Modeling regular polysemy: A study in the semantic classification of Catalan adjectives

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Outline

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Overview

Automatic acquisition of semantic classes for adjectives
[Boleda et al., 2007, Boleda et al., prep]

Given: classification, set of adjectives, corpus
Task: infer the class for each adjective in the set

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- no established semantic classification or dataset
- we have to build these as we go along
  - → exploratory nature of the experiments
- two classifications tested
  - experiments 1 and 2

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- some adjectives are polysemous → have more than one sense → belong to more than one class
- we provide two alternative models
  - experiments 1 and 2

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Task: infer the class for each adjective in the set
→ identifying polysemous adjectives

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$\rightarrow$ identifying polysemous adjectives

- some adjectives are polysemous $\rightarrow$ have more than one sense $\rightarrow$ belong to more than one class
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Hypotheses and contribution

Lexical Acquisition

1. there is a stable relationship between semantic properties and other linguistic properties
   - Distributional Hypothesis [Harris, 1968]
2. linguistic properties can be modeled using observable cues in corpora
3. $\rightarrow$ observable cues can be used to induce semantic properties

Hypotheses and contribution

This study

1. it is possible to use observable cues to
   - induce semantic classes for adjectives
   - identify polysemous adjectives
2. computational methodology can give feedback to theoretical questions

Hypotheses and contribution

This study

1. it is possible to use observable cues to
   - induce semantic classes for adjectives
     - most work on lexical acquisition on verbs (vs. adjectives)
     - and English (vs. Catalan)
   - identify polysemous adjectives
2. computational methodology can give feedback to theoretical questions

Hypotheses and contribution

This study

1. it is possible to use observable cues to
   - induce semantic classes for adjectives
   - identify polysemous adjectives
     - polysemy largely ignored in related work on lexical acquisition
     - regular polysemy: studied on a theoretical level, not in empirical approaches to computational semantics
2. computational methodology can give feedback to theoretical questions

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Semantic classification

- insights from descriptive grammar and formal semantics

Qualitative adjectives denote attributes or properties of objects.

Examples: ample, autònom
'wide', 'autonomous'

Intensional adjectives denote second order properties.

Examples: presumpte, antic
'alleged', 'former'

Relational adjectives denote a relationship to an object.

Examples: pulmonar, botànic
'pulmonary', 'botanical'

- semantic classes
- correlate with other linguistic properties

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Example property: predicativity

qualitative (1)	intensional (2)	relational (3)
predicative	non-predicative	marginally predicative

(1) el carrer és ample
the street is wide

(2) #l' assassí és presumpte
the murderer is alleged

(3) ?la malaltia és pulmonar
the disease is pulmonary

Polysemy

- Polysemy cutting across two classes: relational (4a) and qualitative (4b):

(4) a. la recuperació econòmica
the recovery economic
'the economic recovery'

b. els pantalons econòmics
the trousers economic
'the cheap trousers'

(5) a. ?la recuperació és econòmica
the recovery is economic
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b. els pantalons són econòmics
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in each sense, the adjective's behaviour corresponds to that of the relevant class

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Regular polysemy [Apresjan, 1974, Copestake and Briscoe, 1995]

- same type of polysemy for a range of adjectives

(6) a. reunió familiar / cara familiar
meeting familiar / face familiar
'family meeting / familiar face'

b. problema amorós / noi amorós
problem $\text{love}_{\text{SUFFIX}}$ / boy $\text{love}_{\text{SUFFIX}}$
'love problem / lovely boy'

- in general:
relation to **object** $\rightarrow$ salient property of the **object**
- we only consider class-related polysemy

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Experiment 1: Motivation

- classification based on linguistic literature
- does it account for the semantics of a broad range of adjectives?
- polysemous adjectives should exhibit a different profile than monosemous adjectives
- is this behaviour distinct enough to identify polysemous classes?

