

# **Computational Modelling of Metaphor**

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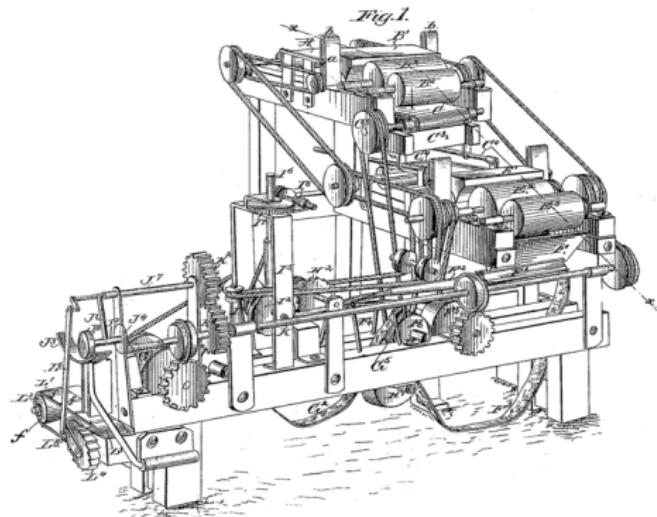
## Modelling metaphor: Why?

*I think that metaphor really is a key to explaining thought and language. [...] Our powers of analogy allow us to apply ancient neural structures to newfound subject matter, to discover hidden laws and systems in nature, and not least, to amplify the expressive power of language itself. (Pinker, 2007)*

- Metaphor structures our conceptual system
- It helps us derive and comprehend new information
- It is frequent in language

# What is metaphor?

*"A political machine"*



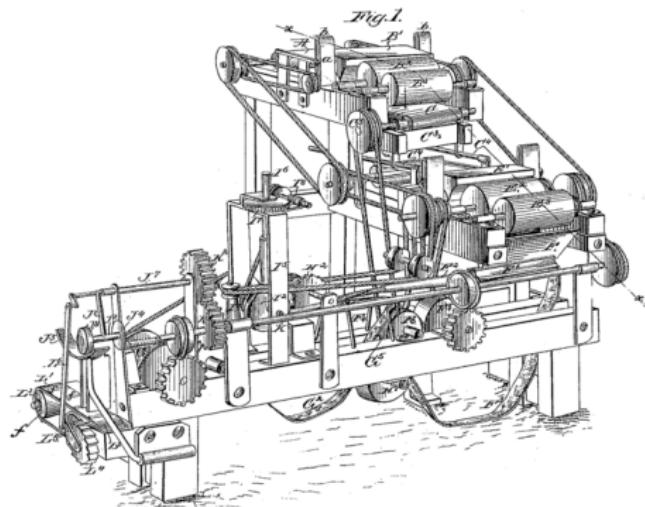
# What is metaphor?

“A political *machine*”

“The *wheels* of Stalin’s regime were *well oiled* and already *turning*”

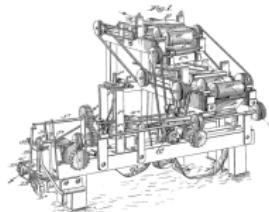
“Time to *mend* our foreign policy”

“20 Steps towards a Modern, *Working Democracy*”



## How does it work?

Conceptual Metaphor Theory  
(Lakoff and Johnson, 1980)



### Metaphorical associations between concepts

POLITICAL SYSTEM is a MECHANISM  
*target*                           *source*

### Cross-domain knowledge projection and inference

Reasoning about the target domain in terms of the properties of the source

## A few more examples

### ARGUMENT is a WAR

He *shot down* all of my arguments.

He *attacked* every point in my argument.

