire (send)</td>
<td>allegato (attached)</td>
<td>certificato (certificate)</td>
</tr>
<tr>
<td>corredare (equip)</td>
<td>inviato (sent)</td>
<td>documento (document)</td>
</tr>
<tr>
<td>inviare (send)</td>
<td>apposito (specific)</td>
<td>ricevuta (receipt)</td>
</tr>
<tr>
<td>inoltrare (forward)</td>
<td>modulistico (of form)</td>
<td>modulo (form)</td>
</tr>
<tr>
<td>stampare (print)</td>
<td>leggibile (readable)</td>
<td>questionario (questionnaire)</td>
</tr>
<tr>
<td>copiare (copy)</td>
<td>firmato (signed)</td>
<td>autocertificazione (self-certification)</td>
</tr>
<tr>
<td>archiviare (file)</td>
<td>informatico (of computer)</td>
<td>pdf (pdf)</td>
</tr>
<tr>
<td>ricevere (receive)</td>
<td>digitale (digital)</td>
<td>documentazione (documentation)</td>
</tr>
<tr>
<td>modulare (modulate)</td>
<td>valido (valid)</td>
<td>informazione (information)</td>
</tr>
<tr>
<td>certificare (certify)</td>
<td>scaricabile (downloadable)</td>
<td>E-mail (e-mail)</td>
</tr>
<tr>
<td>trasmettere (transmit)</td>
<td>On-line (on-line)</td>
<td>dato (datum)</td>
</tr>
<tr>
<td>consegnare (deliver)</td>
<td>telematico (telematic)</td>
<td>posta (mail)</td>
</tr>
<tr>
<td>depositare (deposit)</td>
<td>redatto (written)</td>
<td>verbale (report)</td>
</tr>
<tr>
<td>reperire (find)</td>
<td>disponibile (available)</td>
<td>originale (original)</td>
</tr>
<tr>
<td>redigere (write)</td>
<td>lino (of linen)</td>
<td>scheda (card)</td>
</tr>
<tr>
<td>sottoscrivere (sign)</td>
<td>postale (postal)</td>
<td>certificazione (certificate)</td>
</tr>
<tr>
<td>pervenire (reach)</td>
<td>reperibile (available)</td>
<td>autenticazione (authentication)</td>
</tr>
<tr>
<td>munire (provide)</td>
<td>identificativo (identifying)</td>
<td>formato (format)</td>
</tr>
</tbody>
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A dimension picked for both VPhys and AdjPhys

We applied an extension of NMF to jointly induce latent factors for three different modes (N, V, and A).
Results of predicate extraction

- We applied an extension of NMF to jointly induce latent factors for three different modes (N, V, and A).
- We produced matrixes with the pairwise co-occurrence frequencies for the different modes and then interleaved then.

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With the aid of manual selection, we obtained 4 lists containing from 37 AdjPhys to 91 AdjInfo, which we used as fillers for the pattern to extract copredications contexts.
Results of predicate extraction

- We applied an extension of NMF to jointly induce latent factors for three different modes (N, V, and A).
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- We successfully merged manually-based, pattern-based and distributionally-based methodologies to gather data for the investigation of the theoretical construct of inherent polysemy.
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Functional notion of polysemy.

Formal models propose that context-sensitivity is not confined to words with functional roles (traditionally verbs and adjectives), but extends e.g. to nouns (see Pustejovsky’s qualia theory).
What is the best model (formal, distributional, probabilistic) to predict the observed contextual variation in word meanings?
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Can a single model serve both linguistic and computational purposes?

To what extent statistics about word context and exploitation of co-occurrence information (distributionally-represented knowledge) can serve as a proxy for semantic grounding – and how can it inform us about compositionality in language?
We argue that a basic requirement of a context-sensitive lexical semantic model is, above all, a clear standpoint with respect to the interplay between the lexicon, cognition and pragmatic processes.
Words denote classes of entities and are associated with conceptual categories, for example a *dog* denotes an *animal*, a *table* denotes an *artifact*, *bread* denotes a kind of *food*, a *park* denotes a *location*, *run* denotes a *process*, *love* denotes a *state*, and so forth.
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A conceptual category may be analyzed as a set of salient attributes or properties, for example the concept *dog* has properties: breathes, barks, wags its tail, has fur, and so forth (Baroni and Lenci, 2008, Poesio and Almuhareb 2008).

