Implications of Sense Distinctions

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July 25, 2011
LING7800-006

Goals – Ex. Answering Questions

- *Similar concepts*
  - *Where are the grape arbors located?*
  - *Every path from back door to yard was covered by a grape-arbor, and every yard had fruit trees.*

Outline

- WordNet, OntoNotes Groupings, PropBank
- VerbNet
  - Verbs grouped in hierarchical classes
  - Explicitly described class properties
- FrameNet
- Links among lexical resources
  - PropBank, FrameNet, WordNet, OntoNotes groupings
- Automatic Semantic Role Labeling with PropBank/Verbnet

WordNet – Princeton

(Miller 1985, Fellbaum 1998)

On-line lexical reference (dictionary)

- Nouns, verbs, adjectives, and adverbs grouped into synonym sets
- Other relations include hypernyms (ISA), antonyms, meronyms
- Typical top nodes - 5 out of 25
  - *(act, action, activity)*
  - *(animal, fauna)*
  - *(artifact)*
  - *(attribute, property)*
  - *(body, corpus)*

WordNet – Princeton – *leave, n.4, v.14* (*Miller 1985, Fellbaum 1998*)

- Limitations as a computational lexicon
  - Contains little syntactic information
  - No explicit lists of participants
  - Sense distinctions very fine-grained,
  - Definitions often vague
- Causes problems with creating training data for supervised Machine Learning – SENSEVAL2
  - Verbs > 16 senses (including *call*)
  - Inter-annotator Agreement ITA 71%,
  - Automatic Word Sense Disambiguation, WSD 64%

Dang & Palmer, SIGLEX02

Creation of coarse-grained resources

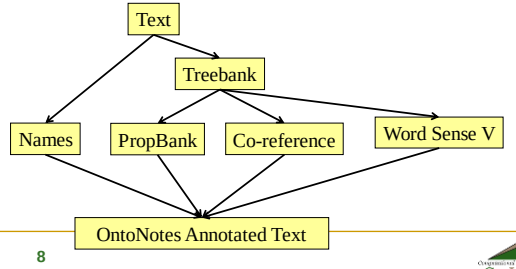
- Unsupervised clustering using rules (Mihalcea & Moldovan, 2001)
- Clustering by mapping WN senses to ODE (Navigli, 2006).
- OntoNotes - Manually grouping WN senses and annotating a corpus (Hovy et al., 2006)
- Supervised clustering WN senses using OntoNotes and another set of manually tagged data (Snow et al., 2007) .

OntoNotes

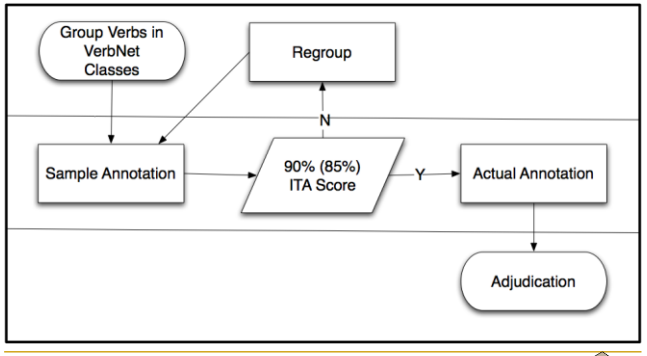
- DARPA-GALE, OntoNotes 5.0
  - BBN, Brandeis, Colorado, Penn
  - Multilayer structure
  - Three languages: English, Arabic, Chinese
  - Several Genres (@ ≥ 200K): NW, BN, BC, WT
  - Parallel data, E/C, E/A
  - PropBank frame coverage for rare verbs
  - Recent PropBank extensions

OntoNotes: Multilayer Design

- **The literal meaning of sentences**
  - **A frame-based representation of predicates and their arguments**
  - **Referring expressions and the textual phrases they refer to**
  - **Coarse-grained word sense tags for most polysemous verbs**
- **Does this lay a foundation for inference?**



Empirical Validation – Human Judges



Groupings Methodology – Human Judges (w/ Dang and Fellbaum)

- Double blind groupings, adjudication
- Syntactic Criteria (VerbNet was useful)
  - Distinct subcategorization frames
    - *call him an idiot*
    - *call him a taxi*
  - Recognizable alternations – regular sense extensions:
    - *play an instrument*
    - *play a song*
    - *play a melody on an instrument*

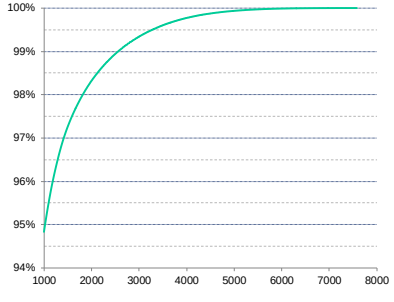
SIGLEX01, SIGLEX02, JNLE07, Duffield, et. al., CogSci 2007

Groupings Methodology (cont.)