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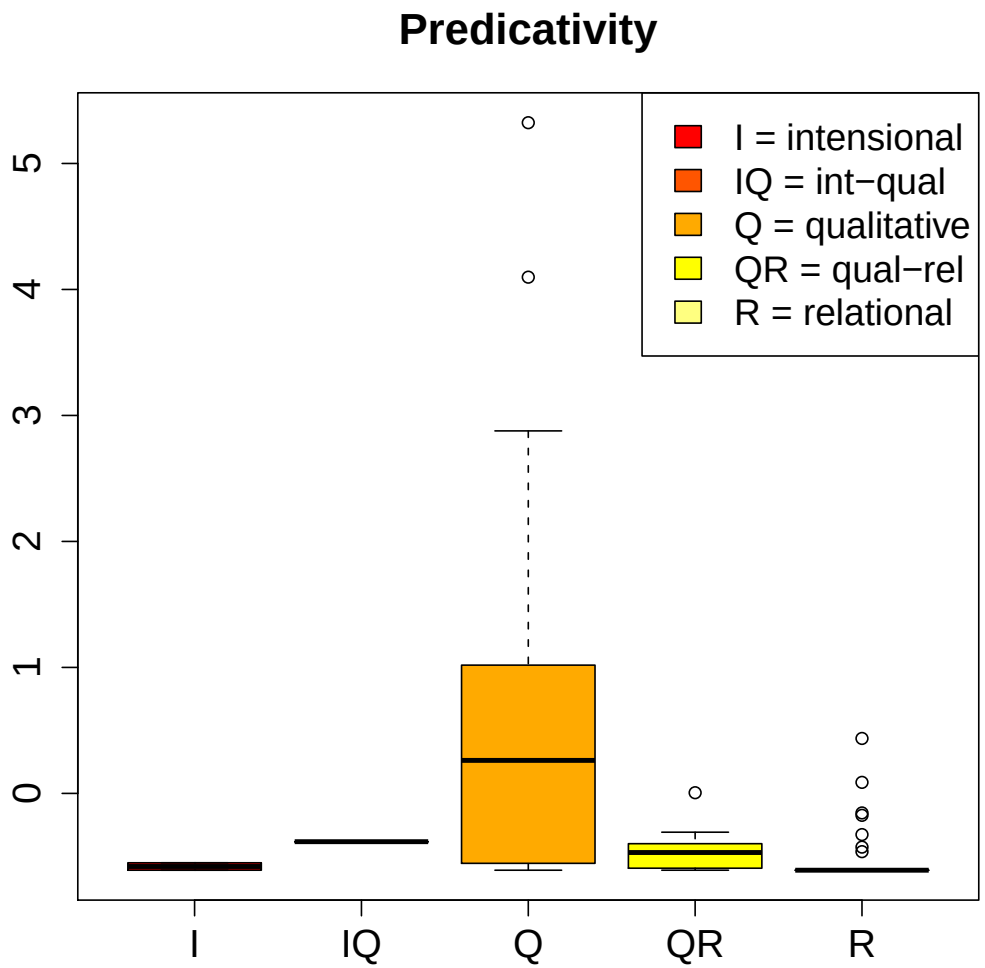
Material and method (I)

- CTILC corpus (*Institut d'Estudis Catalans*):
  - 14.5 million words, written, formal texts
  - manually lemmatised and POS-tagged
  - automatically shallow-parsed (noise)
- adjective database [Sanromà and Boleda, 2010]:
  - almost 2,300 lemmata from CTILC corpus
  - morphological information manually coded

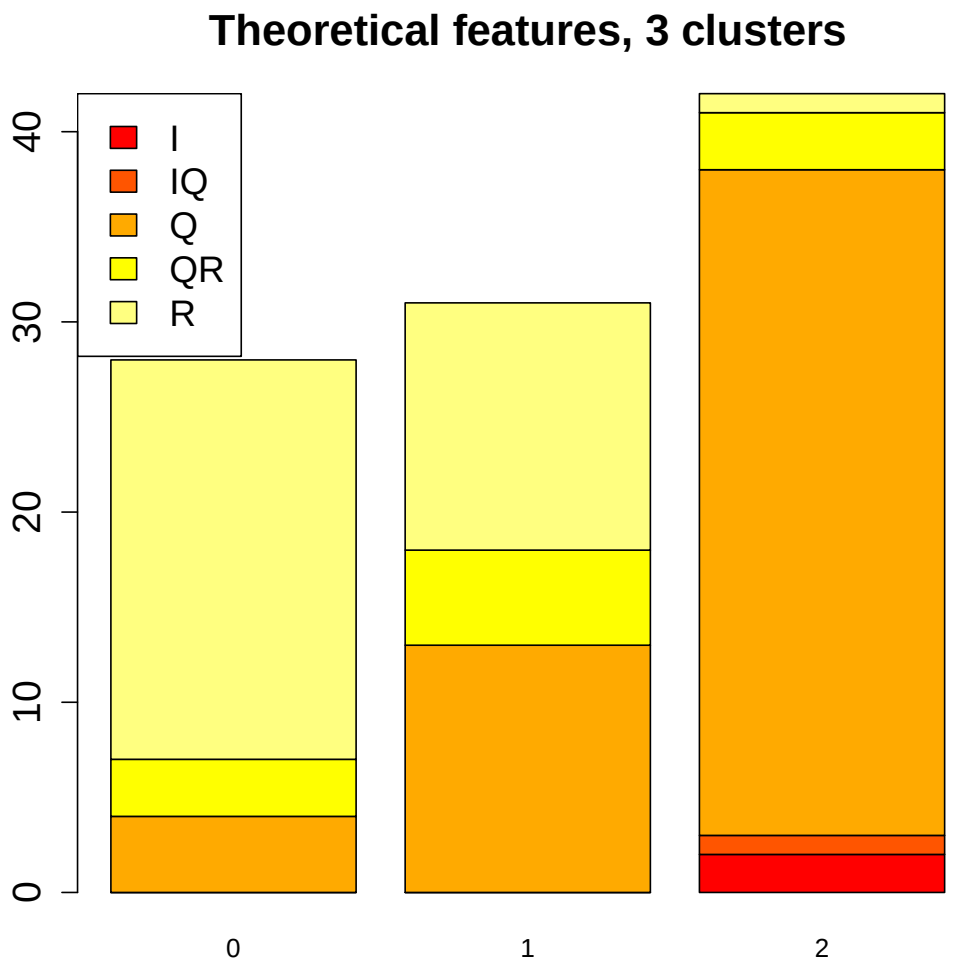
Material and method (II)