He *lost* that verbal *battle*

You disagree? Okay, *shoot!*

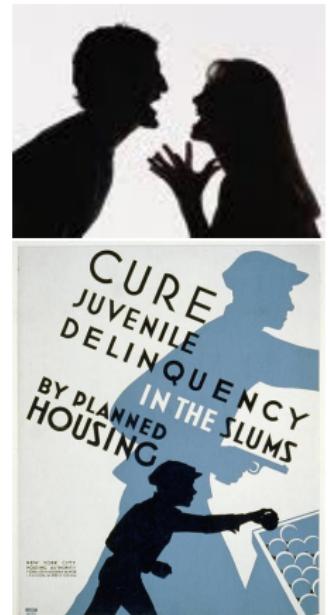
### CRIME is a DISEASE / VIRUS

*Cure* juvenile delinquency in the slums!

The best way to *diagnose* corruption is ...

Intergenerational *transmission* of abuse

Find a *cure* for crime



## Metaphor influences our decision-making

Thibodeau and Boroditsky (2011)

- investigated how metaphor influences decision-making
- subjects read a text containing metaphors of either
  - ① CRIME IS A VIRUS
  - ② CRIME IS A BEAST
- then they were asked a set of questions on how to tackle crime in the city
  - ① preventive measures
  - ② punishment, restraint



# Real-world text processing applications

that we no longer believe in hell, and that man, carrying some of these principles, are out of favour. The changes have been most fundamental and many of them may have affected us without our realising it. We have seen the most remarkable changes in the social conditions of change; but few would doubt that in the nineteenth century ~~there was~~<sup>there was</sup> greatly increased wealth, that much was apparent in the more prosperity of those living at that time. There was also a great increase in the number of people who were educated, in which better education and beneficial technology would ensure wealth and hence life all. This was Matthew Spender's view, namely that an *enlarged opportunity* was present in the nineteenth century. In the same way, the historian J. R. Green, in his history of England, said that - *"the growing power of change" were carrying them in "break-neck speed".* And he was impressed by the rapidity of the changes. *"Break-neck speed" was a break-neck speed.* Into the new age - *"Black" - I pitch!* Must the way ever - *"Gone - I fall!"* The historian, too, had to *"面對" the feelings moment" and "make take" it. Calm and historical periods differ greatly in their concept of time and the continuity of life. We live in a *"continuity"* of time, whereas the historian has to *"面對" the feelings moment" and "make take" it.* From which we can *"only" load on our way*. Once for better or for worse, in the century of *"Yester"* earlier centuries, in contrast had an appreciation of the past that was very different from ours. The historian, too, had to *"面對" the feelings moment" and "make take" it.* He had the belief that *"as long as days had provided some guidance on how to live and what to expect in the life to come. For the way" -* on such of each individual was not a *"break-neck speed"* but a *"slow walk"*. The historian, too, had to *"面對" the feelings moment" and "make take" it.* To unknown land was *"slow - move from place" as the memorial tablet had. A bad road was formed by the church, the floor and walls of which had been built by the family. Familiar church there *"furniture"*, whether these had lived in humble cottage or in magnificence. Some people had their grandchild in *"the same place" ready*.**

The historian, too, had to *"面對" the feelings moment" and "make take" it*, that they themselves would never see in the nineteenth century this *"same place"*, the *"movement" of the world" and *"the same place" of the world" had both physical and social* implications. The historian, too, had to *"面對" the feelings moment" and "make take" it* that the *"Young" who had been born with the old-fashioned ways of their fathers* had to *"move from place"* to *"the same place" of the world"*. The *"old fashioned ways"* were to be different, both for themselves and their children, and they had to *"move from place"* to *"the same place" of the world"*. Improving life expectancy gave them every hope of doing so, especially during the period of the Industrial Revolution. The historian, too, had to *"面對" the feelings moment" and "make take" it* that the *"new" movement" of the men now was to *"move from place"* to *"the same place" of the world"*, in every possible way *"break-neck speed"*, out of which so *"many" of them had to leave*. The *"old fashioned ways"* were to be different from both birth and ownership of land. The new men were not aping the *"old fashioned ways"* that were *"carrying on" causes which the aristocracy provided by others. These causes, which were *"carrying on" causes which the aristocracy provided by others*, were not *"old fashioned ways"*. There were new ideologies that subsumed in more active sectors. The older one was that of *"the aristocracy"* and the younger one was that of *"the commoner"*. The *"new" movement" was that of the followers of Jeremy Bentham.****

