

## Implications of Sense Distinctions

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July 25, 2011  
LING7800-006

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## 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.*

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## 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/Verbnets



## 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*)

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## 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*

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## 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) .

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## OntoNotes

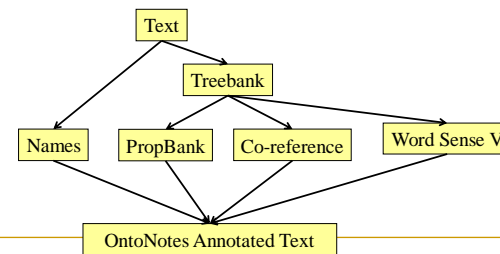
- DARPA-GALE, OntoNotes 5.0
  - BBN, Brandeis, Colorado, Penn
  - Multilayer structure
  - Three languages: English, Arabic, Chinese
  - Several Genres (@ ≥ 200K ): NW, BN, BC, WT
  - Parallel data, E/C, E/A
  - PropBank frame coverage for rare verbs
  - Recent PropBank extensions

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## OntoNotes: Multilayer Design

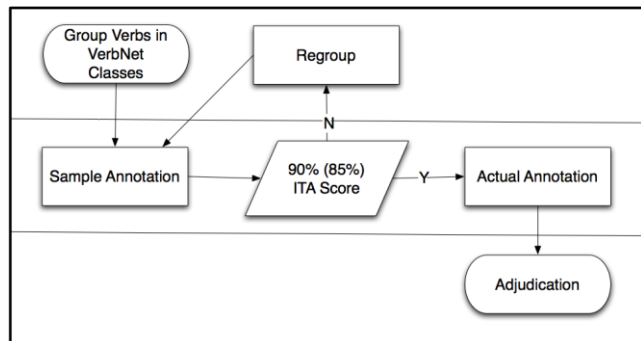
- The literal meaning of sentences
  - A frame-based representation of predicates and their arguments
  - Referring expressions and the textual phrases they refer to
  - Coarse-grained word sense tags for most polysemous verbs
- Does this lay a foundation for inference?



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## Empirical Validation – Human Judges



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## 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

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## Groupings Methodology (cont.)

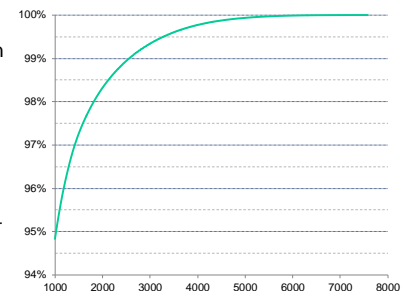
- Semantic Criteria
  - Differences in semantic classes of arguments
    - Abstract/concrete, human/animal, animate/inanimate, different instrument types,...
  - Differences in the number and type of arguments
    - Often reflected in subcategorization frames
    - *John left the room.*
    - *I left 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

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## 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.



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## 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.

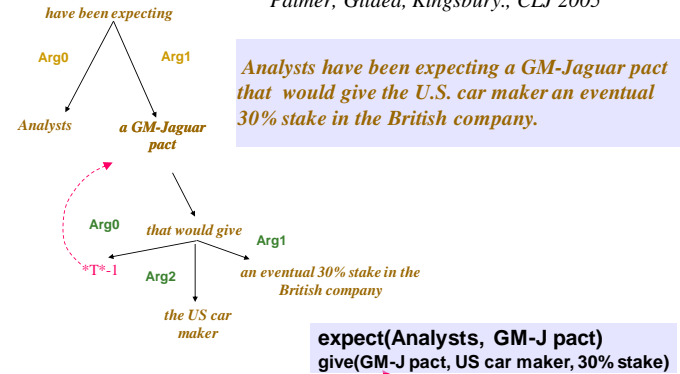
How do the PropBank verb frames relate to Word Senses?

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## PropBank – WSJ Penn Treebank

Palmer, Gildea, Kingsbury., CLJ 2005



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## 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*

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## 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?

