Computational Linguistics

7

CSC 2501 / 485
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7. Lexical semantics

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Reading: Jurafsky & Martin: 19.1–4, 20.8; Bird et al: 2.5

Lexical semantics

- Word meanings and their internal structure.
- The structure of the relations among words and meanings.

Current CL research

- Current focus in CL on lexical semantics:
  - word senses;
  - detailed lexical representations/vectors;
  - organization of senses, or lexical entries more generally (like a dictionary entry? Probably not).

Knowledge about words

Lexicon with ***entry*** for each word (or fixed phrase).

- Senses (meanings). For each:
  - Surface form:
    - Orthography, phonology, …
  - Syntax:
    - Part-of-speech, morphology, subcategorization, …
- Behaviour, usage, …:
  - Collocations, register and genre, …

Word senses

- How are word senses defined?
  - Grounded in world knowledge?
- Are they defined and fixed at all?
  - Or wholly context-dependent? (See also slide 9)
- *Constructional* versus *differential* approaches.

Sense is built from elements of a set of *universal primitives of meaning.*

Sense is distinguished from others by a set of (ad hoc) *differentia*.

Relations between words and senses

- ***Synonymy:*** Two (or more) words (*synonyms)* having the same meaning.

What does this mean?

- ***Homonymy, polysemy:*** Two (or more) meanings having the same word (*homonym*, *polyseme*).

- Lexical ambiguity

Lexical ambiguity: Homonymy

- ***Homonymy***: meanings are unrelated.
  [Etymology or history of word is not a deciding factor.]
- Due to same spelling (*homography*):
  - *bank* for money, *bank* of river, *bank* of switches, …*bank* → *banque* or *bord* or *rangée* or …?
    bass: “bȧss” fish, “bās” guitar;
    bow: “bau” to the audience, tie a “bō”.
- Due to same sound (*homophony*):
  - *wood, would; weather, whether; you, ewe, yew; bough, bow.*

Lexical ambiguity: Polysemy 1

- ***Polysemy:*** meanings are related.
  - *run:* of humans, rivers, buses, bus routes, …
    line: of people, of type, drawn on paper, transit route, …
- Often, no clear line between polysemy and homonymy.

Lexical ambiguity: Polysemy 2

- Sense *modulation* by context:
  - *fast* train, *fast* typist, *fast* road.
- *Systematic* polysemy or sense *extension*:
  - *bank* as financial institution and as building; *window* as hole in wall or what fits in hole; *bottle, book, DVD, Toyota, lamb, …*
- Applies to most or all senses of certain semantic classes.

Relations between senses 1

- ***Hyponymy, hyperonymy:*** subtype, supertype:
  - *sedan* is a hyponym of *car*;
    car is a hyperonym of *sedan*.

[*hypo-* = under; *hyper-* = over]

  - The fundamental relation for creating a *taxonomy*: a tree-like structure that expresses classes and inheritance of properties.

[*Terminology:*
- **is-a** relation in ontologies of (language-independent) concepts;
- *hyponymy* relation in taxonomies of (language-dependent) senses.]

Relations between senses 2

- ***Meronymy, holonymy:*** part/whole, or membership:
  - *leg* is a meronym of *chair*;
    chair is a holonym of *leg* and a meronym of *dining-set*.
  - Many subtypes of meronym relations.
    Component-of: *kitchen–apartment*
    Member-of: *soldier–army*
    Portion-of: *slice–pie*

Examples of meronymy from Roxana Girju, Adriana Badulescu, and Dan I. Moldovan, “Automatic discovery of part-whole relations”, *Computational Linguistics,* 32(1), 2006, 83–135, based on relations from Morton E. Winston, Roger Chaffin, and Douglas Herrmann, “A taxonomy of part-whole relations”, *Cognitive Science,* 11(4), 1987, 417–444.

Relations between senses 3

- ***Entailment, implicature:*** various kinds:
  - *snore* entails *sleep*;
    manage implies *try*.

Lexical acquisition 1

- *Problem:* Need a complete lexicon for each natural language.
- Dictionary as starting point? Limitations?
- Learner's dictionary? Limitations?
- Text (corpus) as starting point? Limitations?
- Build by hand (*lexicographers*) or automatically? Limitations?

Lexical acquisition 2

- Corpus-based pattern recognition methods.
  - Accurate, representative information.
  - Includes statistical information.
- Extraction from online dictionary.
  - More knowledge-based.
  - Can treat dictionary as highly specialized corpus.

