Lecture 15: Lexical Semantics and Semantic Change

L98: Introduction to Computational Semantics

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what is the meaning of life? — life'

Lecture 15: Lexical Semantics and Semantic Change

1. Lexical semantics
2. Polysemy
3. Semantic relations
4. Diachronic semantics

Lexical Semantics

Last time: semantic grounding

Experience Grounds Language (Bisk et al., 2020)

We posit that the present success of representation learning approaches trained on large, text-only corpora requires the parallel tradition of research on the broader physical and social context of language to address the deeper questions of communication.

[Bisk, Y. et al., 2020. Experience Grounds Language. In EMNLP.]

Linguistic relativity

from https://photos.com/featured/swan-and-reflection-cavemanboon.html

Sign

De Saussure: The linguistic sign is a two-sided psychological entity:

- signifier: 'sound-image'
- signified: 'concept'
- the arbitrary nature of linguistic signs

Garry Larson on De Saussure

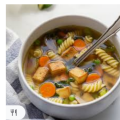"Now! . . . *That* should clear up a few things around here!"

what makes soup, soup?

www.youtube.com/watch?v=Y1HVTNxwt7w&t=22s

What makes soup, soup? (1)
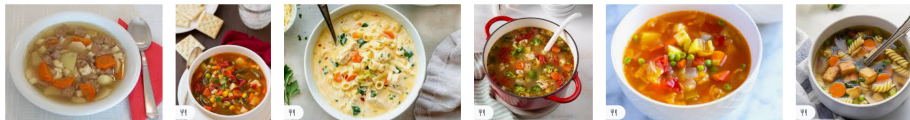
Formal semantics: extension — what words denote
e.g., soup': the set of all soups.

What makes soup, soup? (1)

Formal semantics: extension — what words denote
e.g., soup': the set of all soups.

❓ if a and b designate the same object, there would be no difference.

❓ *Boris Johnson=Prime Minister*

A sign has both a reference and a "sense"

What makes soup, soup? (2)

- Limited domain: mapping to some knowledge base term(s).
- Knowledge base constrains possible meanings.
  e.g. BabelNet (`babelnet.org`)

BabelNet

EN **soup** 🔊 🔊 💬

Liquid food especially of meat or fish or vegetable stock often containing pieces of solid food 🔊 *WordNet* ⊖ 缺少定义

- Soup is a primarily liquid food, generally served warm or hot, that is made by combining ingredients such as meat and vegetables with stock, juice, water, or another liquid. 🔊 *Wikipedia*

- A liquidy food 🔊 *Wikipedia (disambiguation)*

- Primarily liquid food 🔊 *Wikidata*

- A cooked, liquid dish (made from meat or vegetables that are mixed with broth in a pot) that is often sold in tins. 🔊 *OmegaWiki*

- The liquid part of such a dish; the broth. 🔊 *Wiktionary*

The idea of joint visual semantic space

Encode visual and textual information into a shared space.
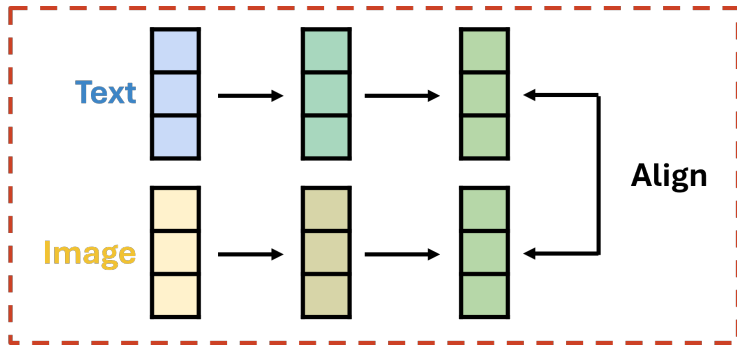
from Freda Shi

Approaches to lexical meaning

- Formal semantics: extension — what words denote

- Semantic primitives are a set of basic, universal concepts proposed to exist in all languages.
  e.g., *kill* means CAUSE(NOT(ALIVE))

- Meaning postulates:
  $\forall e_1, x, y[\text{kill'}(e_1, x, y) \rightarrow \exists e_2[\text{cause'}(e_1, x, e_2) \wedge \text{die'}(e_2, y)]]$

- Various criticisms from linguists, philosophers, and cognitive scientists.

