Computational Modelling of Metaphor

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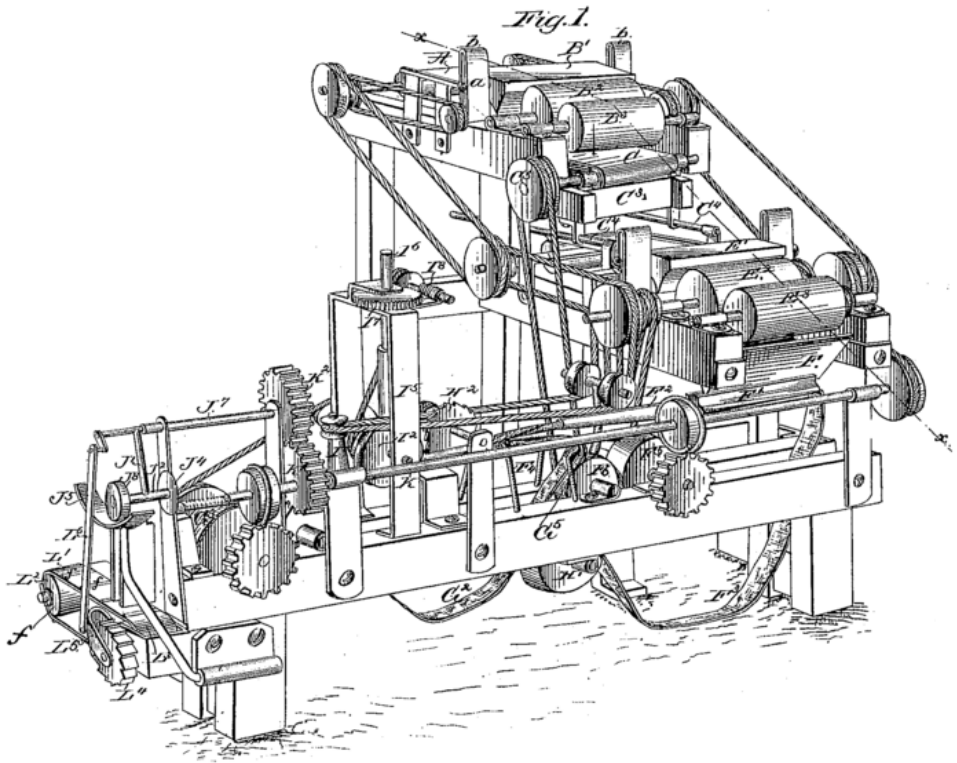
Modelling metaphor: Why?

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*"



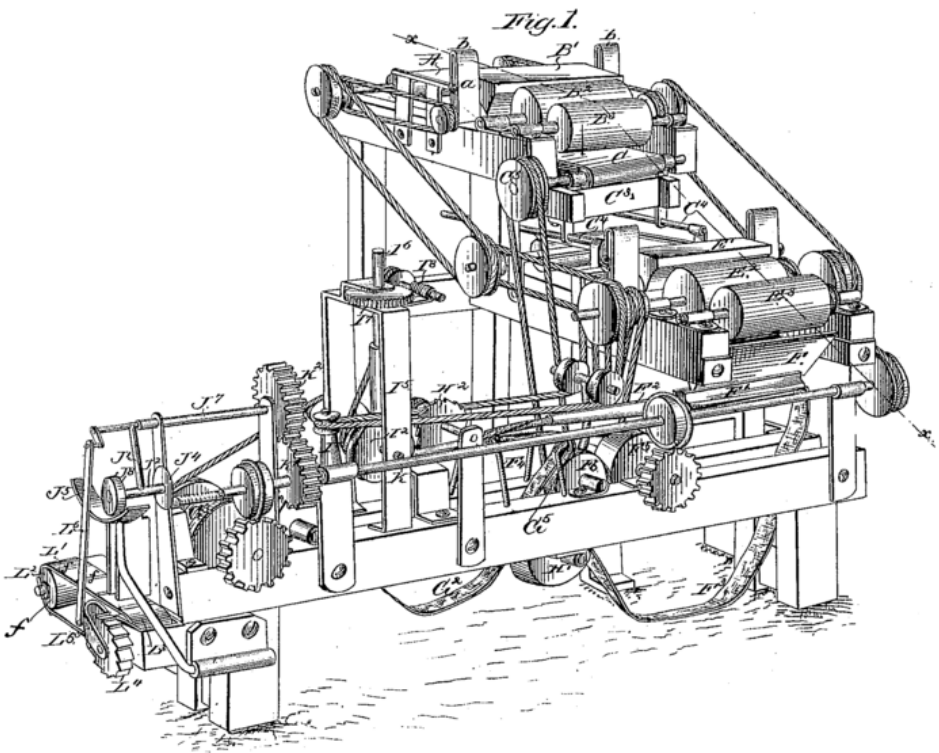
What is metaphor?