- Gold Standard: 101 lemmata, random choice except for intensional class
  - 4 judges, κ 0.54-0.64
  - for each adjective, choose semantic class
  - target classes:
    - basic classes: qualitative (Q), relational (R)
    - polysemous "class": qualitative-relational (QR)
- technique: clustering, *k*-means
  - 3,521 objects (freq $>$ 10)
- features:
  - theoretically motivated: predicativity, . . . (6)
  - POS: POS unigrams; 2 words left and right of target (36)

Feature example: value distribution across classes



Results



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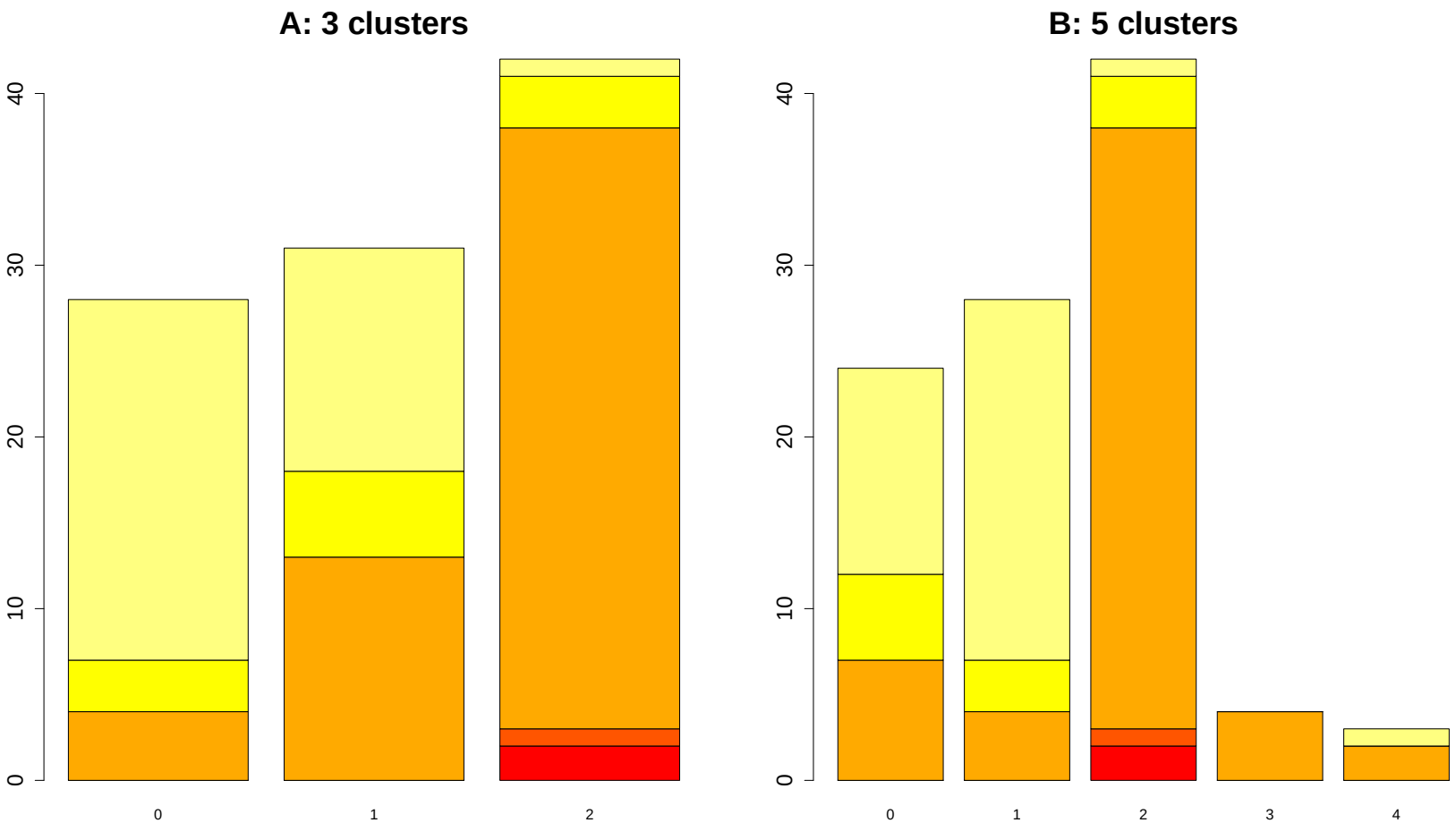
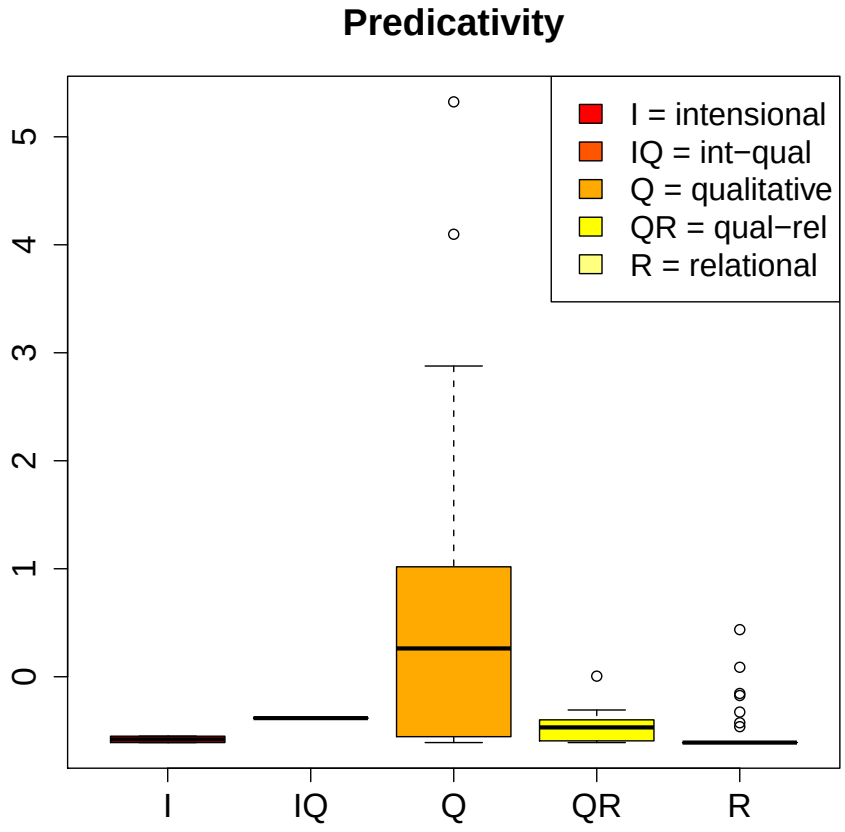