- Distributional approaches (information vs knowledge)

- Ontological relationships; once a popular method in NLP

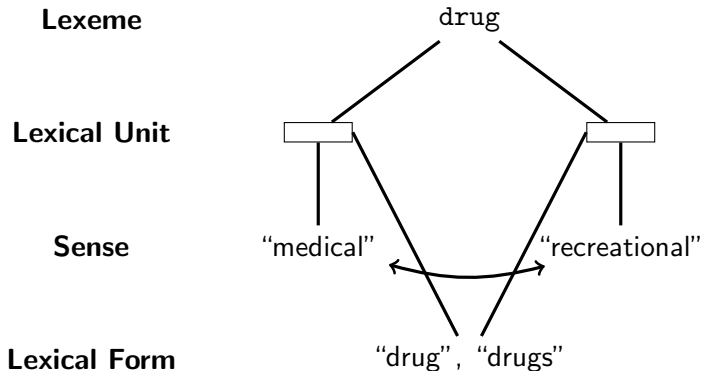# Word Senses

Word senses

There are two ways in which a word form can be ambiguous:

- Random historic effects bring two unrelated words together $\rightarrow$ homonymy (same name)
- Senses evolve during language evolution, but there is a connection $\rightarrow$ polysemy (multiple senses)

Polysemy

A lexical form corresponding to a single lexeme which has a number of senses is polysemous.

Types of polysemy

Systematic polysemy: two senses are in a systematic semantic relation to each other. This process is productive.

- plant vs food (e.g. *wheat*)
- content vs physical object (e.g. *book*)
- rabbit: animal vs meat (e.g. *rabbit*)
- instrument vs process (e.g. *shower*)
- unit vs type (e.g. *I want that shirt*)

Idiosyncratic polysemy

- *Has Arthur changed his position?* (metaphor)
- *The ham sandwich asked for the bill.* (situational)

Homonymy

| **Lexeme** | bank_1 | bank_2 |

| **Lexical Unit** | | |

| **Sense** | "financial" | "side of river" |

| **Lexical Form** | "bank", "banks" | |
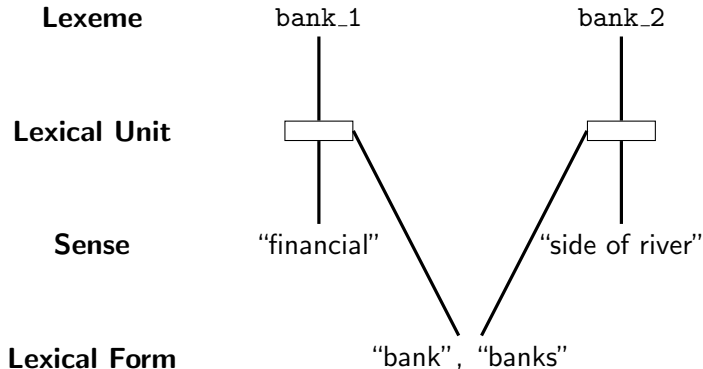
A lexical form corresponding to more than one lexeme, each with their sense(s) is homonymous.

Sense 1 of "bank"

"Arthur reached the bank"

Sense 2 of "bank"

"Arthur reached the bank"

Word sense induction based on clustering

- For each token w_i of word w in a corpus, compute a context vector c.
- Use a clustering algorithm to cluster these word-token context vectors c into a predefined number of groups or clusters. Each cluster defines a sense of w.
- Compute the vector centroid of each cluster. Each vector centroid s_j is a sense vector representing that sense of w.