"*A political machine*"

"*The wheels of Stalin's regime were well oiled and already turning*"

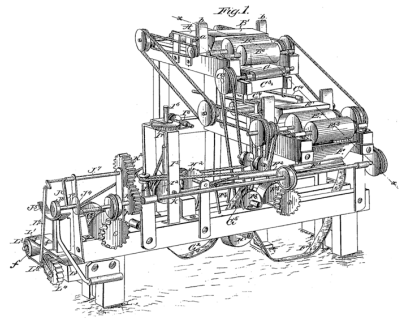
"*Time to mend our foreign policy*"

"*20 Steps towards a Modern, Working Democracy*"



How does it work?

Conceptual Metaphor Theory
(Lakoff and Johnson, 1980)



Metaphorical associations between concepts

POLITICALSYSTEM is a *MECHANISM*

target *source*

Cross-domain knowledge projection and inference

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

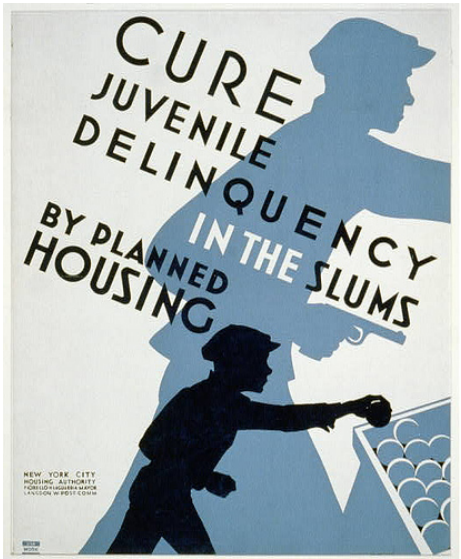
A few more examples

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

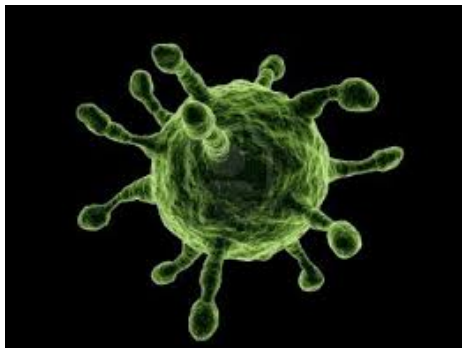
Cure juvenile delinquency in the slums!
The best way to *diagnose* corruption is ...
Intergenerational *transmission* of abuse
Find a *cure* for crime