- Semantic Criteria
  - Differences in semantic classes of arguments
    - Abstract/concrete, human/animal, animate/inanimate, different instrument types,…
  - Differences in the number and type of arguments
    - Often reflected in subcategorization frames
    - *John left the room.*
    - *I left my pearls to my daughter-in-law in my will.*
  - Differences in entailments
    - Change of prior entity or creation of a new entity?
  - Differences in types of events
    - Abstract/concrete/mental/emotional/….
  - Specialized subject domains

PropBank Verb Frames Coverage

- The set of verbs is open
- But the distribution is highly skewed
- For English, the 1000 most frequent lemmas cover 95% of the verbs in running text.
  - Graphs show counts over English Web data containing 150 M verbs.



Verb Frames Coverage By Language

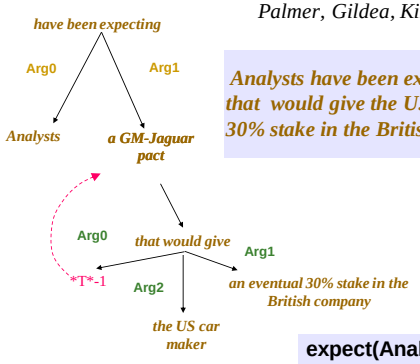
Language	Projected Final Count	Estimated Coverage in Running Text
English	5,100	99%
Chinese	18,200	96%
Arabic	5,250*	99%

* This covers all the verbs and most of the predicative adjectives/nouns in ATB.

How do the PropBank verb frames relate to Word Senses?

PropBank – WSJ Penn Treebank

Palmer, Gildea, Kingsbury., CLJ 2005



Analysts have been expecting a GM-Jaguar pact that would give the U.S. car maker an eventual 30% stake in the British company.

expect(Analysts, GM-J pact)
give(GM-J pact, US car maker, 30% stake)

Lexical Resource - Frames Files:

give

Roles:
- Arg0: giver
- Arg1: thing given
- Arg2: entity given to

Example: double object

The executives gave the chefs a standing ovation.

Arg0:	*The executives*
REL:	*gave*
Arg2:	*the chefs*
Arg1:	*a standing ovation*

Word Senses in PropBank

- Orders to ignore word sense not feasible for 700+ verbs
  - *Mary left the room*
  - *Mary left her daughter-in-law her pearls in her will*

Frameset **leave.01** "move away from":
Arg0: entity leaving
Arg1: place left

Frameset **leave.02** "give":
Arg0: giver
Arg1: thing given
Arg2: beneficiary

How do these relate to word senses in other resources?

Sense Hierarchy

(Palmer, et al, SNLU04 - NAACL04, NLE07, Chen, et. al, NAACL06)

- PropBank Framesets – ITA >90%
  coarse grained distinctions
  20 Senseval2 verbs w/ > 1 Frameset
  Maxent WSD system, 73.5% baseline, 90%

  - Sense Groups (Senseval-2) - ITA 82%
    Intermediate level
    (includes Levin classes) – 71.7%

    - WordNet – ITA 73%
      fine grained distinctions, 64%

Tagging w/groups, ITA 90%, 200@hr, Taggers - 86.9% Semeval07

Chen, Dligach & Palmer, ICSC 2007

Power behind the throne - VerbNet

- Groupings include links to VerbNet classes
- PropBank includes links to VerbNet classes and thematic roles
- Intention to ensure that VerbNet class members are handled consistently in PropBank and Groupings
- What is VerbNet?

Levin classes *(Levin, 1993)*

- 3100 verbs, 47 top level classes, 193 second and third level
- Each class has a syntactic signature based on alternations.
  John broke the jar. / The jar broke. / Jars break easily.