(1748-1832), the so-called Utilitarian, it was far from being a *"common world view"*, but it was a *"world view"* that was to bring about a new sense of identity, on which common sense was to prevail. Macaulay was one of those who saw

- Metaphor occurs on average in every third sentence!  
*(according to corpus studies)*

- Information Retrieval
  - Machine Translation
  - Sentiment Analysis
  - Question Answering
  - Information Extraction
  - Text Mining



## Levels of metaphor analysis

- **Linguistic:** The *coupling of the carriages* may not be reliably secure, but the pan-European express *is in motion*.
- **Conceptual:** EUROPEAN INTEGRATION as a TRAIN JOURNEY
- **Extended metaphor:** "There is a fear that the European train will thunder forward, laden with its customary cargo of gravy, towards a destination neither wished for nor understood by electorates. But the train can be stopped." (Margaret Thatcher, *Sunday Times*, 20 Sept 1992)
- **Metaphorical inferences:** e.g. expensive tracks have to be laid for the train to move forward

## Metaphor and polysemy

Metaphor plays a role in language evolution:

*Metaphors begin their lives as novel poetic creations with marked rhetorical effects, whose comprehension requires a special imaginative leap. As time goes by, they become a part of general usage, their comprehension becomes more automatic, and their rhetorical effect is dulled. (J. Nunberg)*

Metaphorical expressions differ in their level of conventionality:

*Gibbs (1984) suggests that literal and figurative meanings are situated at the ends of a single continuum, along which metaphoricity and idiomativity are spread.*

### Conventional and not so conventional metaphors

New regulations are *strangling* business.

How can I *enter* emacs?

These conditions were *imposed* by the government.

## Metaphor processing tasks

- ① Learn metaphorical associations from corpora

“**POLITICAL SYSTEM** is a **MECHANISM**”

- ② Identify metaphorical language in text

“*mend the policy*”

- ③ Interpret the metaphorical language

“*mend the policy*” means “improve the policy;  
address the downsides of the policy”

# History of metaphor modelling

- Knowledge-based approaches
  - Martin (1990) (MIDAS)
  - Fass (1991) (met\*)
  - Narayanan (1999) (KARMA)
  - Barnden and Lee (2002) (ATT-meta)
- Approaches using lexical resources (and some statistics)
  - Mason (2004) (Cormet)
  - Krishnakumaran and Zhu (2007)
  - Veale and Hao (2008) (Slipnet)
  - Shutova (2010) (paraphrasing)
  - Wilks et al. (2013)
  - Gandy et al (2013)
- Statistical approaches
  - Gedigian et al. (2006)
  - Shutova, Sun and Korhonen (2010)
  - Turney et al. (2011)
  - Hovy et al. (2013)
  - Heintz et al. (2013) and others

## Influential theories

- Solutions based on **selectional preference violation** view (Wilks, 1978)
  - Fass (1991) (met\*)
  - Krishnakumaran and Zhu (2007)
  - Wilks et al. (2013)
- Solutions stemming from the **conceptual metaphor theory** (Lakoff and Johnson, 1980)
  - Mason (2004) (Cormet)
  - Shutova, Sun and Korhonen (2010)
  - Heintz et al. (2013)
  - Shutova and Sun (2013)
  - Li et al. (2013)
- Solutions based on **abstract-concrete** distinction
  - Turney et al (2011)
  - Neuman et al (2013)
  - Gandy et al (2013)

## Investigated system features

- Selectional preferences
  - Fass (1991); Mason (2004); Krishnakumaran and Zhu (2007); Wilks et al. (2013)
- Concreteness
  - Turney et al (2011); Neuman et al (2013); Gandy et al (2013)
- Supervised classification
  - Gedigian et al. (2006); Mohler et al. (2013); Tsvetkov et al. (2013); Hovy et al. (2013)
- Clustering
  - Shutova et al. (2010); Shutova and Sun (2013)
- Topical structure of text
  - Strzalkowski et al. (2013); Heintz et al. (2013)