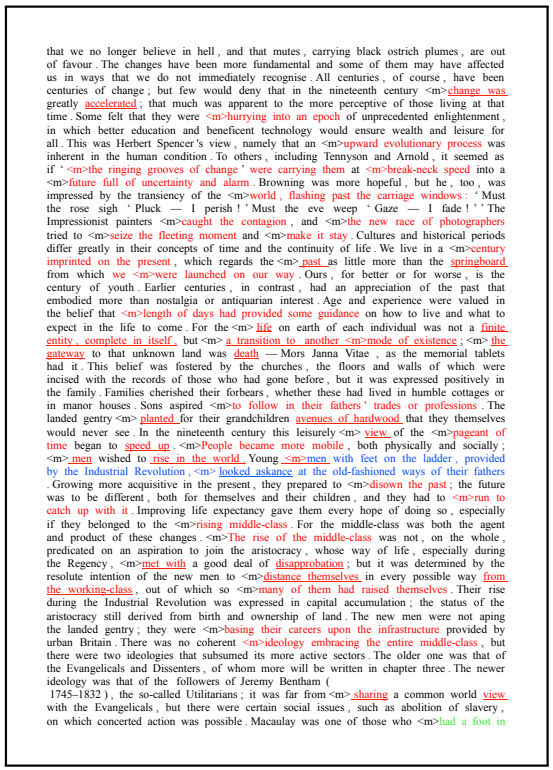
Metaphor influences our decision-making

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 mutes , carrying black ostrich plumes , are out of favour . The changes have been more fundamental and some of them may have affected us in ways that we do not immediately recognise . All centuries , of course , have been centuries of change ; but few would deny that in the nineteenth century <m>change was greatly accelerated ; that much was apparent to the more perceptive of those living at that time . Some felt that they were <m>hurrying into an epoch of unprecedented enlightenment , in which better education and beneficent technology would ensure wealth and leisure for all . This was Herbert Spencer 's view , namely that an <m>upward evolutionary process was inherent in the human condition . To others , including Tennyson and Arnold , it seemed as if ' <m>the ringing grooves of change ' were carrying them at <m>break-neck speed into a <m>future full of uncertainty and alarm . Browning was more hopeful , but he , too , was impressed by the transiency of the <m>world , flashing past the carriage windows : ' Must the rose sigh ' Pluck — I perish ! ' Must the eve weep ' Gaze — I fade ! ' ' The Impressionist painters <m>caught the contagion , and <m>the new race of photographers tried to <m>seize the fleeting moment and <m>make it stay . Cultures and historical periods differ greatly in their concepts of time and the continuity of life . We live in a <m>century imprinted on the present , which regards the <m> past as little more than the springboard from which we <m>were launched on our way . Ours , for better or for worse , is the century of youth . Earlier centuries , in contrast , had an appreciation of the past that embodied more than nostalgia or antiquarian interest . Age and experience were valued in the belief that <m>length of days had provided some guidance on how to live and what to expect in the life to come . For the <m> life on earth of each individual was not a finite entity , complete in itself , but <m> a transition to another <m>mode of existence ; <m> the gateway to that unknown land was death — Mors Janna Vitae , as the memorial tablets had it . This belief was fostered by the churches , the floors and walls of which were incised with the records of those who had gone before , but it was expressed positively in the family . Families cherished their forbears , whether these had lived in humble cottages or in manor houses . Sons aspired <m>to follow in their fathers ' trades or professions . The landed gentry <m> planted for their grandchildren avenues of hardwood that they themselves would never see . In the nineteenth century this leisurely <m> view of the <m>pageant of time began to speed up . <m>People became more mobile , both physically and socially ; <m> men wished to rise in the world . Young <m>men with feet on the ladder , provided by the Industrial Revolution , <m> looked askance at the old-fashioned ways of their fathers . Growing more acquisitive in the present , they prepared to <m>disown the past ; the future was to be different , both for themselves and their children , and they had to <m>run to catch up with it . Improving life expectancy gave them every hope of doing so , especially if they belonged to the <m>rising middle-class . For the middle-class was both the agent and product of these changes . <m>The rise of the middle-class was not , on the whole , predicated on an aspiration to join the aristocracy , whose way of life , especially during the Regency , <m>met with a good deal of disapprobation ; but it was determined by the resolute intention of the new men to <m>distance themselves in every possible way from the working-class , out of which so <m>many of them had raised themselves . Their rise during the Industrial Revolution was expressed in capital accumulation ; the status of the aristocracy still derived from birth and ownership of land . The new men were not aping the landed gentry ; they were <m>basing their careers upon the infrastructure provided by urban Britain . There was no coherent <m>ideology embracing the entire middle-class , but there were two ideologies that subsumed its more active sectors . The older one was that of the Evangelicals and Dissenters , of whom more will be written in chapter three . The newer ideology was that of the followers of Jeremy Bentham (1745–1832) , the so-called Utilitarians ; it was far from <m> sharing a common world view with the Evangelicals , but there were certain social issues , such as abolition of slavery , on which concerted action was possible . Macaulay was one of those who <m>had a foot in

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

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

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 idiomaticity 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*) =/= (*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 at 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)