But which properties of a concept are genuinely distinctive and enter into the lexical make-up of a word and which ones do not?
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But which properties of a concept are genuinely distinctive and enter into the **lexical make-up** of a word and which ones do not?
Lexicon and world knowledge

There are deep controversies regarding what piece of information associated with a word should enter into its definition, and constitute what is called its **lexical information**.
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It has to do with the speaker’s perception of the world, and the analogies speakers establish between objects and events, rather than with their linguistic knowledge.
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According to some authors, it is not even necessary.
Lexicon and world knowledge

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Lexicon and world knowledge

■ The distinction is very difficult to draw.
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■ Others believe it should be conceived as a continuum rather than a dichotomy.
■ Opinions differ because there is no consensus about what criteria must be satisfied for a piece of information to qualify as encyclopedic knowledge instead of linguistic meaning, or vice versa.
■ Those who make a distinction take different positions on the subject.
According to the **minimalist position**, nothing of what we know about, say, the entity called *dog* is part of the lexical information associated with the word *dog*, except for those features that are necessary to define it as a domestic animal (as opposed to a wild one) and allow us to distinguish it from other entities falling into the same category.
According to the maximalist position, the opposite is instead true, that is, the lexical information associated with the word *dog* incorporates our knowledge that dogs can be aggressive (and therefore bite and attack), that they have an acute sense of smell, that they like to chase cats, and so on.
Maximalism

According to the **maximalist position**, the opposite is instead true, that is, the lexical information associated with the word *dog* incorporates our knowledge that dogs can be aggressive (and therefore bite and attack), that they have an acute sense of smell, that they like to chase cats, and so on.

This additional knowledge about dogs is what we know from our individual experience.
A radical position is that taken by those who hold that the distinction between lexical information and world/encyclopedic/commonsense knowledge is artificial or useless, and should be eliminated.
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According to this position, words give access to concepts, and all the properties that enter into the constitution of a concept can in principle be exploited in language through the use of words.
No distinction

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According to this position, words give access to concepts, and all the properties that enter into the constitution of a concept can in principle be exploited in language through the use of words.

The contexts in which words are used determine which property/ies of the concept is/are activated in the specific case.
The lexicon is interpreted as the **access node** into the vast repository of information associated with conceptual categories.
No distinction

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- This position is dominant in cognitive semantics and pragmatics (Sperber and Wilson 1995; Carston 2002), where context-dependency is dealt with at the conceptual level (instead of at the lexical level).
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Ad-hoc concepts (Barsalou 1983, 2010; Wilson and Carston 2007)
General extenders (“whales, candlelight and stuff like that” Overstreet 1999).
Meaning Eliminativism (ME)

- Extreme version of contextualism (Recanati, 2004).

We don't need abstract scheme in the form of context-independent linguistic meaning as input to the composition process. This can proceed without the help of conventionalized context-independent word meanings. ME gets rid of abstract meaning in favour of observed occasion of particular uses.
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Language models which follow this view are deemed to fail in accounting for semantic composition in natural language. There are at least three different types of arguments for this claim.
First, if we allow that context does all the work required to obtain the assignment of explicit semantic values to word occurrences, the range of interpreted values assignable to a given lexical entry is in principle unlimited.
Why the ME and the no-distinction are not tenable

First, if we allow that context does all the work required to obtain the assignment of explicit semantic values to word occurrences, the range of interpreted values assignable to a given lexical entry is in principle unlimited.

In this perspective, there is nothing preventing speakers from uttering a word instead of another in their speech, which is obviously not the case.
Why the ME and the no-distinction are not tenable

Second, there clearly is stability in the assignment of semantic values to lexical items across speakers.
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Both these aspects support the idea that lexical meanings have a robust psychological reality.
Third, there are constraints to the way we can stretch the meaning of words in the context of use.
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These constraints do not appear to be systematically predictable on the basis of conceptual knowledge, suggesting that constraints operate not only at the cognitive level but also at the **lexical semantics level**, and there exists a distinction between the two.
Consider the concepts expressed by the following words and the relations existing among them: *museo* ‘museum’, *quadro* ‘painting’ and *collezione* ‘collection’.
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- *museo* denotes both the **LOCATION** where paintings are stored, and the **INSTITUTION** which is in charge of exhibiting them;
- *quadro* is the prototypical **OBJECT** associated with the **EXHIBIT** event; specifically, the participant playing the role of Theme;
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- *museo* denotes both the **location** where paintings are stored, and the **institution** which is in charge of exhibiting them;

- *quadro* is the prototypical **object** associated with the **exhibit** event; specifically, the participant playing the role of Theme;

- *collezione* refers to a **group** of accumulated paintings, usually considered as a whole because of the way it was put together.
The concepts expressed by these three words are clearly related.
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There exists:
Corpus Investigation

- The concepts expressed by these three words are clearly related.
- There exists:
  - a containment relation between *quadro* and *museo*;
  - a relation of participation between *quadro* and the relational concept expressed by *exhibit*.
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There exists:

- a **containment** relation between *quadro* and *museo*;
- a **part_of** relation between *quadro* and *collezione*;
The concepts expressed by these three words are clearly related.