WordNet 1

- ***WordNet:*** A hierarchical (taxonomic) lexicon and thesaurus of English.
  - Developed by lexicographers at Princeton, 1990s to present.
- Graph structure:
  - Nodes are ***synsets*** ("synonym sets") (≈ word senses).

http://wordnetweb.princeton.edu/perl/webwn

Noun *slip*

Synonyms for this sense

Gloss

- faux pas#1, gaffe#1, solecism#1, **slip#1**, gaucherie#2 *(a socially awkward or tactless act)*
- **p#2**, slip-up#1, miscue#2, parapraxis#1 *(a minor inadvertent mistake usually observed in speech or writing or in small accidents or memory lapses etc.)*
- **slip#3** *(potter's clay that is thinned and used for coating or decorating ceramics)*
- cutting#2, **slip#4** *(a part (sometimes a root or leaf or bud) removed from a plant to propagate a new plant through rooting or grafting)*
- **slip#5** (*a young and slender person*) *"he's a mere slip of a lad"*
- mooring#1, moorage#2, berth#2, **slip#6** *(a place where a craft can be made fast)*
- **slip#7**, trip#3 *(an accidental misstep threatening (or causing) a fall) "he blamed his slip on the ice"; "the jolt caused many slips and a few spills"*
- slickness#3, slick#1, slipperiness#1, **slip#8** *(a slippery smoothness) "he could feel the slickness of the tiller"*
- strip#2, **slip#9** *(artifact consisting of a narrow flat piece of material)*
- **slip#10**, slip of paper#1 *(a small sheet of paper) "a receipt slip"*
- chemise#1, shimmy#2, shift#9, **slip#11**, teddy#2 *(a woman's sleeveless undergarment)*
- …

Example

Noun *slip*: Hyperonyms

- **slip#10**, slip of paper#1 *(a small sheet of paper)*
  - sheet#2, piece of paper#1, sheet of paper#1 *(paper used for writing or printing*
    - paper#1 *(a material made of cellulose pulp derived mainly from wood or ra*
      - material#1, stuff#1 *(the tangible substance that goes into the makeup of a*
        - substance#1 *(the real physical matter of which a person or thing consis*
          - matter#3 *(that which has mass and occupies space)*
            - physical entity#1 *(an entity that has physical existence)*
              - entity#1 *(that which is perceived or known or inferred to have it*
        - part#1, portion#1, component part#1, component#2, constituent#3 *(so*
          - relation#1 *(an abstraction belonging to or characteristic of two entit*
            - abstraction#6, abstract entity#1 *(a general concept formed by extr*
  - entity#1 *(that which is perceived or known or inferred to have it*

Noun *slip*: Sister terms

- sheet#2, piece of paper#1, sheet of paper#1 *(paper used for writing or printing*
- **slip#10**, slip of paper#1 *(a small sheet of paper)*
- signature#5 *(a sheet with several pages printed on it; it folds to page size and is*
- leaf#2, folio#2 (a sheet of any written or printed material *(especially in a manus*
- tear sheet#1 *(a sheet that can be easily torn out of a publication)*
- foolscap#1 *(a size of paper used especially in Britain)*
- style sheet#1 *(a sheet summarizing the editorial conventions to be followed in pr*
- worksheet#1 *(a sheet of paper with multiple columns; used by an accountant to*
- revenue stamp#1, stamp#6 *(a small piece of adhesive paper that is put on an obj*