  *John cut the bread. / *The bread cut. / Bread cuts easily.*

  *John hit the wall. / *The wall hit. / *Walls hit easily.*

Levin classes *(Levin, 1993)*

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- Each class has a syntactic signature based on alternations.
  *John broke the jar. / The jar broke. / Jars break easily./ *Roy broke at the vase./Sam broke Lee's finger./*Sam broke Lee on the finger.*

  *John cut the bread. / *The bread cut. / Bread cuts easily./ Mary cut at the bread/ Mary cut Bill's arm./ Mary cut Bill on the arm.*

  *John hit the wall. / *The wall hit. / *Walls hit easily./Sam hit at the wall./Sam hit Lee's back./Sam hit Lee on the back.*

Summary of semantic components

- Verb class hierarchy: 3100 verbs, 47 top level classes, 193
- Each class has a syntactic signature based on alternations.

John broke the jar. / The jar broke. / Jars break easily.
change-of-state

*John cut the bread. / *The bread cut. / Bread cuts easily.*
change-of-state, recognizable action,
sharp instrument, contact, motion

*John hit the wall. / *The wall hit. / *Walls hit easily.*
contact, exertion of force, motion

*John touched the wall. / *The wall touched. / *Walls touch easily.*
contact

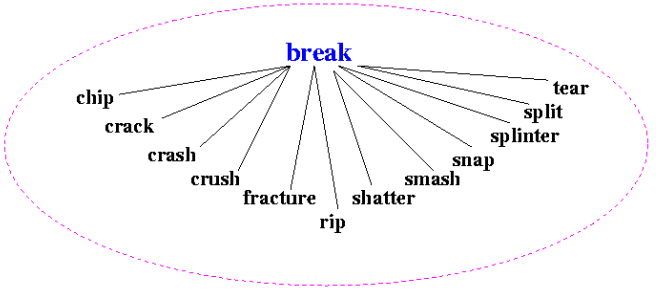
Summary of syntactic patterning

	Touch	Hit	Cut	break
Conative	No	Yes	Yes	No
Body-part ascension	Yes	Yes	Yes	No
Middle	No	No	Yes	yes

Common class components markers, not distinguishers

- *cut* [CAUSE] [CHANGE] [MOTION] [CONTACT]
- *break* [CAUSE] [CHANGE]
- *touch* [CONTACT]
- *hit* [MOTION] [CONTACT]

Break Levin class - *Change-of-state*



Which semantic components are *grammatically* relevant?

- Pinker
  - Set of conceptually interpretable elements
  - Smaller than # of verbs, universal
  - Used by children
  - Have grammatical relevance
  - Distinguish classes that have different sets of lexical rules

Limitations to Levin Classes

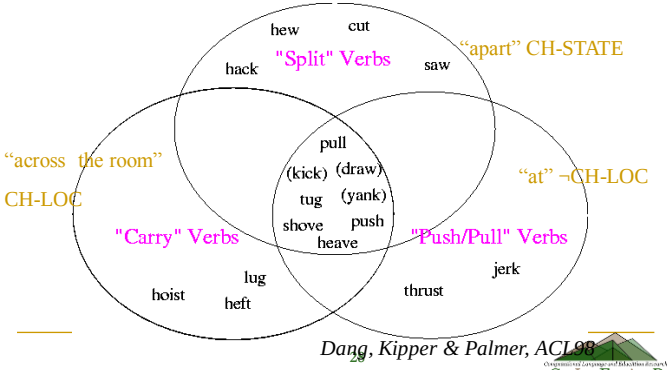
Dang, Kipper & Palmer, ACL98

- Coverage of only half of the verbs (types) in the Penn Treebank (1M words,WSJ)
- Usually only one or two basic senses are covered for each verb
- Confusing sets of alternations
  - Different classes have almost identical "syntactic signatures"
  - or worse, contradictory signatures

Multiple class listings

- Homonymy or polysemy?
  - *draw a picture, draw water from the well*
- Conflicting alternations?
  - *Carry* verbs disallow the Conative, *(*she carried at the ball),* but include *{push,pull,shove,kick,yank,tug}*
  - also in *Push/pull* class, does take the Conative *(she kicked at the ball)*

Intersective Levin Classes



Dang, Kipper & Palmer, ACL98

VerbNet: Basis in Theory

- Beth Levin, *English Verb Classes and Alternations* (1993)
- Verb class hierarchy: 3100 verbs, 47 top level classes, 193
- *"Behavior of a verb . . . is to a large extent determined by its meaning"* (p. 1)
  - Amanda hacked the wood with an ax.
  - Amanda hacked at the wood with an ax.
  - Craig notched the wood with an ax.
  - *Craig notched at the wood with an ax.
- Can we move from syntactic behavior back to semantics?