There exists:

- a containment relation between quadro and museo;
- a part_of relation between quadro and collezione;
- a relation of participation between quadro and the relational concept expressed by EXHIBIT.
Corpus data

(1) a. “Il museo apre alle alle 9.00”. (1627 hits) ‘The museum opens at 9.00’
   c. “I quadri aprono alle 9.00”. (0 hits) ‘The paintings open at 9.00’.

Corpus ItTenTen (4.9 billion words) queried through the Sketch Engine (Kilgarriff et al 2014) using CQL.
Words which are cognitively related such as *collezione* and *quadro* (being collection a word that denotes both the act and the result of gathering together a number of painting) exhibit in the data different semantic behaviors in composition with respect to the extent to which their meaning is stretched.
Results

- Words which are cognitively related such as *collezione* and *quadro* (being collection a word that denotes both the act and the result of gathering together a number of painting) exhibit in the data different semantic behaviors in composition with respect to the extent to which their meaning is stretched.

- There appear to be constraints to the way we stretch the meaning of words, which are not necessarily motivated cognitively.
One might argue that this is related to conventions in language.
Results

- One might argue that this is related to conventions in language.
- We content that this is precisely the argument in favour of distinguishing conceptual knowledge from the actual knowledge associated with lexical items of a specific language, and constitutes its semantics.
We theorize that besides being constrained, stretching phenomena are \textit{graded}, that is, they vary depending on how much the lexical content is \textit{exploited} or \textit{enriched} in the context of use.

We run an experiment to obtain human judgements on a total of 100 verb-object and subj-verb contextualised dyads, where 2 annotators were asked to rate how literal the interpretation of the highlighted noun in the given dyad was, within a span of 1 (literal) to 5 (shifted in context), and a tag for semantically not acceptable (odd).
We proposed the task as follows:
Annotation Task

- We proposed the task as follows:
- “How literal is the interpretation of the highlighted word in the contexts below? Rate it from 1 (literal) to 5 (shifted in context) and use the last column if you think the example is semantically odd or non interpretable.”
The dyads consist of corpus-derived examples of matching (42) and mismatching (58) taken from T-PAS study outlined above from the Italian section of the dataset of the SemEval 2010 Task 7 on Argument Coercion (Pustejovský et al. 2010).
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Additional examples were constructed manually with the goal of testing acceptability.
Sample of the dataset

Sample of the dataset for the It. verb *annunciare* ‘announce’. The noun to be annotated is the one in subject position that is assumed to be typed as [[Human]] by the selecting verb.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>13</td>
<td><em>lo speaker</em> annuncia la partenza del treno</td>
</tr>
<tr>
<td>14</td>
<td><em>Una tromba</em> annuncia un parlamentare</td>
</tr>
<tr>
<td>15</td>
<td><em>Questa tromba</em> annuncia una sventura</td>
</tr>
<tr>
<td>16</td>
<td><em>i telegiornali</em> annunciano la ricomparsa della madre</td>
</tr>
<tr>
<td>17</td>
<td><em>una telefonata</em> annuncia la presenza di un ordigno</td>
</tr>
<tr>
<td>18</td>
<td><em>L’ altoparlante</em> annuncia ritardi a catena</td>
</tr>
<tr>
<td>19</td>
<td><em>La voce</em> metallica dell’altoparlante ha annunciato che il regionale sarebbe arrivato in ritardo</td>
</tr>
<tr>
<td>20</td>
<td><em>il premier</em> spagnolo annuncia il ritiro immediato delle truppe</td>
</tr>
<tr>
<td>21</td>
<td><em>Washington</em> ha annunciato un programma di aiuti</td>
</tr>
<tr>
<td>22</td>
<td><em>Il governo</em> coreano ha annunciato la vendita della Dae-woo</td>
</tr>
<tr>
<td>23</td>
<td><em>Il comunicato</em> annuncia la nomina del consiglio di amministrazione</td>
</tr>
<tr>
<td>24</td>
<td><em>Una voce</em> dalla radio annuncia lo sciopero generale</td>
</tr>
<tr>
<td>25</td>
<td><em>Gli organizzatori</em> annunciano una sorpresa</td>
</tr>
</tbody>
</table>

**Table:** Sample of the dataset
The two annotators marked the same judgements in 57 cases out of the 100 proposed (57% of observed agreement).
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Cohen’s kappa (K) takes into account the possibility of the agreement occurring by chance; the formula subtracts the probability of agreement by chance from the observed agreement.
Overall, the results show that the two annotators express a variety of graded judgments on coercions when allowed to do so by the task.
Qualitative Analysis

- Overall, the results show that the two annotators express a variety of graded judgments on coercions when allowed to do so by the task.