- Sister terms belong to *synsets*

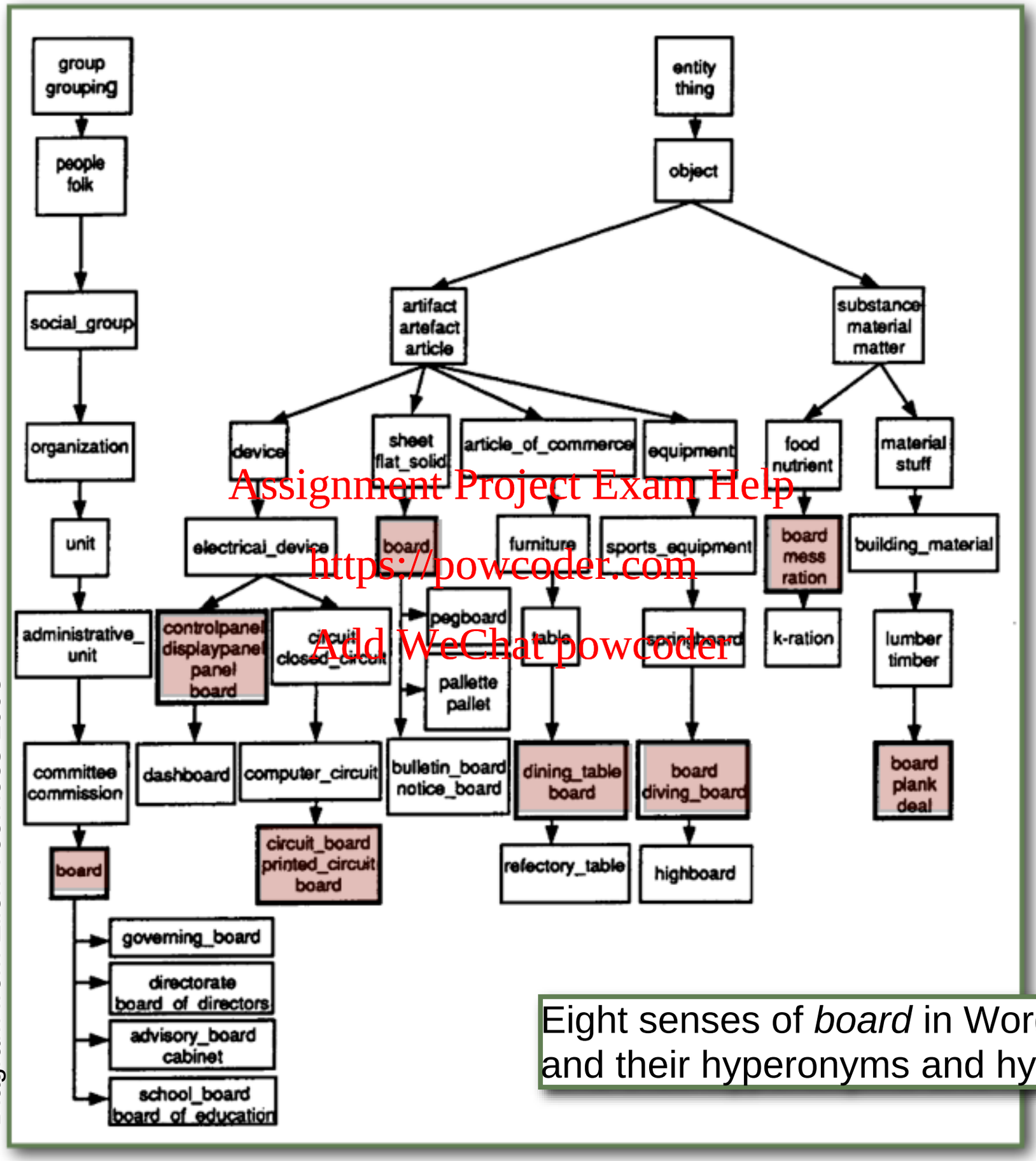

Diagram from Ellen Voorhees 1998

Eight senses of *board* in WordNet, and their hyperonyms and hyponyms

WordNet 2

- Graph structure (cont.):
  - Edges from hyponymy relations: near-tree.
  - Edges from meronymy relations: network.
- Index maps each word to all of its *synsets*.
- Separate trees for nouns, verbs, adjectives, adverbs (with derivational cross-connections).
- Differential approach to meaning:
  - The hyponyms of a node are *differentiations* of its meaning.

WordNet 3

- WordNets now available or under construction for many languages.

Afrikaans, Albanian, Arabic, Bantu, Basque, Bengali, Bulgarian, Catalan, Chinese, Croatian, Czech, Danish, Dutch, English, Estonian, Farsi (Persian), Finnish, French, German, Greek, Hebrew, Hindi, Hungarian, Icelandic, Indonesian, Italian, Irish, Japanese, Kannada, Korean, Latin, Latvian, Macedonian, Maltese, Marathi, Moldavian, Mongolian, Myanmar, Nepali, Norwegian, Oriya, Polish, Portuguese, Romanian, Russian, Sanskrit, Serbian, Slovenian, Spanish, Swedish, Tamil, Thai, Turkish, Vietnamese

www.globalwordnet.org, July 2013

Building and updating WordNets

- *Problem:* Need a complete lexicon *and lexical relations* for each natural language.
- Dictionary as starting point? Limitations?
- Another WordNet as starting point? Limitations?
- Build by hand (*lexicographers*) or automatically? Limitations?
- Text (corpus) as starting point? Limitations?