VerbNet – *Karin Kipper Schuler*

- Class entries:
  - Capture generalizations about verb behavior
  - Organized hierarchically
  - Members have common semantic elements, semantic roles, syntactic frames, predicates
- Verb entries:
  - Refer to a set of classes (different senses)
  - each class member linked to WN synset(s) and FrameNet frames

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Hacking and *Notching*

- Same thematic roles:
  - Agent, Patient, Instrument
- Some shared syntactic frames,
  - e.g. Basic Transitive (Agent V Patient)
- Different Semantic predicates

VerbNet Semantic Predicates

- *Hack: cut-21.1*

  cause(Agent, E)
  manner(during(E), Motion, Agent)
  contact(during(E), ?Instrument, Patient)
  degradation_material_integrity(result(E), Patient)
- *Notch: carve-21.2*

  cause(Agent, E)
  contact(during(E), ?Instrument, Patient)
  degradation_material_integrity(result(E), Patient)
  physical_form(result(E), Form, Patient)

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VerbNet example – *Pour-9.5*

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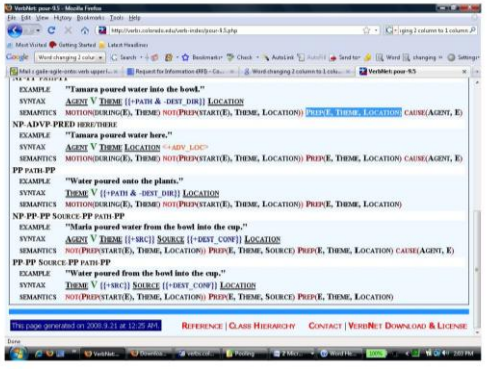
VerbNet *Pour-9.5* (cont.)



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Hidden Axioms

- EXAMPLE: *Tamara poured water into the bowl.*
- SYNTAX: AGENT V THEME LOCATION
- SEMANTICS
  - CAUSE(AGENT,E)
  - MOTION(DURING(E), THEME),
  - NOT(PREP(START(E), THEME, LOCATION)),
  - PREP(E, THEME, LOCATION)

Hidden Axioms REVEALED!

- EXAMPLE: *Tamara poured water into the bowl.*
- SYNTAX: AGENT V THEME LOCATION
- SEMANTICS
- POUR.*pour9.5* (AGENT, THEME LOCATION) →

  CAUSE(AGENT,E),
  MOTION(DURING(E), THEME),
  NOT(PREP(START(E), THEME, LOCATION)),
  PREP(E, THEME, LOCATION).

Hidden Axioms REVEALED!

- EXAMPLE: *Tamara poured water into the bowl.*
- SYNTAX: AGENT V THEME LOCATION
- SEMANTICS
- POUR.*pour9.5* (AGENT, THEME LOCATION) →

CAUSE(Tamara,E),
MOTION(DURING(E), water),
NOT(into(START(E), water, bowl)),
into(E, THEME, bowl).

VerbNet – *cover fill-9.8*

- **WordNet Senses:** …, cover(1,2, 22, 26),…, staff(1),
- **Thematic Roles:** Agent [+animate]
  Theme [+concrete],
  Destination [+location, +region]
- **Frames with Semantic Roles**
  "The employees staffed the store"
  " The grape arbors covered every path"
  Theme V Destination

location(E,Theme,Destination)
location(E,grape_arbor,path)

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VerbNet as a useful NLP resource

- Semantic role labeling
- Inferences

*While many of the weapons used by the insurgency are leftovers from the Iran-Iraq war, Iran is still **providing** deadly weapons such as EFPs -LRB- or Explosively Formed Projectiles -RRB-.*

provide(Agent, Theme, Recipient)

VerbNet as a useful NLP resource

- Semantic role labeling
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*While many of the weapons used by the insurgency are leftovers from the Iran-Iraq war, Iran is still **providing** deadly weapons such as EFPs -LRB- or Explosively Formed Projectiles -RRB-.*

provide(Iran, weapons, ?Recipient) →
cause(Iran, E)
has_possession(start(E), Iran, weapons)
has_possession(end(E), ?Recipient, weapons)
transfer(during(E), weapons)