Discussion: polysemy

- approach to polysemy is clearly wrong



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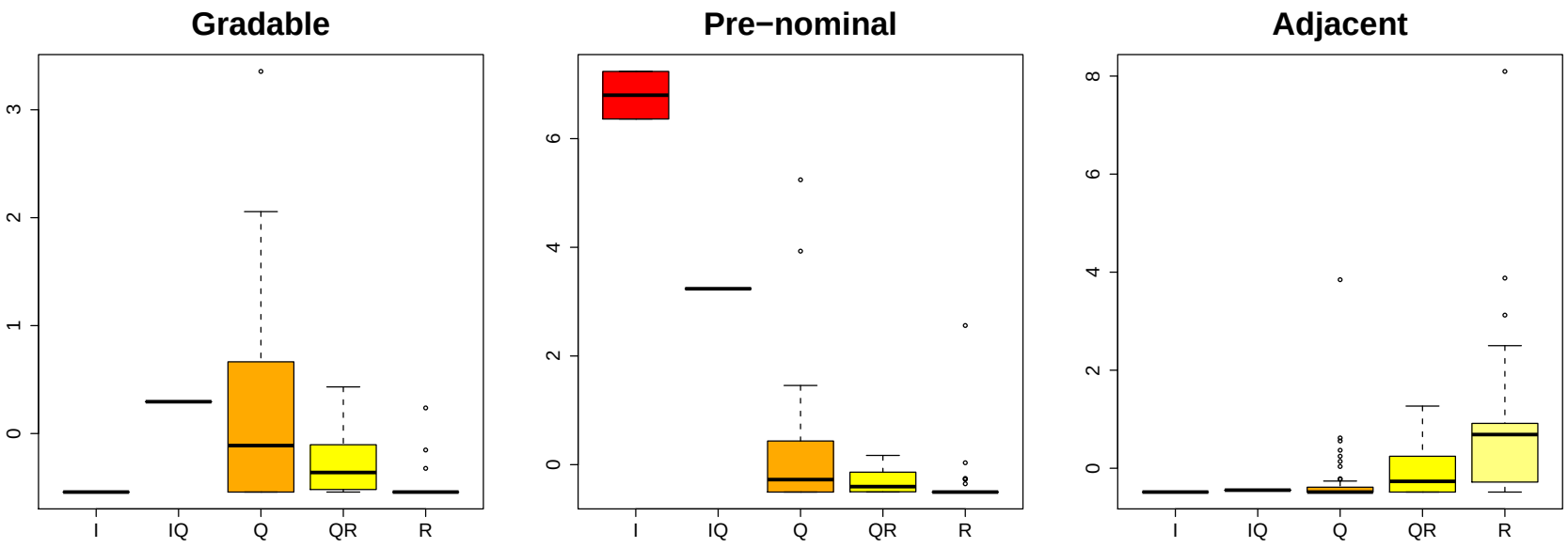

Discussion: polysemy

- polysemous adjectives do not have a homogeneous, differentiated profile
- most adjectives are used predominantly in one of their senses, corresponding to one of the classes
  - irònic ('ironic'): qualitative-relational.
    - mainly used as qualitative in the corpus
    - systematically assigned to the qualitative cluster
  - militar ('military'): qualitative-relational.
    - mainly used as relational in the corpus
    - systematically assigned to the relational cluster

Discussion: classification

- “mixed” cluster: group of problematic adjectives identified in error analysis:

indicador,	parlant,	protector,	salvador, …
‘indicating’,	‘speaking’,	‘protecting’,	‘saviour’, …

- these adjectives do not fit into the classification

→ create new class

Outline

Modified classification

Qualitative adjectives

Relational adjectives

Event-related adjectives denote a relationship to an event.

Examples: protector, ‘protecting’, variable ‘variable’

- relationship with morphology

qualitative	event	relational
non-derived	deverbal	denominal

- supported by Ontological Semantics [Raskin and Nirenburg, 1998]

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Experiment 2: Motivation

Experiment 1 shows that

- polysemous adjectives *do* exhibit a different profile from monosemous adjectives
- . . . but it is *not* distinct enough to identify polysemous classes
- polysemy = membership in more than one class

→ multi-label classification

- a lemma can belong to more than one target class
- look for properties of each of the classes

Material: Gold Standard

- same corpus and database as in Experiment 1
- Gold Standard: 210 lemmata
- stratified sampling approach
  - frequency, morphology
- large-scale manual annotation experiment
  - task: choose one or more pseudo-dictionary definitions
  - administered via Web
  - 322 naive subjects
  - does not yield reliable classification (κ 0.31-0.45)
- Gold Standard classification: committee of 3 experts
  - agreement subjects-experts: p_o 0.68, κ 0.55

Method

- classifiers: Decision Trees (flat), ensemble classifiers
- features:

Type	**Explanation**	**# F.**
morph	morphological properties ex.: *suffix*	2
func	syntactic function ex.: *predicate in copular sentence*	4
uni	uni-gram distribution ex.: *-1noun*	24
bi	bi-gram distribution ex.: *-1noun+1adj*	50
theor	distributional cues of theoretical properties ex.: *gradable*	18

Table: Experiment 2: features.

Procedure

Standard procedure for multi-label classification

1. binary decision
2. merge classifications
   - econòmic:

qualitative	relational	event	merged
yes	yes	no	qualitative-relational (QR)

   - rationale: if an adjective is polysemous, it will exhibit properties of each class it belongs to

Evaluation

- 10 run, 10-fold cross-validation
- baseline: most frequent class

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Results

Classifier	**Accuracy**
baseline	*51.0±0.0*
best flat	62.5±2.5
Att. Bagg.$_{FS,bin}$,i=100	**69.1**±1.0
Human agreement	68

Table: Experiment 2: summary of results.