Hearst Discovering lexical relations 1

- Corpus-based method.
- Makes “suggestions” for lexicographers.
- Scan partially-parsed text looking for instances of patterns.

“*such* NP_1 *as* {NP_i}* {*or*|*and*} NP_i”
→ NP_1 is a hyperonym of the NP_i

Hearst, Marti. Automated discovery of WordNet relations. In: Fellbaum, Christane (editor), *WordNet: An electronic lexical database,* The MIT Press, 1998, pages 131–151.

"such as"

Search

Advanced Preference

Web Video Personalized Result

AUE: FAQ excerpt: "like" vs "**such as**"

The Little, Brown Handbook (6th ed., HarperCollins, 1995) says: "Strictly, **such as** precedes an example that represents a larger subject, whereas like ...

alt-usage-english.org/excerpts/fxlike00.html - 8k - Cached - Similar pages

How can I insert special characters, **such as** dingbats and accented ...

Word has also made it very easy for you to insert many of these characters without recourse to the dialog - in particular special characters **such as** ® and ...

word.mvps.org/FAQs/General/InsertSpecChars.htm - 2k - Cached - Similar pages

Finding and replacing non-printing characters (**such as** paragraph ...

For other symbols, **such as** Upper Unicode characters, and symbols from decorative fonts **such as** Symbol and Wingdings, things get a little more complicated, ...

word.mvps.org/FAQs/General/FindingSpecialCharacters.htm - 2k - Cached - Similar pages

mime encapsulation of aggregate documents **such as** html

Also with other protocols **such as** HTTP or FTP, there may sometimes be a need to retrieve aggregate documents. Receiving agents also have several differing ...

www.rfc-editor.org/rfc/rfc2557.txt - 61k - Cached - Similar pages

Certain Foie Gras Linked To Diseases **Such As** Alzheimer's And ...

Experimental data shows a potential link between foie gras consumption and amyloid-related diseases **such as** Alzheimer's, rheumatoid arthritis and adult ...

www.sciencedaily.com/releases/2007/06/070618174658.htm - 45k - Cached - Similar pages

Hearst Discovering lexical relations 2

- Develop patterns
  - “by hand”, or
  - by scanning for sentences containing known related pairs.

Hearst Results (good)

1. Some relations already in WordNet:
   - *fabric–silk, grain–barley, disorders–epilepsy,* …
2. Some relations not already in WordNet (but the words were):
   - *crops–milo, perishables–fruit, conditions–epilespy,* …
3. Some relations with words not yet in WordNet:
   - *companies–Shell, institutions–Tufts,* …

Hearst Results (less good)

4. Some too-general relations:
   - *things–exercise, topics–nutrition, areas–Sacremento*
5. Some too-context-specific relations:
   - *others–Meadowbrook, classics*–Gaslight, *categories–drama*, …
6. Some really bad relations (usually due to parsing errors, not detecting full NP):
   - *children–Headstart, jobs–computer, companies–sports*

Hearst Limitations

- Problems:
  - Which word is the hyperonym?
    A bearing is a structure that supports a rotating part of a machine, such as a shaft, axle, spindle, or wheel.

  - Can’t find good patterns for meronyms.
  - How to evaluate method quantitatively?

Since Hearst's paper 1

- Methods that use syntactic (not just lexical) patterns, and which derive the patterns from corpora.
- Methods that use senses, not words.
- Methods for finding coordinate (sister) terms by distributional similarity in text.
- Methods that combine the evidence from all of these to identify additional hyponym relations.
  - SISTER(X,Y) ∧ HYPONYM (Y,Z) ⇒ HYPONYM (X,Z)

Since Hearst's paper 2

- Methods for meronymic relations.
  - Each subtype tends to have its own indicators.
  - These tend to have much more ambiguous patterns than hyponymy.
  - Complex methods for learning additional semantic constraints on the patterns.

Since Hearst's paper 3

- Methods for causal relations.
  - Look esp for verbs such as *give rise to*, *induce*, *generate*, *cause*, …
- "Learning ontologies from text" as important research topic.
- "Learning commonsense knowledge from text" as new research topic.
- Lots of interest right now in *temporal* information (e.g., learning a timeline of events described in a news story).