- Both annotators make extensive use of tag 1 (52 tags for ANN 1 and 49 tags for ANN 2), and their agreement on this tag - identifying the most literal reading - is higher than on any other tag (41 agreement on tag 1; 6 on tag 2; 2 on tag 3; 4 on tag 4, 1 on tag 5; 3 on odd).
Conventionalized coercions

Agreements on tag 1 do not include conventionalized coercions:

"aprire il vino rosso in anticipo" 'open the red wine in advance' (tag 3, 4)
"finire il bicchiere prima di andarsene" 'finish the glass before leaving' (tag 4, 4)
"divorare Asterix" 'devour Asterix' (tag 3, 5)
"Freuds e in edicola" 'Freud is at the newsstand' (tag 5, 5)
"Washington ha annunciato un programma di aiuti" 'Washington announced an aid campaign' (tag 4, 5)
"L'altoparlante annuncia ritardi a catena" 'The loudspeaker announces successive delays' (tag 5, 5)
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Overall Variation

- The largest variation between the two annotators is to be found in tags higher than 1.
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Compared to ANN 2, ANN1 underuses tag 3 (total of 5 annotations), perhaps under the suggestion that it is a “neutral” score and does not disambiguate clearly between literal and non literal.
There is agreement between the annotators on the oddness (tag: odd) of the following two expressions, validating the corpus-based analysis in section 4, according to which the It. noun *quadro* is not successfully used as a coercion to Institution.

- "i quadri aprono alle 9.00". 
  'The paintings open at 9.00'
- "visitare i quadri". 
  'visit the paintings'
There is agreement between the annotators on the oddness (tag: odd) of the following two expressions, validating the corpus-based analysis in section 4, according to which the It. noun *quadro* is not successfully used as a coercion to Institution.

(3) a. “i quadri aprono alle 9.00”.
   ‘The paintings open at 9.00’

b. “visitare i quadri”.
   ‘visit the paintings’
Concluding thoughts

- Although the annotations span over all degrees, their total between 1 and 3 (151) is much higher than the total between 3 and 5 (55).
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- Although the annotations span over all degrees, their total between 1 and 3 (151) is much higher than the total between 3 and 5 (55).
- In light of the ratio between selection and coercion in the dataset (42/58), this result suggests that coercion mechanisms is perhaps not perceived as highly non literal by speakers, whereas this could not be the case with metaphorical uses.
Stretching phenomena in semantics are both \textit{graded} and \textit{constrained}, as shown by corpus evidence and data about human judgements.
Stretching phenomena in semantics are both **graded** and **constrained**, as shown by corpus evidence and data about human judgements. The presence of constraints on stretching phenomena constitutes linguistic evidence that points towards a rejection of meaning eliminativism and towards moderate minimalism in lexical semantics.
Although context can stretch the meaning of words, some combinations are uninterpretable, and others are highly unlikely, because **words do carry a meaning on their own**, and the construction of interpretation is **not entirely a matter of context**.
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A word can be seen as a collection of “pointers” to “fragments” of conceptual knowledge.
Words as Collections of Pointers

- Although context can stretch the meaning of words, some combinations are uninterpretable, and others are highly unlikely, because words do carry a meaning on their own, and the construction of interpretation is not entirely a matter of context.

- A word can be seen as a collection of “pointers” to “fragments” of conceptual knowledge.

- The way conceptual knowledge is packed into lexical items and available for exploitation in actual use presupposes the existence of a specific mental entity, lexical meaning, which acts as interface between concepts and words.
Three components in verb’s denotation, which together constitute different aspect of the same object, i.e. an eventuality.
The meaning of verbs and their representation in a vector-based model of compositionality

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- Time and time structure.
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- Time and time structure.
- Argumenthood.
- Inherent Meaning.
Time and time structure

- The denotation of a verb is an eventuality, and an eventuality is located and structured in time.
- states (own)
The denotation of a verb is an eventuality, and an eventuality is located and structured in time.

- states (own)
- processes (work, sleep)
Time and time structure

- The denotation of a verb is an eventuality, and an eventuality is located and structured in time.
- states (own)
- processes (work, sleep)
- punctual events (find, arrive)
Time and time structure

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- Processes (work, sleep)
- Punctual events (find, arrive)
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Event Ontologies.
Co-composition

Verb meaning is co-dependent on those of its arguments.
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- take a tablet | a train.
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- Verb meaning is co-dependent on those of its arguments.
- take a tablet | a train.
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Cf. “intersective method of combination is well-known to fail in many cases”, Baroni and Zamparelli 2010

Formal mechanism of co-composition in Pustejovsky 1995
Co-composition

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In distributional semantics, verbs have often been represented through vectors built on verbs themselves or on the sum of the arguments vectors (see for the latter Grefenstette and Sadrzadeh, 2011; Kartsaklis and Sadrzadeh, 2013).
Augmented Verb Vectors

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- In Bundell, Sadrzadeh and Jezek 2017, we propose to build vectors for verbs by augmenting the verb vector with the vector of the argument(s), with the goal of providing a better distributional representation for the verb itself.
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- In Bundell, Sadrzadeh and Jezek 2017, we propose to build vectors for verbs by augmenting the verb vector with the vector of the argument(s), with the goal of providing a better distributional representation for the verb itself.