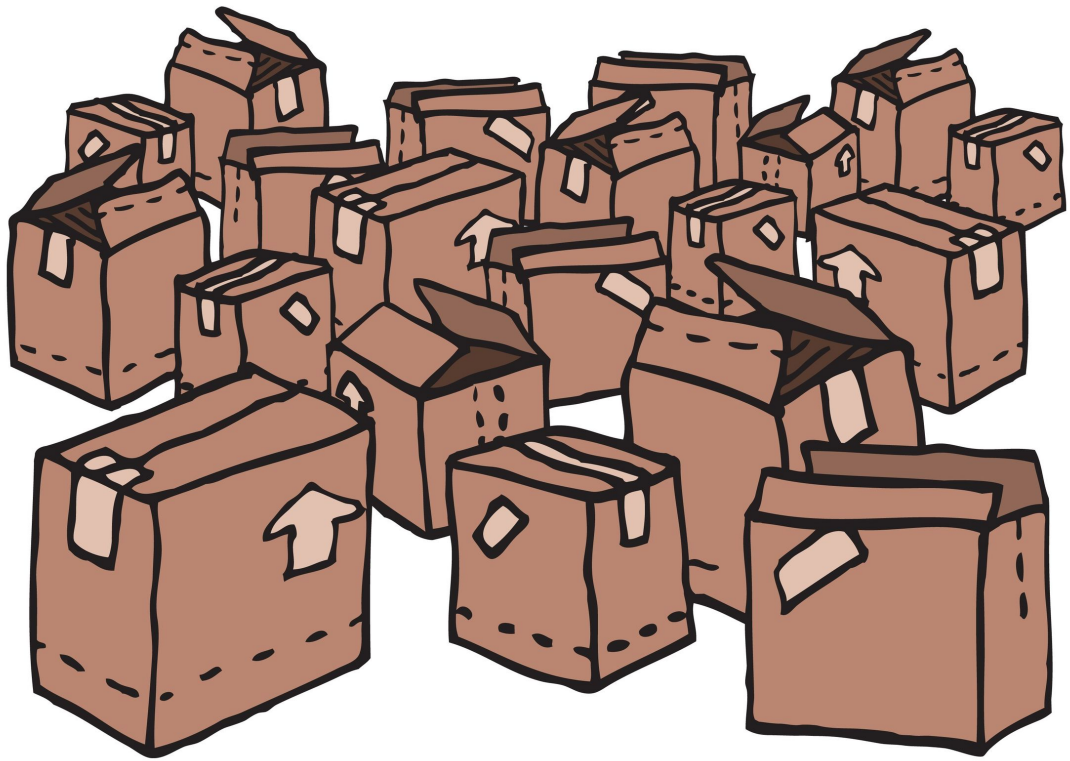
- annotate metaphor at the sentence level, in English and Russian
- using coarse semantic features (concreteness, animateness, named entity labels, coarse-grained WordNet features, e.g. *noun.artifact, verb.motion*)
- trained a logistic regression classifier on English
- ported the trained model to Russian 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
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28 enter
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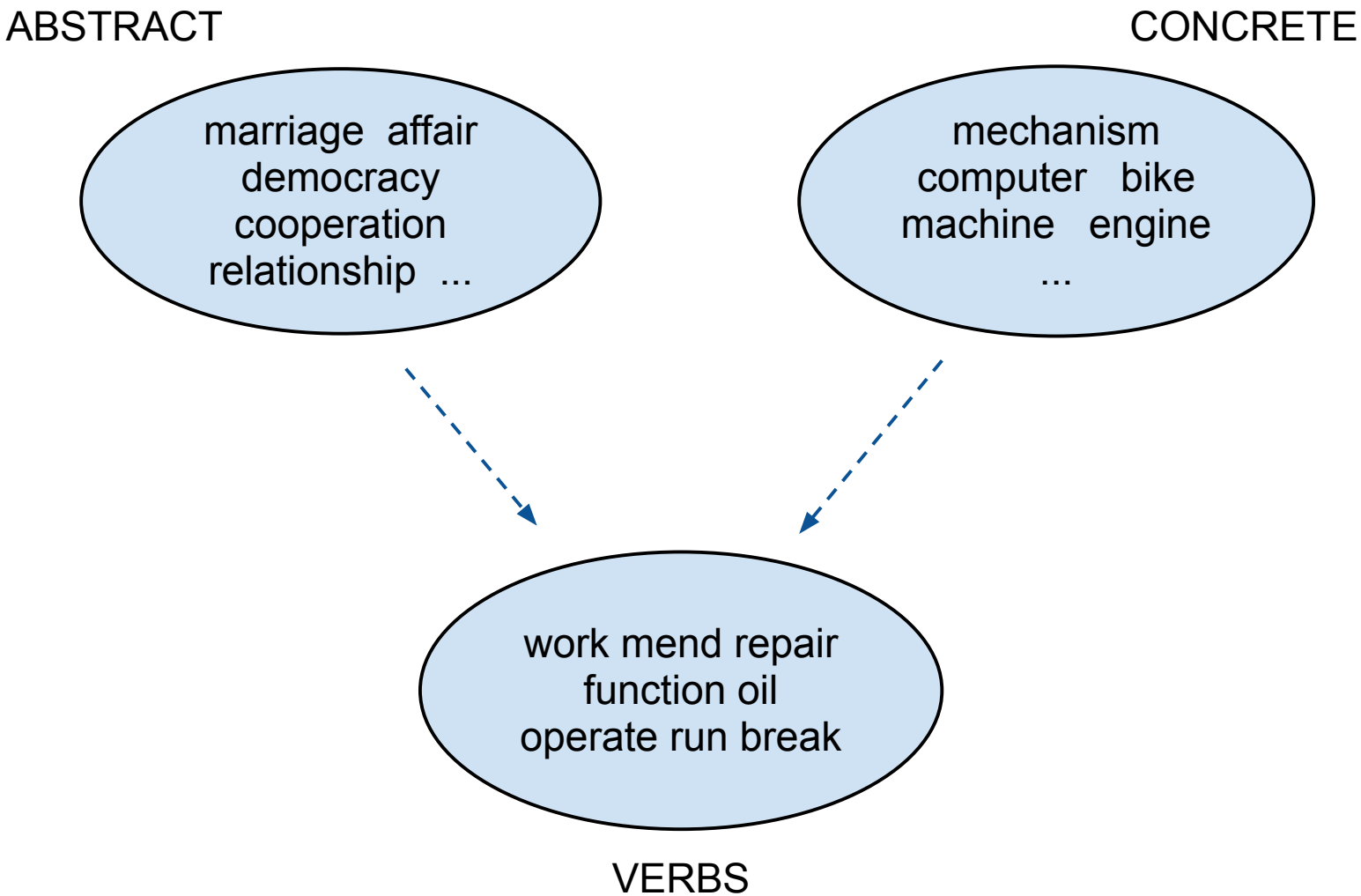
NEED TO FIND A GOOD WAY TO PARTITION THE SPACE!