Semantic Relations

Taxonomic realtions

Hyponymy: IS-A

- (a sense of) *dog* is a hyponym of (a sense of) *animal*; *animal* is a *hypernym* of *dog*
- *dog* is more specific and belongs to a subclass of *animal*.
- *entailment*/IS-A: a sense A is a hyponym of a sense B if everything that is A is also B, and hence being an A entails being a B.
- hyponymy relationships form a *taxonomy*
- works best for concrete nouns

Taxonomic realtions

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Some issues concerning hyponymy

- not useful for all words: *thought*, *democracy*, *push*, *sticky*?
- individuation differences: is *table* a hyponym of *furniture*?
- multiple inheritance: e.g., is *coin* a hyponym of both *metal* and *money*?
- what does the top of the hierarchy look like?

Other semantic relations

Classical relations

- **Meronomy**: PART-OF e.g., *arm* is a meronym of *body*, *steering wheel* is a meronym of *car* (piece vs part)
- **Synonymy** e.g., *aubergine*/*eggplant*.
- **Antonymy** e.g., *big*/*little*
- **Near-synonymy/similarity** e.g., *exciting*/*thrilling*
  e.g., *slim*/*slender*/*thin*/*skinny*

The word *synonym* is commonly used to describe a relationship of approximate or rough synonymy.

- *craft*, *skill*
- *apple*, *fruit*

WordNet   `wordnet.princeton.edu`

- large-scale, open source resource for English
- wordnets being built for other languages, e.g. Open Multilingual Wordnet (`compling.hss.ntu.edu.sg/omw`)
- hand-constructed
- organized into *synsets*: synonym sets (near-synonyms)

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Overview of adj red

S: (adj) **red**, reddish, ruddy, blood-red, carmine, cerise, cherry, cherry-red, crimson, ruby, ruby-red, scarlet (of a color at the end of the color spectrum (next to orange); resembling the color of blood or cherries or tomatoes or rubies)

Wordnet as a Meta language

- Wordnet groups word forms into synsets (synonym sets), per POS.
- One synset = one sense; this grouping constitutes the senses's definition.
- Homonyms and polysemous word forms are therefore associated with multiple (different) synsets.
- No distinction between the two
- Senses are indicated by slashes and numbers: `interest/1`, `interest/2`...
- Synsets are organized into a hierarchical structure by the use of hyponymy, e.g. *dog* is-a *pet*, *pet* is-a *animal*
- Other relations: meronymy (part-of), paronymy (same stem, morphological variation), antonymy (opposite)

WN example – "interest"

Noun

- S (n) **interest**, involvement (a sense of concern with and curiosity about someone or something) *"an interest in music"*
- S (n) sake, **interest** (a reason for wanting something done) *"for your sake"; "died for the sake of his country"; "in the interest of safety"; "in the common interest"*
- S (n) **interest**, interestingness (the power of attracting or holding one's attention (because it is unusual or exciting etc.)) *"they said nothing of great interest"; "primary colors can add interest to a room"*
- S (n) **interest** (a fixed charge for borrowing money; usually a percentage of the amount borrowed) *"how much interest do you pay on your mortgage?"*
- S (n) **interest**, stake ((law) a right or legal share of something; a financial involvement with something) *"they have interests all over the world"; "a stake in the company's future"*
- S (n) **interest**, interest group (usually plural) a social group whose members control some field of activity and who have common aims) *"the iron interests stepped up production"*
- S (n) pastime, **interest**, pursuit (a diversion that occupies one's time and thoughts (usually pleasantly)) *"sailing is her favorite pastime"; "his main pastime is gambling"; "he counts reading among his interests"; "they criticized the boy for his limited pursuits"*

Verb:

- S (v) **interest** (excite the curiosity of; engage the interest of)
- S (v) concern, **interest**, occupy, worry (be on the mind of) *"I worry about the second Germanic consonant shift"*
- S (v) matter to, **interest** (be of importance or consequence) *"This matters to me!"*

"interest/4" – a closer look

S: (n) **interest** (a fixed charge for borrowing money; usually a percentage of the amount borrowed) "how much interest do you pay on your mortgage?"
direct hyponym / **full hyponym**

- S: (n) compound interest (interest calculated on both the principal and the accrued interest)