- We base our proposal on the theoretical assumption that argument structure is part of the meaning of the verb and not external to it (Pustejovsky, 1995, Van Valin, 2005, Levin and Rappaport Hovav, 2005).
We test our augmented vectors on a similarity task using the SimVerb-3500 dataset (Gerz et al 2016), designed to represent the complexity of verb meanings and to gain a better understanding of verb semantics in distributional models.
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The dataset contains 3500 verb pairs (827 distinct verbs) with at least 10 human ratings for the similarity for each pair (0-10).

- respond/reply 9.79 vs. run/hit 0.17.
- Annotated relations: antonyms, synonyms, hyper/hyponyms, no relation.
We analyse the dataset in three different ways based on the number of the
We use four different argument combination models to augment the verb vectors in two different conjunctive and disjunctive ways.
Models

- We use four different argument combination models to augment the verb vectors in two different conjunctive and disjunctive ways.
  - **Disjunctive Operations**: summation, point-wise maximum.
We use **four** different argument combination models to augment the verb vectors in **two** different conjunctive and disjunctive ways.

- **Disjunctive Operations**: summation, point-wise maximum.
- **Conjunctive Operations**: point-wise multiplication, point-wise minimum, and Kronecker tensor product.
The resulting representations are evaluated on the verb similarity task in three different vector spaces, trained on the parsed version of the UKWacky corpus.

- Tensor Flow Skip-gram
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- Word2vec CBOW
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- **Tensor Flow Skip-gram**
- **Word2vec CBOW**
- **Count-based model** (PPMI-normalized co-occurrence count).
### Subj-Obj combination Formulae

<table>
<thead>
<tr>
<th>Label</th>
<th>Formula</th>
<th>Label</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arguments Only</strong></td>
<td></td>
<td><strong>Verbs Augmented by Arguments</strong></td>
<td></td>
</tr>
<tr>
<td>Sum</td>
<td>$\overrightarrow{Verb}<em>{i}^{+} = (\sum</em>{i}^{n} \overrightarrow{Sbj}<em>{i}) + (\sum</em>{i}^{n} \overrightarrow{Obj}_{i})$</td>
<td>Sum-Sum</td>
<td>$\overrightarrow{Verb}_{i}^{+} + \overrightarrow{Verb}$</td>
</tr>
<tr>
<td>Kronecker</td>
<td>$\overrightarrow{Verb}<em>{i}^{\otimes} := \sum</em>{i}^{n} \overrightarrow{Sbj}<em>{i} \otimes \overrightarrow{Obj}</em>{i}$</td>
<td>Sum-Mult</td>
<td>$\overrightarrow{Verb}_{i}^{+} \odot \overrightarrow{Verb}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kron-Sum</td>
<td>$\overrightarrow{Verb}_{i}^{\otimes} + (\overrightarrow{Verb} \otimes \overrightarrow{Verb})$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kron-Mult</td>
<td>$\overrightarrow{Verb}_{i}^{\otimes} \odot (\overrightarrow{Verb} \otimes \overrightarrow{Verb})$</td>
</tr>
</tbody>
</table>

Table 1: Subjects/objects combination formulae
## Subject combination Formulae

<table>
<thead>
<tr>
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<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arguments Only</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum</td>
<td>$\overline{\text{Verb}}<em>{\text{it}u}^{+} := \sum_i Sb</em>{j}^{i}$</td>
<td>Sum-Sum</td>
<td>$\overline{\text{Verb}}_{\text{it}u}^{+} + \overline{\text{Verb}}$</td>
</tr>
<tr>
<td>Minimum</td>
<td>$\overline{\text{Verb}}<em>{\text{it}u}^{\text{min}} := \text{argmin}(Sb</em>{j}^{1}, \ldots, Sb_{j}^{k})$</td>
<td>Sum-Mult</td>
<td>$\overline{\text{Verb}}_{\text{it}u}^{+} \circ \overline{\text{Verb}}$</td>
</tr>
<tr>
<td>Maximum</td>
<td>$\overline{\text{Verb}}<em>{\text{it}u}^{\text{max}} := \text{argmax}(Sb</em>{j}^{1}, \ldots, Sb_{j}^{k})$</td>
<td>Min-Sum</td>
<td>$\overline{\text{Verb}}_{\text{it}u}^{\text{min}} + \overline{\text{Verb}}$</td>
</tr>
<tr>
<td>Kronecker</td>
<td>$\overline{\text{Verb}}<em>{\text{it}u}^{\otimes} := \sum_i Sb</em>{j}^{i} \otimes Sb_{j}^{i}$</td>
<td>Min-Mult</td>
<td>$\overline{\text{Verb}}_{\text{it}u}^{\text{min}} \circ \overline{\text{Verb}}$</td>
</tr>
</tbody>
</table>