Clustering-based methods

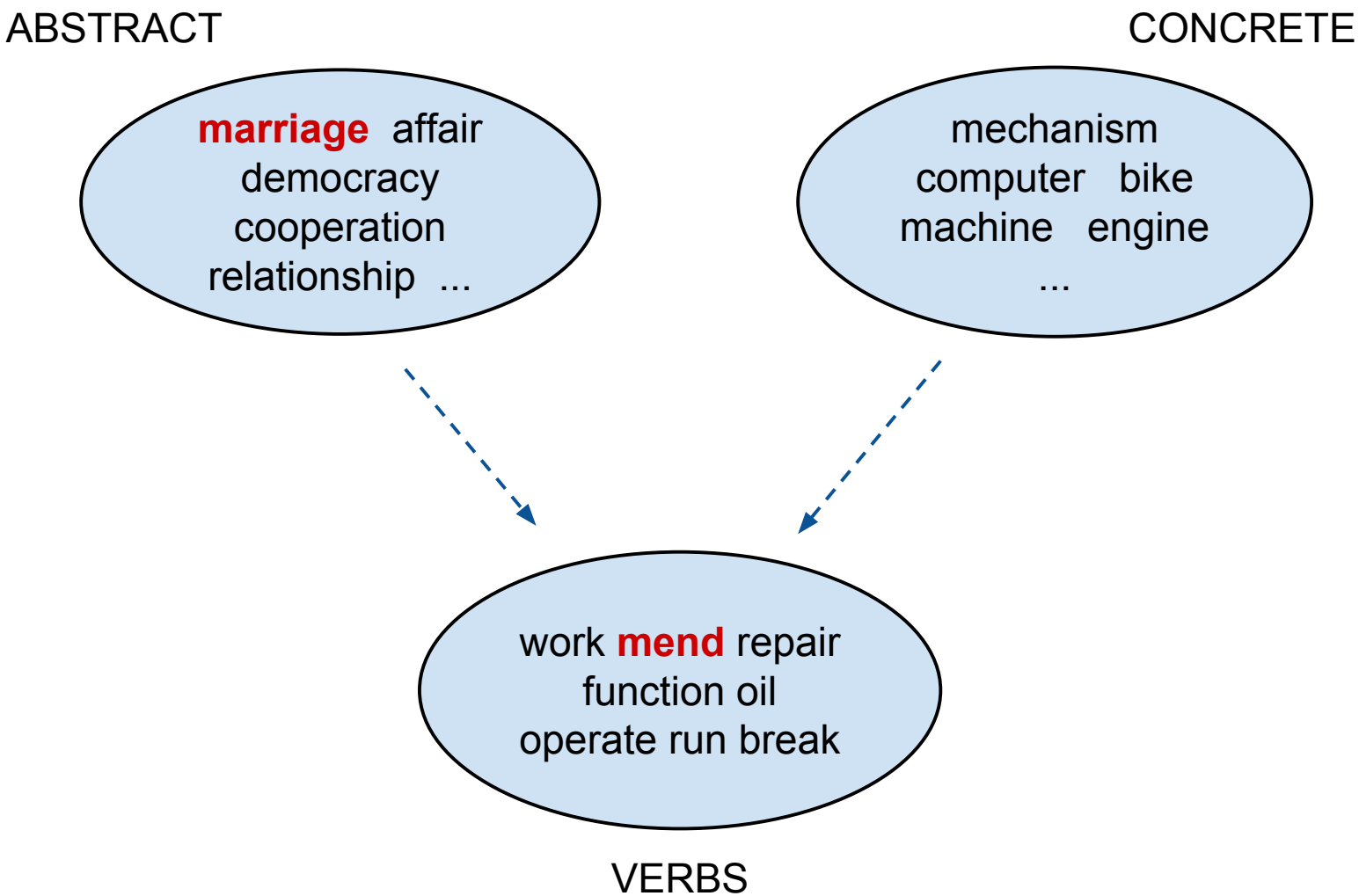
- Use distributional properties of concepts to learn metaphorical associations from large amounts of linguistic data
- Use the identified metaphorical associations to detect metaphorical expressions
- Semi-supervised system of Shutova et al (2010)
  - Spectral clustering of verbs and nouns
  - Use seed 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