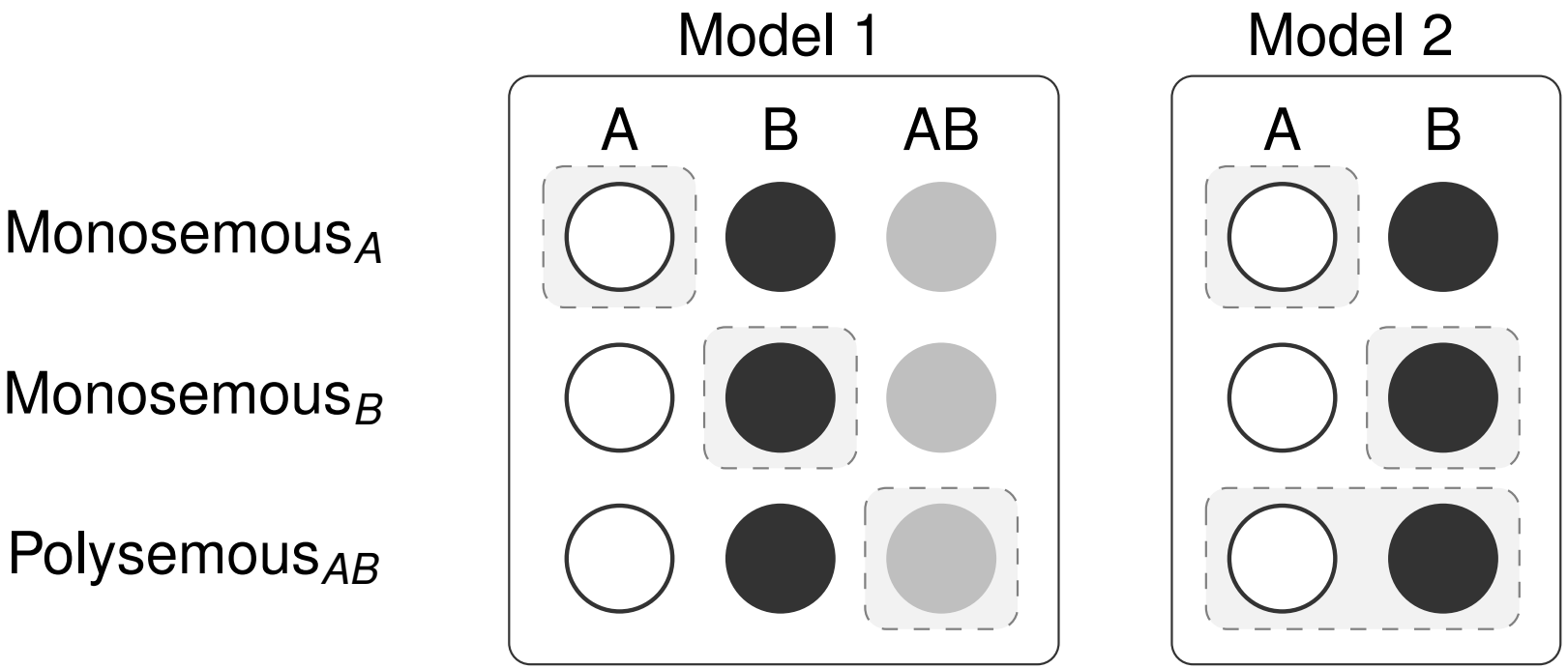
Error analysis

		Best classifier						
		Q	E	R	QR	QE	ER	*Total*
Experts	Q	90	4	2	3	8	0	*107*
	E	10	17	0	1	6	3	*37*
	R	4	0	20	4	0	2	*30*
	QR	5	0	4	13	0	1	*23*
	QE	1	1	0	0	5	0	*7*
	ER	0	0	2	1	0	3	*6*
	Total	*110*	*22*	*28*	*22*	*19*	*9*	*210*

- overgenerated polysemous adjectives: 26
  - undergenerated polysemous adjectives: 13

Outline

Discussion: Two models for regular polysemy



Conclusion

This study

1. it is possible to use observable cues to
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Conclusion

This study

1. it is possible to use observable cues to
   - induce semantic classes for adjectives
     - relationship between observable cues and semantic properties
     - explored morphology-semantics and syntax-semantics interfaces
     - roadblock: human agreement $\rightarrow$ need to improve theory
   - identify polysemous adjectives
2. computational methodology can give feedback to theoretical questions

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1. it is possible to use observable cues to
   - induce semantic classes for adjectives
   - identify polysemous adjectives
     - polysemous adjectives exhibit “hybrid” behaviour
     - tested two models of regular polysemy
     - need to model *both* similarities and differences with respect to basic classes
2. computational methodology can give feedback to theoretical questions

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   - identify polysemous adjectives
2. computational methodology can give feedback to theoretical questions
   - random sampling: emergence of “nonprototypically nonprototypical” adjectives
     - Gold Standards: medium-sized datasets
   - feature representation: empirical properties
   - Machine Learning: evaluation of different models

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Overall research question

How do languages encode meaning?