Properties of verbs Revision

- Subcategorization of verbs:
  - VPs can include more than one NP, can include clauses of various types.
  - Can classify verbs by kinds of VPs they permit.
- Thematic roles of a verb — some common mappings:

Subject ≈ Agent / Experiencer
Object ≈ Theme
Object of preposition ≈ Goal / Location/
Recipient / Instrument

Lexical semantics of verbs 1

Verbs are more complex than nouns.

- They are predicates that encode relations between their arguments.
- They place ***selectional restrictions*** on their arguments.

- E.g., agent of *eat* must be animate; theme must be physical, edible.
- Different senses of verb may impose different selectional restrictions.
- So argument types may disambiguate verb-sense.
- There are numerous subregularities in how senses cluster together, in fact.

Lexical semantics of verbs 2

- Their taxonomy is more difficult to determine.
  - Grouping is not as intuitively clear.
  - Differentiating sister nodes is more complex.

Lexical semantics of verbs 3

WordNet for verbs is not very useful.

- Only shallow hierarchy of ***troponymy*** and *hyperonymy.*
  - e.g., *to saunter* is *to walk* in a certain manner.
- Insufficient information about thematic roles, selectional restrictions, and subcategorization.
- No information about regularity in behaviour of classes of verbs.

Verb

- S: (v) **spray** (be discharged in sprays of liquid) *"Water sprayed all over the floor"*
- S: (v) **spray** (scatter in a mass or jet of droplets) *"spray water on someone"; "spray paint on the wall"*
- S: (v) **spray** (cover by spraying with a liquid) *"spray the wall with paint"*

Verb

- S: (v) **spray** (be discharged in sprays of liquid) *"Water sprayed all over the floor"*
  - *direct hyperonym* / *inherited hypernym* / *sister term*
    - S: (v) scatter, sprinkle, dot, dust, disperse (distribute loosely) *"He scattered gun powder under the wagon"*
      - S: (v) discharge (pour forth or release) *"discharge liquids"*
        - S: (v) spread, distribute (distribute or disperse widely) *"The invaders spread their language all over the country"*
  - *derivationally related form*
  - ***sentence frame***
    - Something ----s
    - Something is ----ing PP

Levin's verb classification 1

- Groups (English) verbs by ***diathesis alternations*** — syntactic patterns of argument structure.
  - May be subtle semantic differences between alternations.
- Shows mapping between semantics of verbs and their syntactic behaviour / subcategorization.

Levin, Beth. *English Verb Classes and Alternations.* University of Chicago Press, 1993.
Palmer, Martha; Gildea, Daniel; Xue, Nianwen. *Semantic Role Labeling*. Synthesis Lectures on Human Language Technologies #6, Morgan & Claypool, 2010. www.morganclaypool.com/toc/hlt/1/1

Examples of verb class behaviour 1

[Verb class 45.1]

break, crack, rip,…

Jay broke Bill's finger.

**Jay broke Bill on the finger.*

Jay broke the vase.

Vases break easily.

Kay touched Bill's neck.

Kay touched Bill on the neck.

Kay touched the cat.

**Cats touch easily.*

- Motion/contact required for *body-part alternation*.
- Change of state required for *middle construction*.

[Verb class 20]

touch, stroke, tickle, …

Example of diathesis alternation

[Alternation 2.3.1]

The *spray–load* alternation

Nadia sprayed paint onto the wall.

Nadia sprayed the wall with paint.

Paint sprayed onto the wall.

Greater suggestion of 'completeness' of action

∗*The wall sprayed with paint.*

∗*Walls spray easily.*

Other verbs that undergo this alternation:
brush, cram, crowd, dust, jam, load, scatter, splash, …

Levin's verb classification 2

- ~80 alternations, ~190 verb classes, ~3000 English verbs classified.
  Subsequently extended by other researchers (Korhonen and Briscoe 2004).
- Different senses of a verb may fall into different classes.
- Used extensively in CL; basis for VerbNet.

Anna Korhonen and Ted Briscoe. Extended lexical-semantic classification of English verbs. *HLT–NAACL Workshop on Computational Lexical Semantics,* Boston, 2004.

VerbNet

- Embeds Levin's classes in a computational lexicon.
  - Adds thematic roles and semantics.
  - Uses WordNet senses.

Karin Kipper, Hoa Trang Dang, Martha Palmer. Class-based construction of a verb lexicon. *17th National Conference on Artificial Intelligence*, 2000.
Karin Kipper Schuler. *VerbNet: A Broad-Coverage Comprehensive Verb Lexicon.* PhD thesis, University of Pennsylvania, 2005.