Clusters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democracy
cooperation
relationship ...
mechanism
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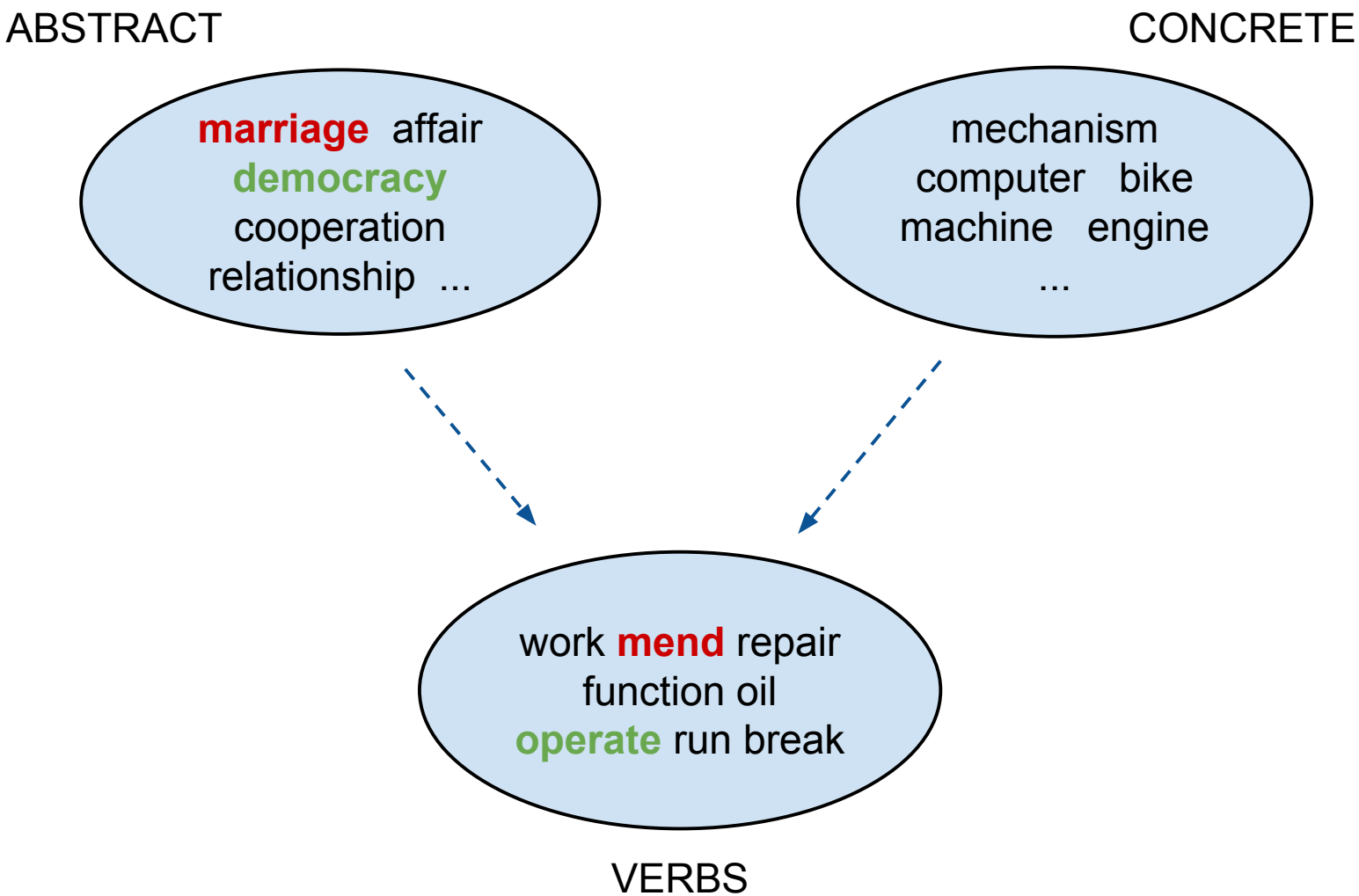
machine engine
...
work mend repair
function oil
operate run break
VERBS