| **Verbs Augmented by Arguments** |                            |                 |                           |
| Sum-Sum         | $\overline{\text{Verb}}_{\text{it}u}^{+} + \overline{\text{Verb}}$ | Sum-Mult        | $\overline{\text{Verb}}_{\text{it}u}^{+} \circ \overline{\text{Verb}}$ |
| Min-Sum         | $\overline{\text{Verb}}_{\text{it}u}^{\text{min}} + \overline{\text{Verb}}$ | Min-Mult        | $\overline{\text{Verb}}_{\text{it}u}^{\text{min}} \circ \overline{\text{Verb}}$ |
| Max-Sum         | $\overline{\text{Verb}}_{\text{it}u}^{\text{max}} + \overline{\text{Verb}}$ | Max-Multiply    | $\overline{\text{Verb}}_{\text{it}u}^{\text{max}} \circ \overline{\text{Verb}}$ |
| Kron-Sum        | $\overline{\text{Verb}}_{\text{it}u}^{\otimes} + (\overline{\text{Verb}} \otimes \overline{\text{Verb}})$ | Kron-Multiply   | $\overline{\text{Verb}}_{\text{it}u}^{\otimes} \circ (\overline{\text{Verb}} \otimes \overline{\text{Verb}})$ |

Table 2: Subject combination Formulae
# 500 Development Set

<table>
<thead>
<tr>
<th>Model</th>
<th>Verb</th>
<th>Sum</th>
<th>Kronecker</th>
<th>Sum-Sum</th>
<th>Sum-Multiply</th>
<th>Kronecker-Sum</th>
<th>Kronecker-Multiply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skip-gram</td>
<td>0.0094</td>
<td>0.0076</td>
<td>0.0348</td>
<td>0.0188</td>
<td>0.0224</td>
<td>0.0465</td>
<td>0.0187</td>
</tr>
<tr>
<td>CBOW</td>
<td>0.1497</td>
<td><strong>0.2013</strong></td>
<td>0.1374</td>
<td>0.2008</td>
<td>0.1684</td>
<td>0.1383</td>
<td>0.1767</td>
</tr>
<tr>
<td>Count</td>
<td>0.2382</td>
<td>0.1270</td>
<td>0.1457</td>
<td>0.1398</td>
<td><strong>0.2773</strong></td>
<td>0.1516</td>
<td><strong>0.2657</strong></td>
</tr>
</tbody>
</table>

**The Original Setting**

<table>
<thead>
<tr>
<th>Model</th>
<th>Verb</th>
<th>Sum</th>
<th>Kronecker</th>
<th>Sum-Sum</th>
<th>Sum-Multiply</th>
<th>Kronecker-Sum</th>
<th>Kronecker-Multiply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skip-gram</td>
<td>0.0141</td>
<td>0.0109</td>
<td>0.0501</td>
<td>0.0108</td>
<td>0.0188</td>
<td><strong>0.0503</strong></td>
<td>0.0223</td>
</tr>
<tr>
<td>CBOW</td>
<td>0.1757</td>
<td>0.1865</td>
<td>0.1003</td>
<td>0.1861</td>
<td><strong>0.1909</strong></td>
<td>0.1014</td>
<td>0.1864</td>
</tr>
<tr>
<td>Count</td>
<td>0.3613</td>
<td>0.2792</td>
<td>0.2772</td>
<td>0.3880</td>
<td>0.2772</td>
<td><strong>0.4206</strong></td>
<td><strong>0.4206</strong></td>
</tr>
</tbody>
</table>