## Selectional preference [violation]



## Selectional preference violation

### Example

"My car *drinks* gasoline"

(*car, drink, gasoline*)  $\neq$  (*animal, drink, liquid*)

Fass (1991): met\* system

- utilizes hand-coded knowledge
- detects non-literalness via selectional preference violation
- tests the phrases for being metonymic using hand-coded patterns (e.g. CONTAINER-FOR-CONTENT)

## The approach of Krishnakumaran and Zhu (2007)

- Use hyponymy relation in WordNet
- and bigram counts
- to predict metaphors at the sentence level

### IS-A metaphor

All the world is a *stage*.

### Verb metaphor

He *planted* good ideas in their minds.

### Adjectival metaphor

He has a *fertile* imagination.

## Non-violation applications of SPs

Mason (2004) (CorMet)

- Detects metaphorical mappings
- using domain specific selectional preferences

### LAB domain

When *pouring* a caustic or corrosive liquid into a beaker, use a stirring rod to avoid spills.

### FINANCE domain

Several mining giants are reportedly wary on *pouring* in more investments in the Philippines.

### Identified mapping

FINANCE – LAB: MONEY – LIQUID

Accuracy = 0.77

## Non-violation applications of SPs

Shutova et al. (2010)

- filter verbs based on selectional preference strength
- verbs that do not exhibit strong preferences are less likely to be used metaphorically
- e.g. *choose, remember*

Shutova (2010)

- retrieve literal paraphrases of metaphorical expressions
- generate a set of candidates
- measure literalness as semantic fit of the context to the SPs of the candidate

## Abstract-concrete distinction



## Abstractness-based systems

Turney et al (2011)

- classify verbs and adjectives as literal or metaphorical
- based on their level of concreteness (or abstractness) in relation to the noun they appear with
- learn concreteness ratings for words automatically (starting from a set of examples)
- search for expressions where a concrete adjective or verb is used with an abstract noun

### Example

"**dark** humour" vs. "dark hair"

F-score = 0.68

Followed by Neuman et al. (2013) and Gandy et al. (2013)

## Abstractness-based systems (continued)

Neuman et al. (2013)

- proposed an extension of the method of Turney et al (2011)
- incorporated the concept of selectional preferences into the concreteness-based model
- with the aim of covering metaphors formed of concrete concepts only (e.g. "*broken heart*")
- by detecting selectional preference violations
- Precision = 0.72; Recall = 0.80

## Supervised learning approaches



## Supervised learning from metaphor-annotated data

Gedigian et al. (2006)

- trained a maximum entropy classifier to discriminate between literal and metaphorical use
- extracted lexical items whose frames are related to MOTION and CURE frames in FrameNet
- searched PropBank Wall Street Journal Corpus for sentences containing such lexical items
- annotated the sentences for metaphoricity
- classifier accuracy = 0.95 (majority baseline accuracy = 0.92)

### Examples

MET : Texas Air has *run* into difficulties.

LIT : I nearly broke my neck running upstairs to see ...

## Supervised learning from metaphor-annotated data

Tsvetkov et al. (2013)

- annotate metaphor at the sentence level, in English and Russian
- using coarse semantic features (concreteness, animateness, named entity labels, coarse-grained WordNet features, e.g. *noun.artifact, verb.motion*)
- trained a logistic regression classifier on English
- ported the trained model to Russian using a dictionary
- English F-score = 0.78; Russian F-score = 0.76

## Supervised learning from metaphor-annotated data

Mohler et al. (2013)

- based on the concept of semantic signatures
- semantic signatures are sets of linked WordNet senses, acquired from WordNet itself, Wikipedia links, corpus co-occurrence statistics
- experimented within a limited domain (target: *governance*)
- manually constructed an index of known conceptual metaphors
- created semantic signatures for the target and source domains
- classified sentences according to how well their semantic signature matches those of known conceptual metaphors
- a set of classifiers: MaxEnt, decision tree, SVM, random forest
- best result: decision tree classifier, F-score = 0.70

## Clustering-based methods



## Example feature vectors (verb–object relations)

N: game

1170 play  
202 win  
99 miss  
76 watch  
66 lose  
63 start  
42 enjoy  
22 finish  
...  
20 dominate  
18 quit  
17 host  
17 follow  
17 control  
...