- S: (n) simple interest (interest paid on the principal alone)

direct hyponym/ **inherited hypernym** / sister term:
- S: (n) fixed charge, fixed cost, fixed costs (a periodic charge that does not vary with business volume (as insurance or rent or mortgage payments etc.))
    - S: (n) charge (the price charged for some article or service) "the admission charge"
        - S: (n) cost (the total spent for goods or services including money and time and labor)
            - S: (n) outgo, spending, expenditure, outlay (money paid out; an amount spent)
                - S: (n) transferred property, transferred possession (a possession whose ownership changes or lapses)
                    - S: (n) possession (anything owned or possessed)
                        - S: (n) relation (an abstraction belonging to or characteristic of two entities or parts together)
                            - S: (n) abstraction, abstract entity (a general concept formed by extracting common features from specific examples)
                                - S: (n) entity (that which is perceived or known or inferred to have its own distinct existence (living or nonliving))

"interest/5" – a closer look

S: (n) **interest**, stake ((law) a right or legal share of something; a financial involvement with something) *"they have interests all over the world"; "a stake in the company's future"*
direct hyponym/ **inherited hypernym** / sister term:
- S: (n) share, portion, part, percentage (assets belonging to or due to or contributed by an individual person or group) "he wanted his share in cash"
  - S: (n) assets (anything of material value or usefulness that is owned by a person or company)
    - S: (n) possession (anything owned or possessed)
      - S: (n) relation (an abstraction belonging to or characteristic of two entities or parts together)
        - S: (n) abstraction, abstract entity (a general concept formed by extracting common features from specific examples)
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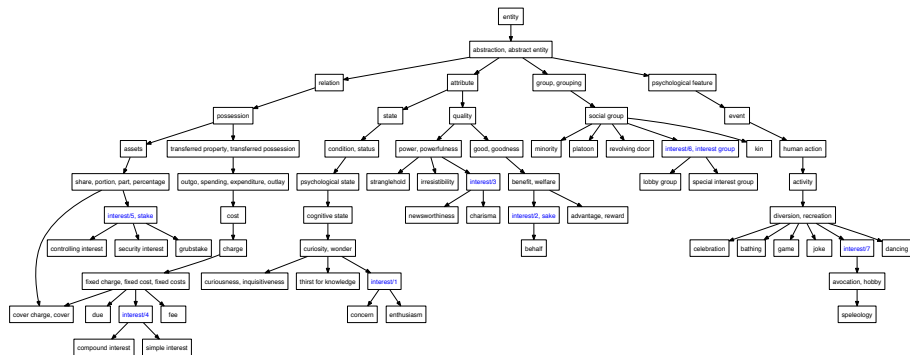
interest/4 and interest/5
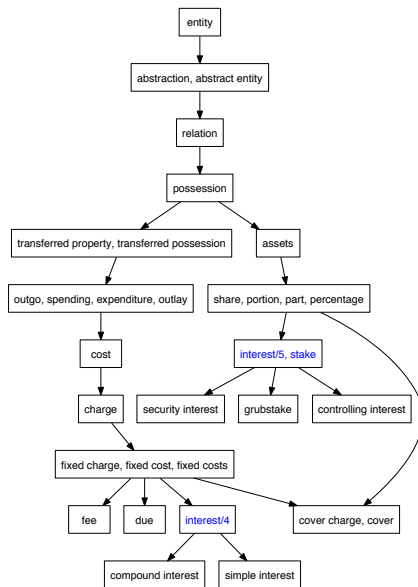
interest/1, interest/2 and interest/3
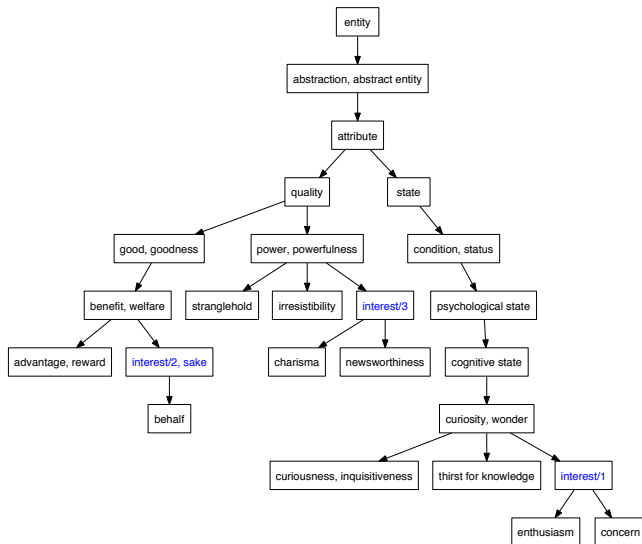
Interest – all senses