**Verbs with Top 5% of Subjects/Objects Removed**

<table>
<thead>
<tr>
<th>Model</th>
<th>Verb</th>
<th>Sum</th>
<th>Kronecker</th>
<th>Sum-Sum</th>
<th>Sum-Multiply</th>
<th>Kronecker-Sum</th>
<th>Kronecker-Multiply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skip-gram</td>
<td><strong>0.4119</strong></td>
<td>0.0784</td>
<td>0.1029</td>
<td>0.0736</td>
<td>0.3409</td>
<td>0.1029</td>
<td>0.3495</td>
</tr>
<tr>
<td>CBOW</td>
<td>0.1437</td>
<td>0.0491</td>
<td>0.0085</td>
<td>0.0491</td>
<td>0.3587</td>
<td>0.0085</td>
<td><strong>0.3832</strong></td>
</tr>
<tr>
<td>Count</td>
<td><strong>0.3613</strong></td>
<td>0.1270</td>
<td>0.1457</td>
<td>0.1398</td>
<td>0.2773</td>
<td>0.1516</td>
<td><strong>0.2657</strong></td>
</tr>
</tbody>
</table>

**Synonyms Only**

<table>
<thead>
<tr>
<th>Model</th>
<th>Verb</th>
<th>Sum</th>
<th>Kronecker</th>
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<th>Sum-Multiply</th>
<th>Kronecker-Sum</th>
<th>Kronecker-Multiply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skip-gram</td>
<td>0.0143</td>
<td>0.0281</td>
<td>0.0669</td>
<td>0.0280</td>
<td>0.0146</td>
<td><strong>0.06721</strong></td>
<td>0.0110</td>
</tr>
<tr>
<td>CBOW</td>
<td>0.1693</td>
<td><strong>0.2059</strong></td>
<td>0.1338</td>
<td>0.2049</td>
<td>0.1706</td>
<td>0.1346</td>
<td>0.1790</td>
</tr>
<tr>
<td>Count</td>
<td>0.2309</td>
<td>0.1331</td>
<td>0.1484</td>
<td>0.1336</td>
<td><strong>0.2787</strong></td>
<td>0.1486</td>
<td>0.2650</td>
</tr>
</tbody>
</table>

**All But Antonyms**

Table 3: Degrees of correlation between human rankings and cosine distances on the 500 development set of SimVerb-3500. Baseline is the verb-only model: the first column on the models row.
3000 Test Set

<table>
<thead>
<tr>
<th>Model</th>
<th>Verb</th>
<th>Sum</th>
<th>Kronecker</th>
<th>Sum-Sum</th>
<th>Sum-Multiply</th>
<th>Kronecker-Sum</th>
<th>Kronecker-Multiply</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Original Setting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>0.1490</td>
<td>0.1183</td>
<td>0.1014</td>
<td>0.1135</td>
<td><strong>0.1632</strong></td>
<td>0.1014</td>
<td><strong>0.1623</strong></td>
</tr>
<tr>
<td><strong>Verbs with Top 5% of Subjects/Objects Removed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>0.1558</td>
<td>0.1557</td>
<td>0.1414</td>
<td>0.1568</td>
<td><strong>0.2055</strong></td>
<td>0.1415</td>
<td><strong>0.2046</strong></td>
</tr>
<tr>
<td><strong>Synonyms Only</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>0.1503</td>
<td>0.0245</td>
<td>0.0093</td>
<td>0.0251</td>
<td><strong>0.0265</strong></td>
<td>0.0093</td>
<td><strong>0.0236</strong></td>
</tr>
<tr>
<td><strong>All But Antonyms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>0.1533</td>
<td>0.1208</td>
<td>0.1074</td>
<td>0.1209</td>
<td><strong>0.1682</strong></td>
<td>0.1075</td>
<td><strong>0.1681</strong></td>
</tr>
</tbody>
</table>

Table 4: Degrees of correlation between human rankings and cosine distances on the 3000 test set of SimVerb-3500 for the best model of the development set. Baseline is the verb-only model: the first column on the models row.
In line with Pado and Erk 2008, we show that argument augmented models perform better than only verb base models in similarity task. Specifically, the conjunctive model based on point-wise multiplication and the Kronecker tensor product performs better than the baseline of verb-only vectors and the other operations. The best model is the count-based model. The best optimization of the dataset is the subset with the top 5 percent of the number of Subject/Objects removed.

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Elisabetta Ježek Streching the Meaning of Words
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We start from the assumption that the set of fillers that occupy the argument positions of a verb in a specific verb sense in its contexts of use (**lexical sets**, Hanks 1996, Hanks and Pustejovky 2005) can ground the semantic types associated with argument positions empirically.
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We start from the assumption that the set of fillers that occupy the argument positions of a verb in a specific verb sense in its contexts of use (**lexical sets**, Hanks 1996, Hanks and Pustejovky 2005) can ground the semantic types associated with argument positions empirically.

For example the lexical set \{gun, rifle, pistol, weapon, ...\} grounds the semantic type *Firearm* for the object position of *to fire* in its ‘to shoot’ sense, whereas the lexical set \{employer, teacher, attorney, manager...\} grounds the semantic type *Human* for the same position in its ‘to dismiss’ sense.
We focus on Italian **Causative/Incoative** verbs: *suonare* (ring, play), *rompere* (break), *riempire* (fill), *seccare* (dry), *affondare* (sink), *finire* (finish)...