Class Spray-9.7

Class Hierarchy

- spray-9.7
  - spray-9.7-1
    - spray-9.7-1-1
  - spray-9.7-2

Roles

- Agent [+animate]
- Theme
- Destination [+location & -region]

Thematic roles and restrictions on them

Semantic form for the kind of event *E* the frame represents

http://verbs.colorado.edu/verb-index/vn/spray-9.7.php

Frames REF KEY

NP V NP PP.destination

EXAMPLE "Jessica loaded boxes into the wagon."

SYNTAX Agent V Theme {{+loc | +dest_conf}} Destination

SEMANTICS
motion(during(E), Theme)
not(Prep(start(E), Theme, Destination))
Prep(end(E), Theme, Destination) cause(Agent, E)

NP V NP.destination PP.theme

EXAMPLE "Jessica loaded the wagon with boxes."

SYNTAX Agent V Destination {with} Theme

SEMANTICS
motion(during(E), Theme)
not(location(start(E), Theme, Destination))
location(end(E), Theme, Destination)
cause(Agent, E)

NP V NP.theme

EXAMPLE "Jessica squirted water."

SYNTAX Agent V Theme

SEMANTICS
motion(during(E), Theme)
not(location(start(E), Theme, ?Destination))
location(end(E), Theme, ?Destination)
cause(Agent, E)

NP V NP.destination

EXAMPLE "Jessica sprayed the wall."

SYNTAX Agent V Destination

SEMANTICS
motion(during(E), ?Theme)
not(location(start(E), ?Theme, Destination))
location(end(E), ?Theme, Destination)
cause(Agent, E)

Class Spray-9.7

Class Hierarchy

- spray-9.7
  - spray-9.7-1
    - spray-9.7-1-1
  - spray-9.7-2

Roles

- Agent [+animate]
- Theme
- Destination [+location & -region]

Thematic roles and restrictions on them

Semantic form for the kind of event *E* the frame represents

http://verbs.colorado.edu/verb-index/vn/spray-9.7.php

Frames REF KEY

NP V NP PP.destination

example "Jessica loaded boxes into the wagon."

syntax Agent V Theme {{+loc | +dest_conf}} Destination

semantics motion(during(E), Theme)
not(Prep(start(E), Theme, Destination))
Prep(end(E), Theme, Destination)

Restriction on preposition Prep

NP V NP.destination PP.theme

example "Jessica loaded the wago

syntax Agent V Destination {with} Theme

semantics motion(during(E), Theme)
not(location(start(E), Theme, Destination))
location(end(E), Theme, Destination)
cause(Agent, E)

NP V NP.theme

example "Jessica squirted water."

syntax Agent V Theme

semantics motion(during(E), Theme)
not(location(start(E), Theme, ?Destination))
location(end(E), Theme, ?Destination)
cause(Agent, E)

Unspecified argument

NP V NP.destination

example "Jessica sprayed the wall."

syntax Agent V Destination

semantics motion(during(E), ?Theme)
not(location(start(E), ?Theme, Destination))
location(end(E), ?Theme, Destination)
cause(Agent, E)

Class Spray-9.7-1

WordNet and FrameNet sense numbers

MEMBERS

KEY

?WASH (WN 8)
BRUSH (FN 1, 2; WN 6; G 2)
DRIZZLE (FN 1, 2; WN 2)
HANG (FN 1, 2; WN 2, 12, 14; G 1)
PLASTER (FN 1; WN 2, 3, 4, 1, 5, 6)
PUMP (FN 1; WN 2, 4, 5; G 2)
RUB (FN 1; WN 1; G 1)
SCATTER (FN 1; WN 3, 4, 6; G 1)
SEED (FN 1; WN 4)
SEW (FN 1; WN 1; G 1)
SHOWER (FN 1, 2, 3; WN 1, 2, 5; G 1, 2)
SMEAR (FN 1, 2; WN 3, 2; G 1)
SMUDGE (WN 1)
SOW (FN 1; WN 1, 3; G 1)
SPATTER (FN 1; WN 1, 3)
SPLASH (FN 1; WN 3, 6; G 1)
SPLATTER (FN 1; WN 1, 2)
SPRAY (FN 1; WN 1, 2, 3; G 1)
SPREAD (FN 1; WN 3, 9, 10; G 2, 3)
SPRINKLE (FN 1; WN 1, 4; G 1)
SPRITZ (WN 1, 2)
SPURT (FN 1; WN 1)
SQUIRT (FN 1; WN 1, 2; G 1)
STICK (FN 1; WN 1, 12, 13; G 1, 2)
STREW (FN 1; WN 1, 2)
STRING (WN 1; G 1)
SWAB (WN 1, 2)
WRAP (FN 1, 2; WN 1, 2, 3; G 1, 2)