Broader coverage still needed

- Only 78% of PropBank verbs included in VN
- Most classes focused on verbs with NP and PP complements
- Neglected verbs that take adverbial, adjectival, and sentential complements
- Extending VerbNet and mapping it to PropBank and FrameNet

Mapping from PropBank to VerbNet (similar mapping for PB-FrameNet)

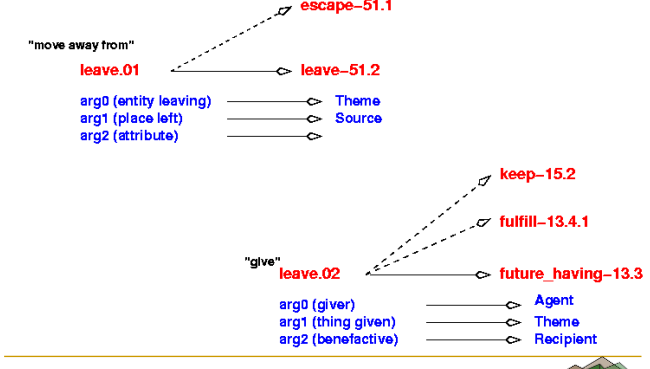
Frameset id = ***ship.01***	Sense = *ship*	VerbNet class = ***Send -11.1***
Arg0	Sender	Agent/Sender*
Arg1	Package	Theme
Arg2	Recipient	Destination/ *Goal OR Recipient
Arg3	Source	Source

*FrameNet Labels

Baker, Fillmore, & Lowe, COLING/ACL-98
Fillmore & Baker, WordNet WKSHP, 2001

Mapping from PB to VerbNet

http://verbs.colorado.edu/semlink



FrameNet

- Baker, Collin F., Charles J. Fillmore, and John B. Lowe. (1998) The Berkeley FrameNet project. In *Proceedings of COLING/ACL-98* , pages 86--90, Montreal.
- Fillmore, Charles J. and Collin F. Baker. (2001). Frame semantics for text understanding. In the *Proceedings of NAACL WordNet and Other Lexical Resources Workshop* Pittsburgh, June.

Introducing FrameNet
Thanks to Chuck Fillmore and Collin Baker

In one of its senses, the verb *observe* evokes a frame called **Compliance**: this frame concerns people's responses to norms, rules or practices.

The following sentences illustrate the use of the verb in the intended sense:

- *Our family **observes** the Jewish dietary laws.*
- *You have to **observe** the rules or you'll be penalized.*
- *How do you **observe** Easter?*
- *Please **observe** the illuminated signs.*

FrameNet

FrameNet records information about English words in the general vocabulary in terms of

1. the **frames** (e.g. **Compliance**) that they **evoke**,
2. the **frame elements** (semantic roles) that make up the components of the frames (in **Compliance**, Norm is one such frame element), and
3. each word's **valence** possibilities, the ways in which information about the frames is provided in the linguistic structures connected to them (with **observe**, Norm is typically the direct object).

theta

The FrameNet Product

The FrameNet database constitutes

- a set of **frame descriptions**
- a set of **corpus examples** annotated with respect to the frame elements of the frame evoked by each lexical unit
- **lexical entries**, including definitions and displays of the combinatory possibilities of each lexical unit, as automatically derived from the annotations
- a display of **frame-to-frame relations**, showing how some frames are elaborations of others, or are components of other frames.

Frame Elements for Compliance

The frame elements that figure in the Compliance frame are called

- **Norm** (the rule, practice or convention)
- **Protagonist** (the person[s] reacting to the Norm)
- **Act** (something done by the Protagonist that is evaluated in terms of the Norm)
- **State_of_affairs** (a situation evaluated in terms of the Norm)

- You do a whole frame for just *observe*?
- No. There are other Compliance words too.