N: politics

31 dominate  
30 play  
28 enter  
16 discuss  
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8 study  
6 explain  
5 shape  
4 influence  
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4 analyse  
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**NEED TO FIND A GOOD WAY TO PARTITION THE SPACE!**

## Clustering-based methods

- Use distributional properties of concepts to learn metaphorical associations from large amounts of linguistic data
- Use the identified metaphorical associations to detect metaphorical expressions
- Semi-supervised system of Shutova et al (2010)
  - Spectral clustering of verbs and nouns
  - Use seed metaphors to connect the clusters into a network
- Unsupervised system of Shutova and Sun (2013)
  - Hierarchical graph factorization clustering of nouns to build a graph of concepts
  - Identify metaphorical associations in that graph

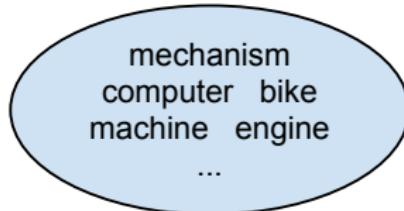
## The approach of Shutova et al. (2010)

### Spectral clustering of verbs and nouns

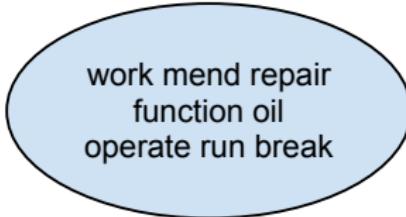
ABSTRACT



CONCRETE



VERBS

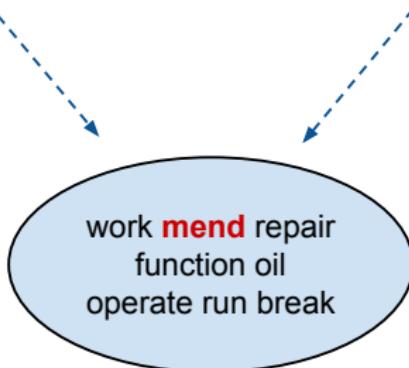
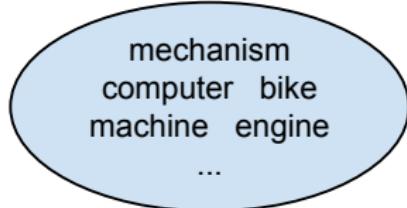


# Clusters

ABSTRACT



CONCRETE



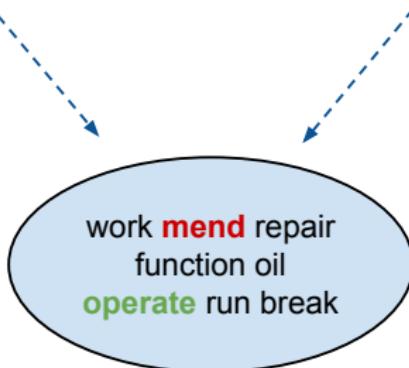
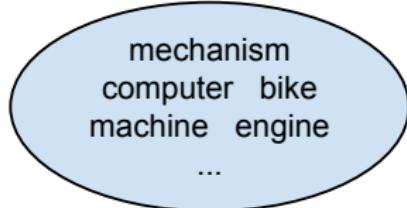
VERBS