ROLES

REF

- THEME [+SUBSTANCE | [+CONCRETE & +PLURAL]]

FRAMES

REF KEY

NP V PP.DESTINATION

EXAMPLE "Paint sprayed onto the wall."
SYNTAX THEME V {{+LOC | +DIR | +DEST_CONF}} DESTINATION
SEMANTICS MOTION(DURING(E), THEME) NOT(PREP(START(E), THEME, DESTINATION))
PREP(END(E), THEME, DESTINATION)

NP V NP PP.DESTINATION-CONATIVE

EXAMPLE "Jessica squirted water at me."
SYNTAX AGENT V THEME (AT) DESTINATION
SEMANTICS MOTION(DURING(E), THEME) NOT(LOCATION(START(E), THEME, DESTINATION)) CAUSE(AGENT, E)

Class Spray-9.7-1-1

MEMBERS

CRAM (FN 1, 2; WN 1, 2; G 1)
CROWD (FN 1; WN 1, 2; G 1, 2)
JAM (FN 1, 2; WN 1, 6, 7; G 1)
PACK (FN 1, 2; WN 1, 2, 3, 7; G 1, 2)
PILE (FN 1, 2; WN 1; G 1)

FRAMES REF KEY

NP.THEME V NP

EXAMPLE "Crowds packed the stands."
SYNTAX THEME V DESTINATION
SEMANTICS LOCATION(DURING(E), THEME, DESTINATION)

Class Spray-9.7-2

MEMBERS

DAB (FN 1, 2; WN 1)
DAUB (FN 1, 2; WN 1, 2, 3)
DRAPE (FN 1, 2; WN 1, 2, 4)
DUST (FN 1, 2; WN 3)
HEAP (FN 1, 2; WN 2, 3)
LOAD (FN 1, 2; WN 1, 4; G 1)
MOUND (WN 1)
PLANT (WN 1, 2; G 1, 2)
SLATHER (WN 1)
STACK (WN 1, 2; G 1)
STOCK (FN 1; WN 6; G 1)
STUFF (WN 1, 2, 6, 7; G 1)

ROLES

- THEME [+CONCRETE]

FrameNet

- Semantics-first classification of verbs (and nouns).
- ***Frame:*** "A conceptual structure that describes a particular type of situation, object, or event along with its participants and props."*
- Groups of predicates in same semantic class share case frames.
- Includes both a lexicon and a corpus of anno-tated sentences to illustrate predicate usage.

*Josef Ruppenhofer et al. *FrameNet II: Extended theory and practice.* June 2010.

Example

Frame APPLY-HEAT:
bake, barbecue, blanch, boil, braise, broil, …, poach, roast, saute, scald, simmer, singe, steam, stew, toast

Nadia fried the sliced onions in a skillet.

Cook *Food* *Heating instrument*

Frame elements

Josef Ruppenhofer et al. *FrameNet II: Extended theory and practice.* June 2010.

Frame elements of Apply_heat

Core elements

Semantic Type Container

Semantic Type Sentient

Semantic Type —

Semantic Type Physical_entity

Semantic Type Temperature

Semantic Type Duration

Semantic Type Manner

Semantic Type State_of_affairs

Semantic Type —

Semantic Type Locative_relation

Semantic Type State_of_affairs

Semantic Type Time

Non-core elements

Semantic Type —

Semantic Type Degree
Duration

Apply_heat

A Cook applies heat to Food, where the Temperature_setting of the heat and Duration of application may be specified. A Heating_instrument, generally indicated by a locative phrase, may also be expressed. Some cooking methods involve the use of a Medium (e.g. milk or water) by which heat is transferred to the Food. A less semantically prominent Food or Cook is marked Co_participant.

Sally FRIED an egg in butter.

Sally FRIED an egg in a teflon pan.

Ellen FRIED the eggs with chopped tomatoes and garlic.

This frame differs from Cooking_creation in focusing on the process of handling the ingredients, rather than the edible entity that results from the process.