Un uomo ha suonato il campanello/la campana/la sveglia.

A man rang the door bell/the bell/*the alarm clock.

Il campanello/la campana/la sveglia ha suonato.

The door bell/the bell/the alarm clock rang.

Montemagni, Pirrelli, Ruimi 1995, Ringing things that nobody can ring.

Elisabetta Ježek

Streching the Meaning of Words
Case study

We focus on Italian **Causative/Incoative** verbs: *suonare* (ring, play), *rompere* (break), *riempire* (fill), *seccare* (dry), *affondare* (sink), *finire* (finish)...

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Montemagni, Pirrelli, Ruimi 1995, Ringing things that nobody can ring.
We harvest the list of fillers for the different argument positions - subject of transitive (A), subject of intransitive (S), object (O) - from the ITWac corpus.
We then transform the fillers for the different argument positions from the ITWaC corpus (A, S, O) into **vectors** using the Word2Vec Continuous Bag of Words (CBOW) Distributional Semantic Model (Mikolov et al, 2013).
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DSMs are based on the assumption that the meaning of words can be inferred by the neighbouring words (distributional hypothesis, Harris 1954, Firth 1957); they represent the similarity of meaning between words as geometric distance in multi-dimensional vector spaces.
Vectors created by these means are then fed to an algorithm (k-means) to obtain **clusters** to be contrasted with the **expected semantic types** associated with the argument positions in specific verb senses.
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The underlying hypothesis is that there is a correlation between the clusters obtained via vector quantization and the semantic types, and that semantic type grounding can benefit from the distributional procedure.
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Ponti, Jezek, Magnini 2016. Grounding the Lexical Sets in Causative / Inchoative Verbs with word Embedding.
Vector quantization is the operation of defining $k$ clusters in a model and then assessing vector membership - abiding the rule that every vector is assigned to one and only one cluster.
Vector Quantization

- **Vector quantization** is the operation of defining $k$ clusters in a model and then assessing vector membership - abiding the rule that every vector is assigned to one and only one cluster.

- The best trade-off is reached by *minimising cluster numbers* and *maximizing their internal similarity*. 
Semantic Types and Lexical Sets

Elisabetta Ježek

Streching the Meaning of Words
Semantic Types and Lexical Sets

Ponti, Jezek, Magnini 2016. Grounding the Lexical Sets in Causative / Inchoative Verbs with word Embedding.
## Semantic Types and Lexical Sets

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Ponti, Ježek, Magnini 2016. Grounding the Lexical Sets in Causative / Inchoative Verbs with word Embedding.
List of fillers of suonare_object in cluster 157

157 chiasso muto grida tuoni tuono brontolio folla cicale agitarsi fischi strepiti baccano clacson fracasso rintocchi fruscio grido frastuono eco silenzio brusio sbadiglio campanello ululati ululato sordo urlando campanacci orecchio gemito gemiti andirivieni sommesso ronzio timpani ruggito ruggiti squillo fragore fragori gorgoglio mormorio rumore rumori urla urlo rantolo stridore udito miagolio tonfo tumulto spari rincorriersi voce sospiri detonazioni singhiozzo campane fischio risa udiva muezzin sirena sirene lamento lamenti tam battito battiti
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Through **heatmaps** (low is white and high is blue) of the density of vectors reduced to 2 dimensions through t-SNE (Maaten and Hinton 2008), it is possible to observe spots in isolation and aggregation for the different argument positions.
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Heatmap finire\_subject

Heatmap affondare_subject

Elisabetta Ježek

Streching the Meaning of Words
Heatmap affondare_subject


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Streching the Meaning of Words
Heatmap affondare_object

Elisabetta Ježek  Streching the Meaning of Words
Heatmap affondare_object

Concluding observations and lines of research

- A plea for moderate minimalism in lexical semantics.
- Enriched and dynamic model of composition (beyond sum) in formal semantics, incorporating gradience and constraints in semantic phenomena.
- Probabilistic approach to identify the degree of stability of meaning components in the lexicon.
- Distributional methodology and geometric representations to gain a better understanding of the structure of our mental lexicon.
- Language properties such as semantic context-sensitivity are not solved in formal semantics: merging formal, distributional and probabilistic approaches represents a multi-side benefit.
THANK YOU FOR LISTENING!
The Lexicon

An Introduction

By Elisabetta Ježek, Associate Professor of Linguistics, University of Pavia

Oxford Textbooks in Linguistics
9780199601530| Hardback| £65.00 | January 2016