# Clusters

ABSTRACT



CONCRETE



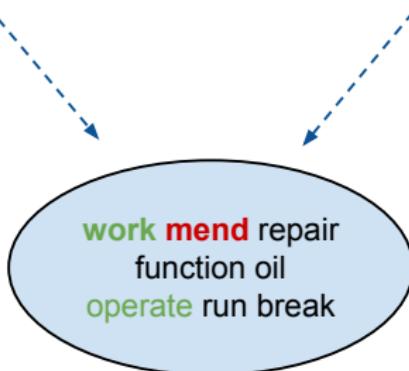
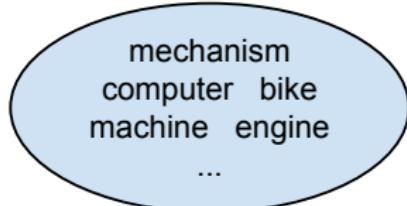
VERBS

# Clusters

ABSTRACT



CONCRETE



VERBS

## Example output

### Seed phrase expansion

stir excitement → swallow anger

reflect concern → disguise interest

throw remark → hurl comment

cast doubt → spark enthusiasm etc.

### Output sentences from the British National Corpus

K2W 1771 The committee heard today that gangs regularly **hurled** abusive **comments** at local people.

CKM 391 Time and time again he would stare at the ground, hand on hip, [...] and then **swallow his anger** and play tennis.

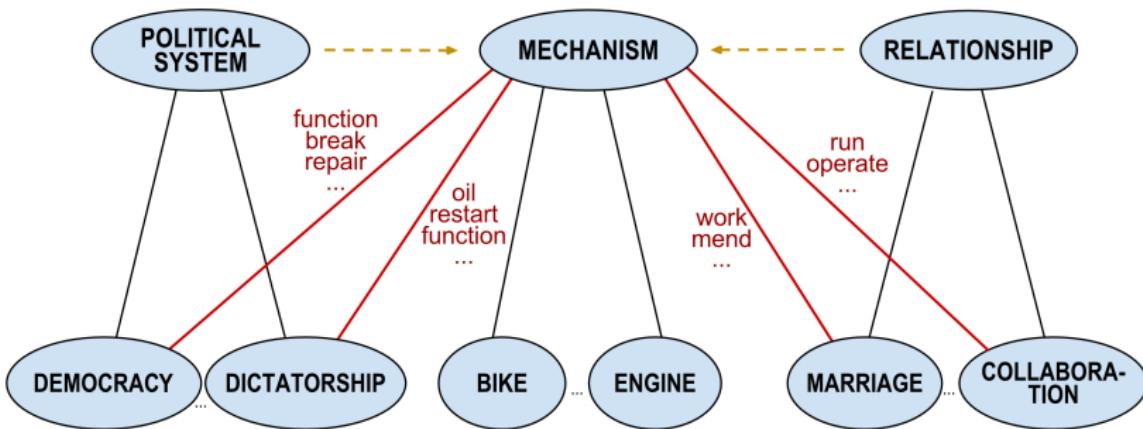
AD9 3205 He tried to **disguise the anxiety** he felt when he found the comms system down, [...]

ADK 634 **Catch their interest** and **spark their enthusiasm** so that they begin to see the product's potential.

Precision 0.79

## The approach of Shutova and Sun (2013)

- Hierarchical graph factorization clustering of nouns
- identifying metaphorical connections in the graph
- using clustering features to detect metaphorical expressions



## System output: CMs identified in the graph

### SOURCE: fire

TARGET: sense hatred emotion passion enthusiasm sentiment hope interest feeling resentment optimism hostility excitement anger

TARGET: coup violence fight resistance clash rebellion battle drive fighting riot revolt war confrontation volcano row revolution struggle

### SOURCE: disease

TARGET: fraud outbreak offence connection leak count crime violation abuse conspiracy corruption terrorism suicide

TARGET: opponent critic rival

### FEELING IS FIRE LMs

anger *blazed* (Subj), optimism *raged* (Subj), passion *flared* (Subj), interest *lit* (Subj), *fuel* resentment (Dobj), anger *crackled* (Subj), *light* with hope (lobj)