Clusters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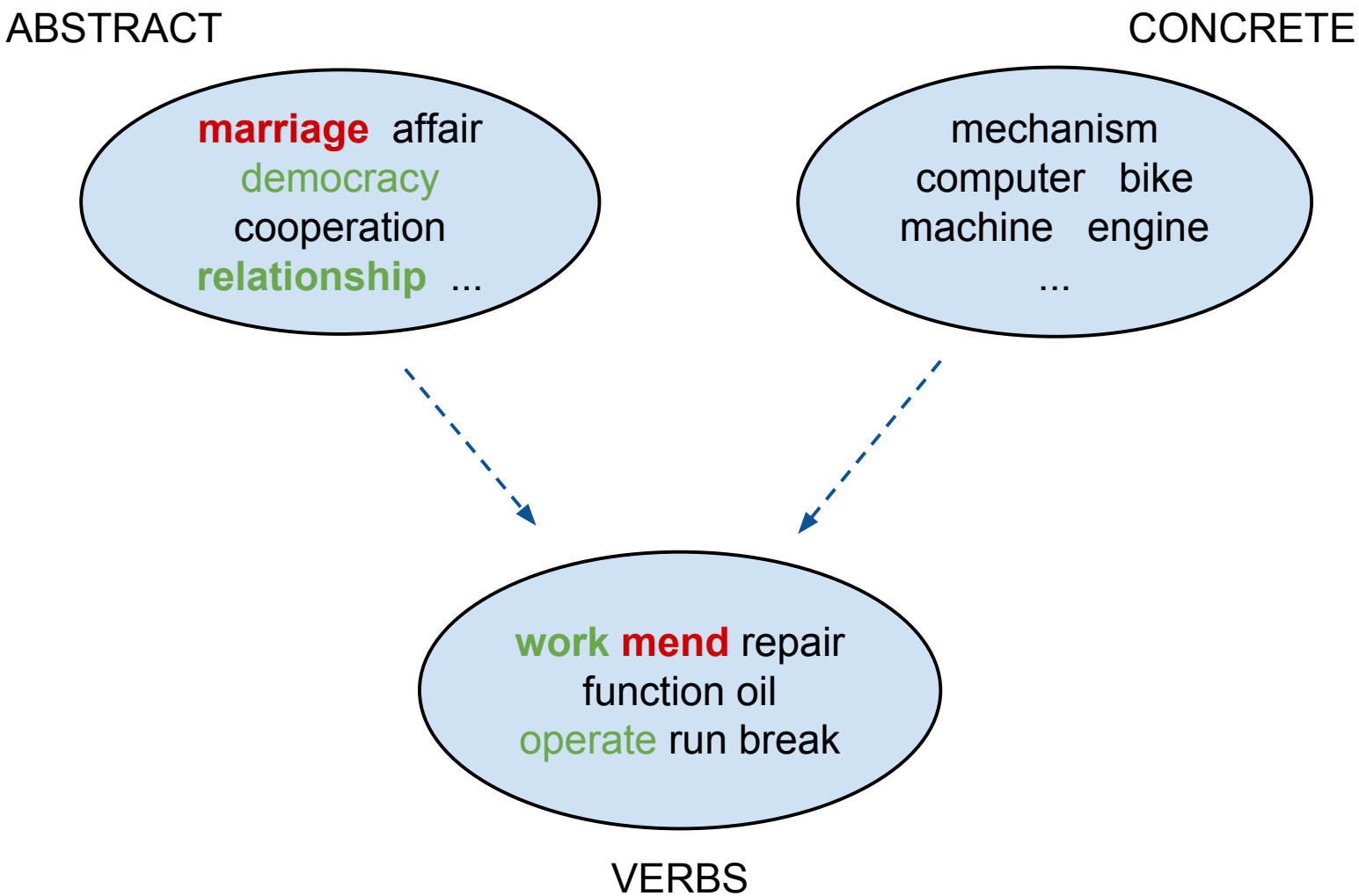
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Example output

Seed phrase expansion

stir excitement –> swallow anger
reflect concern –> disguise interest
throw remark –> hurl comment
cast doubt –> spark enthusiasm etc.

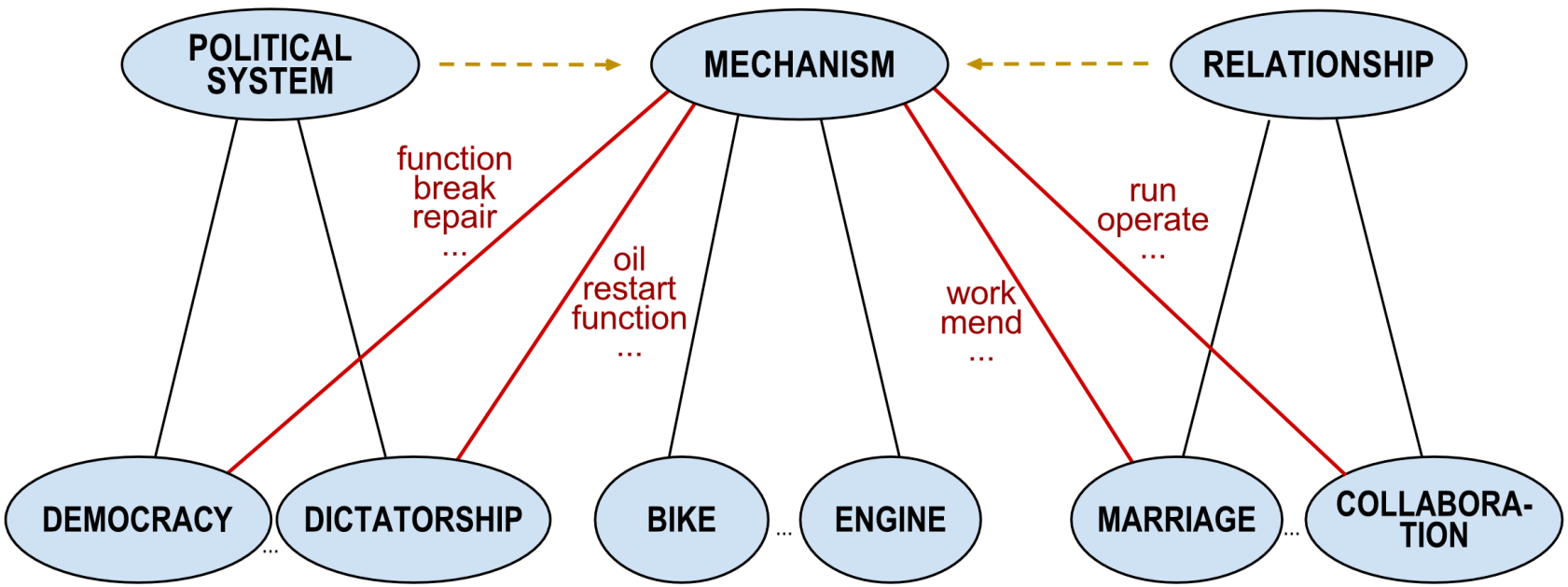
Output sentences from the British National Corpus