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How do words and word combinations encode meaning?

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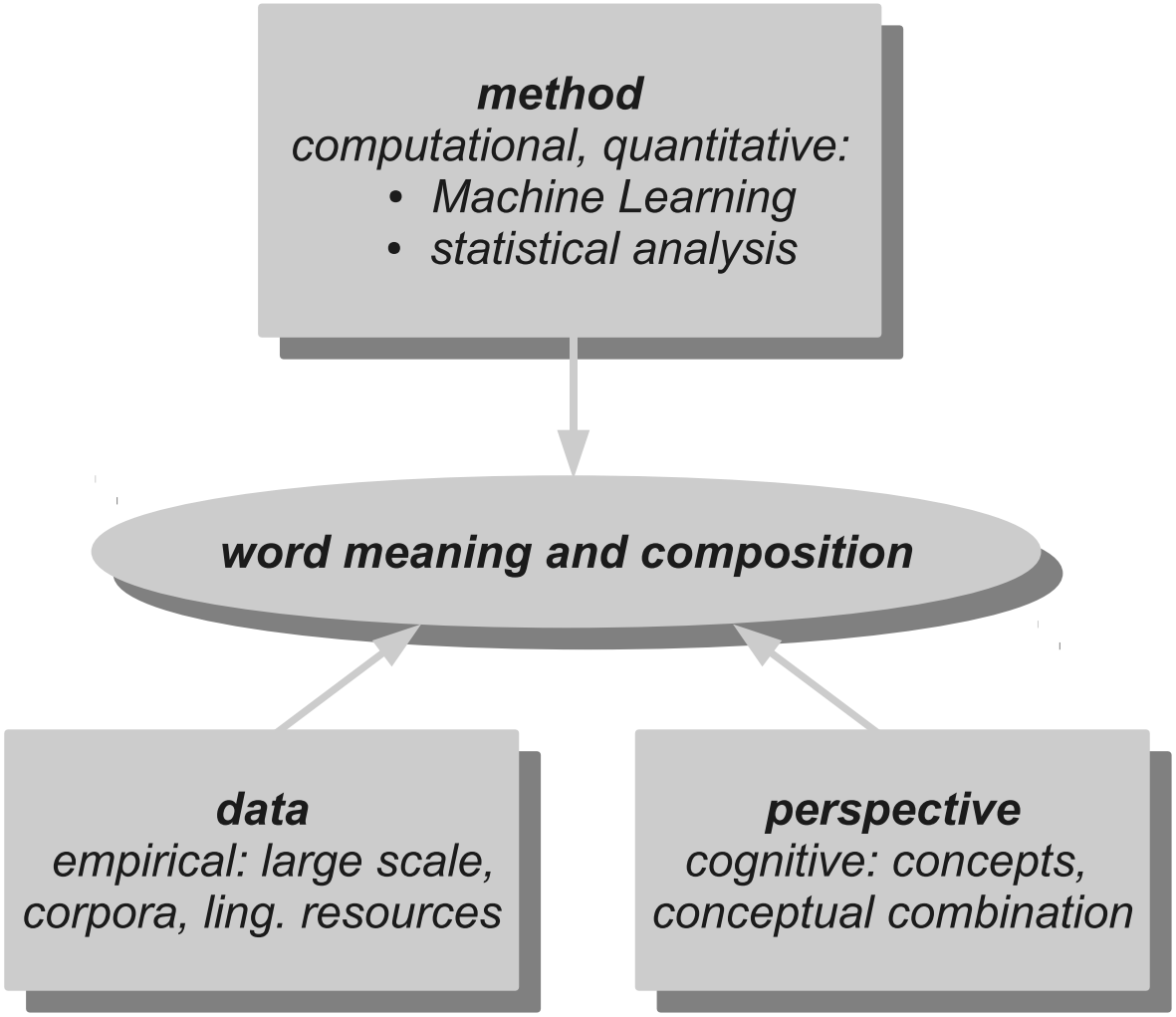
$\rightarrow$ **empirical computational lexical semantics**