Inherits From: Activity, Intentionally_affect
Is Inherited By: —
Is Used By: Cooking_creation
Is Causative of: Absorb_heat

Lexical entry for an Apply_heat word: bake

Frame Element	Number Annotated	Realization(s)
Container	(2)	PP[in].Dep (1) PP[on].Dep (1)
Cook		CNI.-- (11)
Duration	(9)	PP[for].Dep (9)
Food	(11)	NP.Ext (1) NP.Obj (7) CNI.-- (3)
Heating_instrument	(9)	INI.-- (7) PP[in].Dep (2)
Manner	(1)	AVP.Dep (1)
Temperature_setting	(3)	PP[at].Dep (2) 2nd.-- (1)

CNI = Constructional null instantiation

INI = Indefinite null instantiation

Grammatical functions: **Dep**endent, **Ext**ernal argument, **Obj**ect

Lexical entry for an Apply_heat word: bake

Valence patterns

Number Annotated	Patterns				
1 TOTAL	Container	Cook	Duration	Food	
(1)	PP[in] Dep	CNI --	PP[for] Dep	NP Ext	
1 TOTAL	Container	Cook	Duration	Food	Temperature_setting
(1)	PP[on] Dep	CNI --	PP[for] Dep	NP Obj	PP[at] Dep
5 TOTAL	Cook	Duration	Food	Heating_instrument	
(2)	CNI --	PP[for] Dep	CNI --	INI --	
(3)	CNI --	PP[for] Dep	NP Obj	INI --	
2 TOTAL	Cook	Duration	Food	Heating_instrument	Temperature_setting
(1)	CNI --	PP[for] Dep	CNI --	INI --	PP[at] Dep
(1)	CNI --	PP[for] Dep	NP Obj	PP[in] Dep	2nd --
1 TOTAL	Cook	Food	Heating_instrument		
(1)	CNI --	NP Obj	INI --		
1 TOTAL	Cook	Food	Heating_instrument	Manner	
(1)	CNI --	NP Obj	PP[in] Dep	AVP Dep	

Text with FrameNet annotations 1

As capital of Europe's most explosive economy, Dublin seems to be changing before your very eyes.

2. *As* CAPITAL$_{\text{Relational_political_locales}}$ *of* *Europe* *'s* most EXPLOSIVE$_{\text{Expansion}}$ ECONOMY$_{\text{Economy}}$, *Dublin* SEEMS$_{\text{Appearance}}$ *to be* CHANGING$_{\text{Undergo_change}}$ *before your very* EYES$_{\text{Observable_bodyparts}}$.

Subscripts: Frames
Italics: Unannotated words
Yellow: Named entities

Text with FrameNet annotations 2

As capital of Europe's most explosive economy, Dublin seems to be changing before your very eyes.

As capital of Europe 's most EXPLOSIVE economy , Dublin seems to be changing before your very eyes .

As CAPITAL of Europe 's most explosive economy , Dublin seems to be changing before your very eyes .

As capital of Europe 's most explosive ECONOMY , Dublin seems to be changing before your very eyes .

As capital of Europe 's most explosive economy , Dublin SEEMS to be changing before your very eyes .

As capital of Europe 's most explosive economy , Dublin seems to be CHANGING before your very eyes .INI INI

As capital of Europe 's most explosive economy , Dublin seems to be changing before your very EYES .

FrameNet in other languages

- FrameNets now available or under construction for several other languages.

Brazilian Portuguese, Chinese, German, Japanese, Spanish, Swedish

https://framenet.icsi.berkeley.edu/fndrupal/framenets_in_other_languages, June 2014

FrameNet vs VerbNet 1

Complementary resources:

- VerbNet:
  - Groups by syntactic behaviour (Levin classes).
  - Any resultant grouping by meaning is side-effect.
- FrameNet:
  - Groups by meaning class (frame).
  - Not limited to verbs.
  - Any resultant grouping by syntactic behaviour is side-effect.

FrameNet vs VerbNet 2

- Combine both with WordNet.
  - Algorithmic methods to map VerbNet entries to FrameNet entries and vice versa.
  - Semi-automatic methods to map VerbNet constraints into the WordNet hierarchy.

Lei Shi and Rada Mihalcea. "Putting pieces together: Combining FrameNet, VerbNet and WordNet for robust semantic parsing." *6th International Conference on Intelligent Text Processing and Computational Linguistics* (Springer Lecture Notes in Computer Science 3406), 2005, 100–111.