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 (Iobj)

CRIME IS A DISEASE LMs

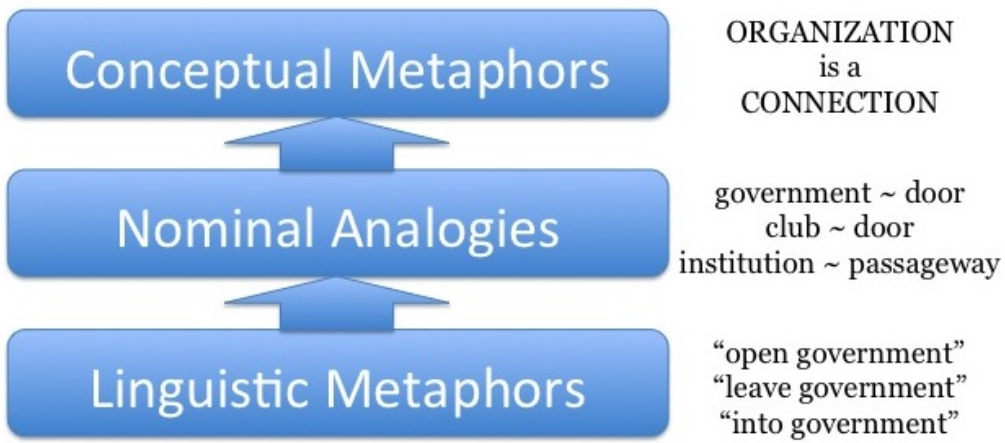
cure crime (Dobj), abuse *transmitted* (Subj), *eradicate* terrorism (Dobj), *suffer from* corruption (Iobj), *diagnose* abuse (Dobj),

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

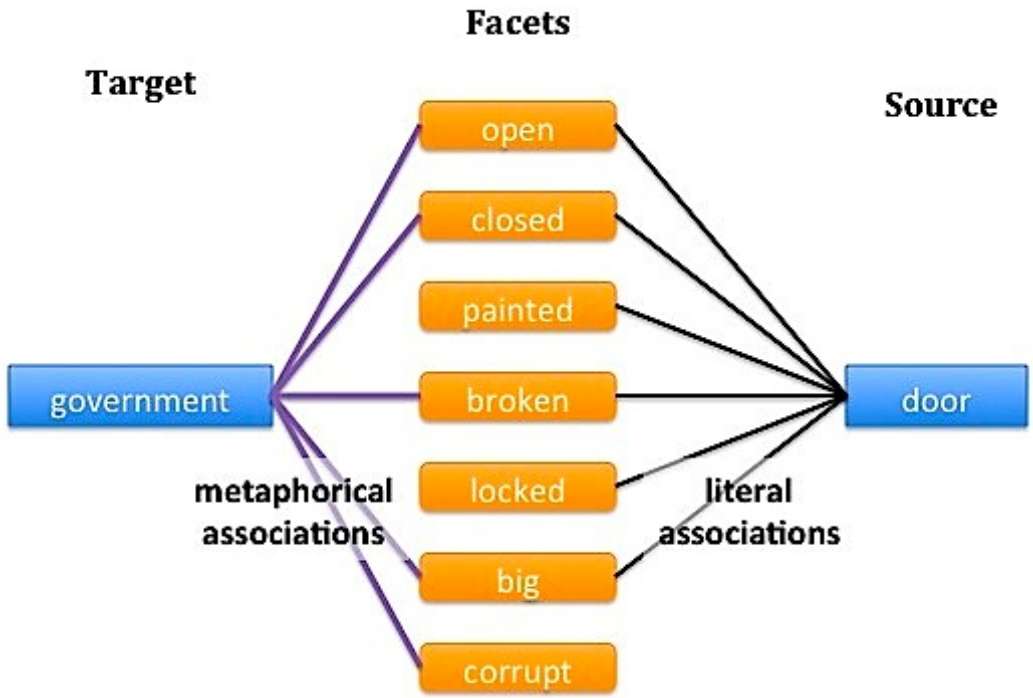
Different use of clustering

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
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- Wikipedia
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