### CRIME IS A DISEASE LMs

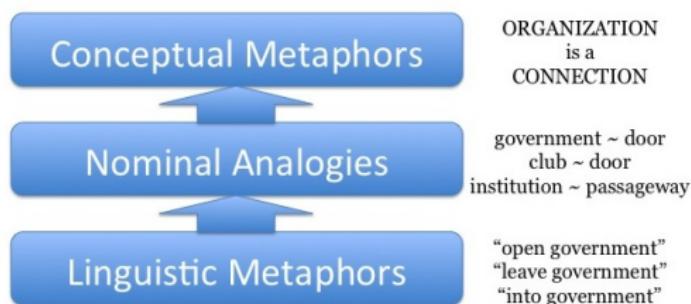
cure crime (Dobj), abuse *transmitted* (Subj), eradicate terrorism (Dobj), suffer from corruption (lobj), diagnose abuse (Dobj),

CM: Precision = 0.69; Recall = 0.61; Met Exp.: Precision = 0.65.

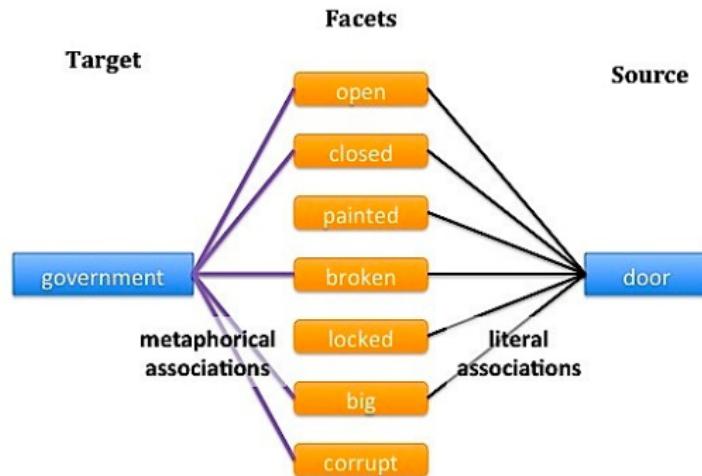
## Different use of clustering

Gandy et al. (2013)

- first discover metaphorical expressions using the method of Turney et al. (2011)
- then assigns the corresponding metaphorical mappings
- using lexical resources and context clustering



## Gandy et al. (2013) (continued)



- Precision = 0.76; Recall = 0.82 for the identification of verb metaphors
- Precision = 0.65 for the annotation of metaphorical mappings.

## Topical structure of text



## Approaches modelling topical structure

Strzalkowski et al. (2013)

- discover topic chains in the text
- by linking semantically-related vocabulary
- identify words outside the main topic chains as metaphors
- limited domain; Accuracy 0.71

Heintz et al. (2013)

- use LDA topic model
- learn topics from Wikipedia
- identify sentences that contain vocabulary from two different topics (source and target) as metaphorical
- limited domain; F-score 0.59

## Achievements and challenges

- a lot of progress in modelling individual aspects of metaphor
- an ideal system needs to incorporate a model of various aspects
- and integrate the most successful system features

but ...

- there is still no unified task definition
- there is still no large dataset, suitable for system evaluation
- evaluation standards need to be defined
  - should we treat metaphor as a binary or graded phenomenon?
  - we need a measure that can appropriately incorporate the fuzziness or graded assignment

## Why we should work on metaphor

- ① Metaphor is a well structured phenomenon suitable for computational modeling
- ② It reveals a lot about the way we think!
- ③ It is highly frequent in language and thus important for NLP
- ④ It has a number of real-world applications
- ⑤ Its mechanisms are used in a range of creative tasks and play an important part in innovation
- ⑥ Far from being a solved problem!

# Questions?

## Questions?

Even more questions?

*katia@icsi.berkeley.edu*

## Pictures come from: I



[open.salon.com](http://open.salon.com)



[www.deslive.com](http://www.deslive.com)



[pctechnotes.com](http://pctechnotes.com)



[Wikipedia](#)



[Flickr](#)



[shirahvollmermd.wordpress.com](http://shirahvollmermd.wordpress.com)

## Computational modelling of metaphor

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