Multilingual aspect of word sense ambiguity

Interest translated into German

- Interesse: curiousness (interest/1)
- Interesse: sake (interest/2)
- Anziehungskraft: attractiveness (interest/3)
- Zins: financial charge (interest/4)
- Anteil: stake in company (interest/5)
- Lobbygruppe: interest group (interest/6)
- Hobby: pastime (interest/7)

Diachronic Semantics
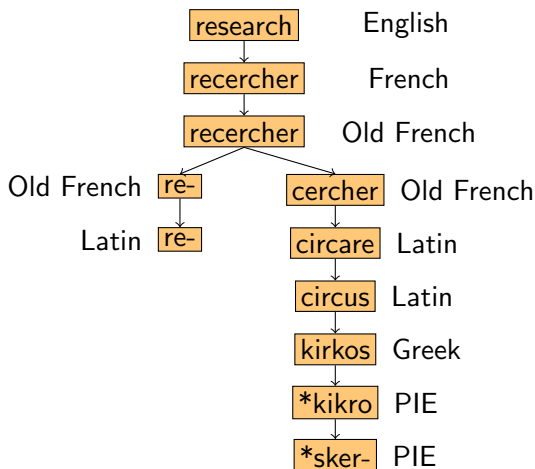
Semantic change

- Old English: any kind of fruit
- Middle English: all fruit other than berries but including nuts

Adding a word sense to the vocabulary of a language

- The notion of polysemy plays a key role in understanding semantic change as a process, because a common way for semantic change to take place is by an intermediate stage of polysemy.
- A word does not change its meaning abruptly over night across an entire speech community.
- A word acquires a novel conventionalised sense, with the original one at least initially remaining intact.
- Eventually the original meaning may, but need not, be lost.
- The loss of meanings is irregular and hence unpredictable.
- The 'apply' case: the French word 'fruit' was introduced into English.

Etymology

research		English
recercher		French
recercher		Old French

Old French re- ← | cercher Old French
Latin re- | circare Latin
| circus Latin
| kirkos Greek
| *kikro PIE
| *sker- PIE

- Etymology is the study of the origin and historical development of words, in particular changes in phonology, morphosyntax and meaning.
- Etymology reveals the cultural and historical contexts that have shaped words' contemporary meanings.

Multilinguality

English	German	Danish	French
tree	Baum	tr??	arbre
wood	Holz		bois
woods	Wald	skov	
forest			forêt

Table: Hjelmslev's depiction of the tree/wood/woods semantic field.

Swadesh list

- The list includes words that are common across languages, such as "water," "hand," and "star."

- These words are considered resistant to borrowing and change, making them useful for comparing languages and estimating their divergence over time.

- The selection of words is somewhat arbitrary.

Computational study of diachronic semantics
WordNet of classical languages

- Hebrew WordNet, HWN
- Latin WordNet, LWN
- Sanskrit WordNet, SWN
- Ancient Greek WordNet, AGWN

Basic methodology
Translating English WordNet.

Computational study of diachronic semantics
Detecting semantic change

Steps

- Collecting historical data and divide it into multiple time bins.
- Derive word representations separately for each time bin.
- Compare and quantitatively assess the difference of the representations of the 'same' word in different time bins.

Word representations

- Count-based models
- Prediction-based models, including pre-training models

Tahmasebi and Dubossarsky. Computational modeling of semantic change.

https://www.changeiskey.org/publication/2023-routlede-handbook/2304.06337.pdf

Readings

- Computational modeling of semantic change Tutorial at EACL 2024
  `https://www.changeiskey.org/event/2024-eacl-tutorial/`