V - *adhere, comply, conform, follow, heed, obey, submit, ...;*

AND NOT ONLY VERBS

N - *adherence, compliance, conformity, obedience, observance, ...;*

A - *compliant, obedient, ...;*

PP - *in compliance with, in conformity to, ...;*

AND NOT ONLY WORDS FOR POSITIVE RESPONSES TO NORMS

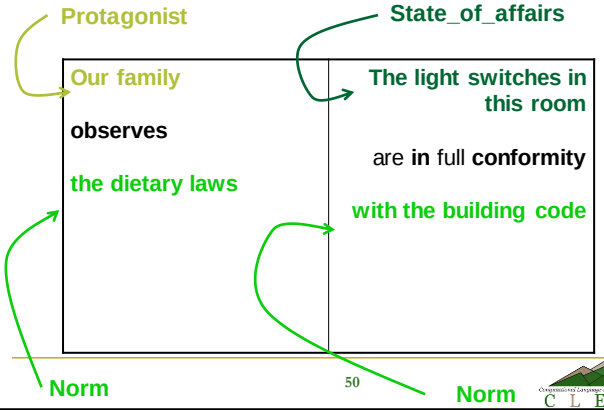
V - *break, disobey, flout, transgress, violate ,...;*

N - *breach, disobedience, transgression, violation,...;*

PP - *in violation of, in breach of, ...*

C L E A R

Tagging Compliance sentences



C L E A R

- Are we finished with the verb *observe*?
- No. This verb has several other meanings too.

- In the **Perception_active** frame we get the uses seen in *observing children at play*, *observing an ant colony*, sharing frame membership with *watch, attend, listen to, view & pay attention*.
- In a **Commenting** frame, *observe* and *observation* share frame membership with *remark & comment*.

C L E A R

Lexical Unit

Our unit of description is not the word (or "lemma") but the **lexical unit** (Cruse 1986), – a pairing of a word with a sense. In our terms this is the pairing of a word with a single frame.

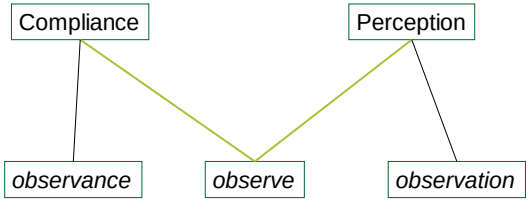
The lexical unit - roughly equivalent to a word in a synset - is the unit in terms of which important generalizations about lexical relations, meanings and syntactic behavior can best be formulated.

C L E A R

LUs and V-N relationships

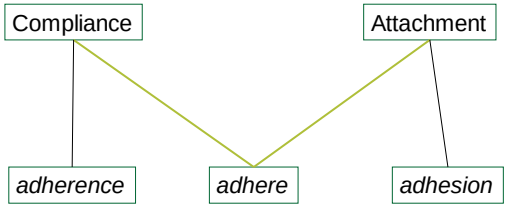
- Note that the nouns based on *observe* are
  - *observance* in the **Compliance** frame,
  - *observation* in the **Perception_active** frame
- Similarly, the nouns based on *adhere* are
  - *adherence* in the **Compliance** frame,
  - *adhesion* in the **Attachment** frame.
- When we need to be precise we show the frame-specific sense of a lemma (the full name of an LU) with a dotted expression:
  - Compliance.*observe*, Attachment.*adhere*, etc.

words, frames, lexical units



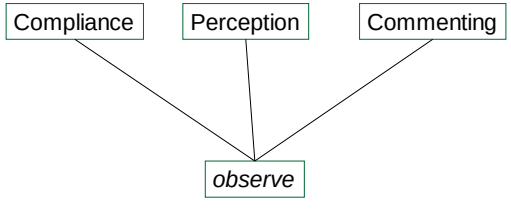
2 lexical units sharing same form:
Compliance.*observe*,
Perception.*observe*

words, frames, lexical units



2 lexical units sharing the same form:
Compliance.*adhere*,
Attachment.*adhere*

The study of polysemy concerns membership in different frames



Different LU, Different Valence

Compliance.*observe* generally has an NP as its direct object.

Perception.*observe* has these patterns:

- NP: *Observe the clouds overhead.*
- NP+V*ing*: *I observed the children playing.*
- *wh*-clause: *Observe what I'm doing.*
- *that*-clause: *We observed that the process terminated after an hour.*

Comment.*observe* occurs frequently with a quoted comment:

- *"That was brilliant," he observed snidely.*

Lexical-units: Wrap-up

Lexical units are the entities with respect to which we define

- meanings
- grammatical behavior
- semantic relations with other entities
- morphological relations with other entities

In short, there aren't interesting things to say about the verb *observe* in general, but only about the individual lexical units that happen to have the form *observe*.