Approach: computational lexical semantics

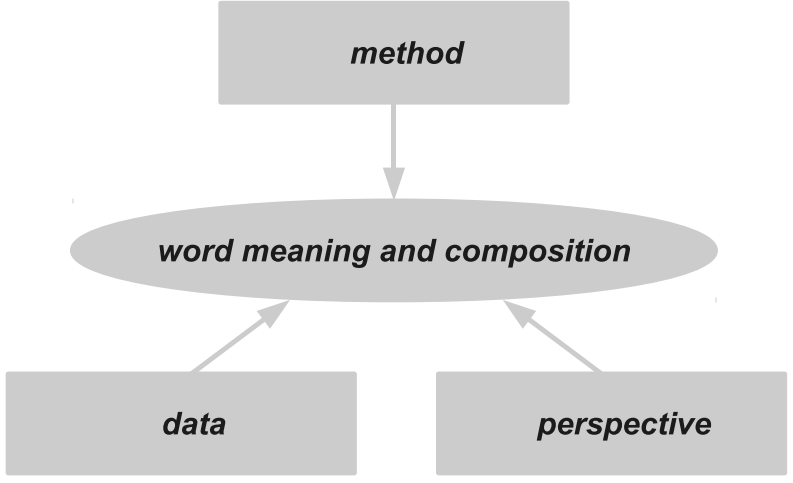


Current research

Goal

computationally model the interpretation processes that take place in semantic composition

→ distributional/vector-space models



Question 1

- While words may have different meanings, when used in a given context not all of them are relevant.

- **Question 1: How does combining two words affect the interpretation of each word?**
  - colour adjectives: *red dress* vs. *red wine*.
    $\rightarrow$ the modifier is altered depending on the head noun.

  - can distributional models account for the different meanings of the modifiers depending on the head noun?

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Question 2

- Often, the interpretation of a complex expression is richer than what can be inferred from the meaning of its parts alone.

- **Question 2: How does combining two words yield the interpretation of a complex expression?**
  - noun-noun compounds: *dog magazine* [Murphy, 2002]
  - → magazine ABOUT dogs – and more!
  - can distributional models account for the relation between a head and its modifier?

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Material for Experiment 2: Gold Standard

class	**#adjs.**	**Examples**
qualitative	107	ample ‘wide’
event	37	revelador ‘revealing’
relational	30	pulmonar, ‘pulmonary’
qual-ev	7	cridaner ‘vociferous/loud-coloured’
qual-rel	23	amorós ‘affectionate/related to love’
ev-rel	6	docent ‘teaching/related to teachers or the teaching task’

Results for Experiment 2: linguistically principled EC

	A: Per-class accuracy			B: Overall accuracy	
	Qualit.	**Event**	**Relat.**	**Full**	**Partial**
best flat (*all*)	**75.5**±9.0	**86.5**±6.4	86.0±6.5	62.5±2.5	**87.6**±2.5
3 best feat. sets	72.9±1.4	**88.2**±1.3	85.4±0.6	61.8±1.7	86.7±0.8
4 best feat. sets	74.6±2.0	**86.5**±1.5	88.1±1.2	63.0±2.4	87.4±1.8
5 best feat. sets	75.2±2.7	86.4±1.4	**90.8**±1.2	**64.8***±2.6	**89.5***±1.5
7 best feat. sets	75.3±2.3	82.7±1.8	**90.8**±1.1	**64.0**±1.5	85.9±1.3
all 9 feat. sets	**75.4**±1.7	80.9±2.1	90.1±1.2	62.4±2.2	84.4±1.3

Results for Experiment 2: other ensemble classifiers

	A: Per-class accuracy			B: Overall accuracy	
	Qualit.	**Event**	**Relat.**	**Full**	**Partial**
best flat (*all*)	75.5±9.0	**86.5**±6.4	86.0±6.5	62.5±2.5	87.6±2.5
best ling. EC (*)	75.2±2.7	**86.4**±1.4	**90.8**±1.2	64.8*±2.6	**89.5***±1.5
adaboost	**82.0***±8.6	85.6±7.1	88.0±6.7	66.0*±1.9	**89.9***±1.3
A. B.$_{FS,bin}$,i=3	76.0±9.4	84.0±7.0	88.3±7.2	64.0±2.5	86.7±2.0
A. B.$_{FS,bin}$,i=4	75.9±9.2	84.7±7.3	89.1±6.9	64.5±1.5	86.6±1.1
A. B.$_{FS,bin}$,i=5	77.0±8.7	85.8±7.1	89.0±6.5	**66.3***±1.1	87.0±1.5
A. B.$_{FS,bin}$,i=100	**81.0**±8.8	86.1±6.9	**90.1***±5.3	**69.1*****±1.0	89.0±1.0
Human agreement	-	-	-	*68*	*85*

Variation in object-object modification

(7) a. world war

b. John's book

c. agreement by France

d. psychological evidence