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## 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)

- 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. / \*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

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## Common class components markers, not distinguishers

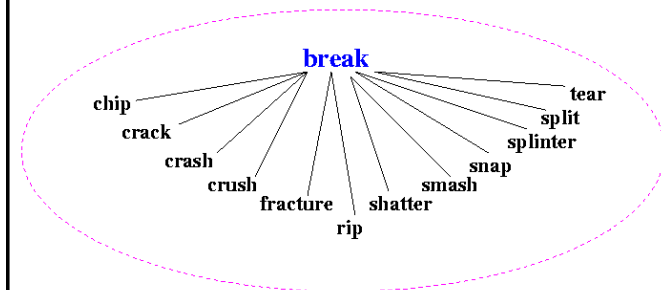
- cut* [CAUSE] [CHANGE] [MOTION] [CONTACT]
- break* [CAUSE] [CHANGE]
- touch* [CONTACT]
- hit* [MOTION] [CONTACT]

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## Break Levin class - *Change-of-state*



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## 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

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## 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

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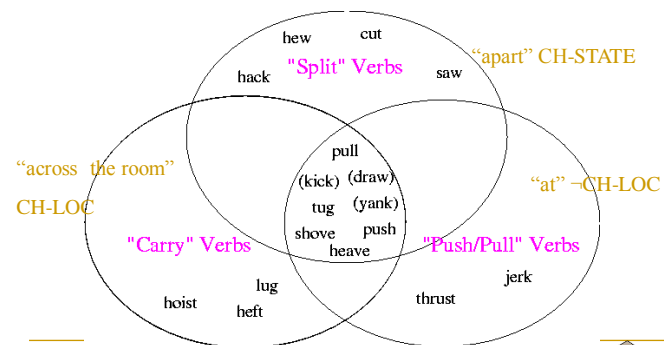
## Multiple class listings

- 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*)

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## Intersective Levin Classes



*Dang, Kipper & Palmer, ACL98*

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## 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*

VerbNet v2.3

**pour-9.5**  
Members: 8, Frames: 1

CLASS HIERARCHY  
pour-9.5  
[N] [P] [L] [E] [F]

MEMBERS

DRIZZLE (FN 1; WN 1, 2)	SPREW (FN 1; WN 1, 2, 3)
DRIPE (FN 1; WN 1, 2)	SPLA (FN 1; WN 1, 2, 3)
POUR (FN 1; WN 1, 3, 4)	TRICKLE (WN 1)
SLOP (WN 1)	
SLOSH (WN 1)	

ROLES

- AGENT [-ANIMATE]
- THEME [-SUBSTANCE] [+CONCRETE & +PLURAL]
- LOCATION [LOCATION & REGION]
- SOURCE [LOCATION & REGION]

FRAMES

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## VerbNet *Pour-9.5* (cont.)

EXAMPLE: "Tamara poured water into the bank."  
SYNTAX: AGENT V THEME [(-PATH & -DEST DIR)] LOCATION  
SEMANTICS: MOTION(DURING(E), THEME) NOT(PREP(START(E), THEME, LOCATION)) PREP(E, THEME, LOCATION) CAUSE(AGENT, E)

NP-ADV-PREP HERE THERE  
EXAMPLE: "Tamara poured water here."  
SYNTAX: AGENT V THEME LOCATION [-ADV, LOC]  
SEMANTICS: MOTION(DURING(E), THEME) NOT(PREP(START(E), THEME, LOCATION)) PREP(E, THEME, LOCATION) CAUSE(AGENT, E)

PP PATH-PP  
EXAMPLE: "Water poured onto the plants."  
SYNTAX: THEME V [(-PATH & -DEST DIR)] LOCATION  
SEMANTICS: MOTION(DURING(E), THEME) NOT(PREP(START(E), THEME, LOCATION)) PREP(E, THEME, LOCATION)

NP-PP-PP SOURCE-PP PATH-PP  
EXAMPLE: "Marie poured water from the bowl into the cup."  
SYNTAX: AGENT V THEME [(-SRC)] SOURCE [(-DEST, CONT)] LOCATION  
SEMANTICS: NOT(PREP(START(E), THEME, LOCATION)) PREP(E, THEME, SOURCE) PREP(E, THEME, LOCATION) CAUSE(AGENT, E)

PP-PP SOURCE-PP PATH-PP  
EXAMPLE: "Water poured from the bowl into the cup."  
SYNTAX: THEME V [(-SRC)] SOURCE [(-DEST, CONT)] LOCATION  
SEMANTICS: NOT(PREP(START(E), THEME, LOCATION)) PREP(E, THEME, SOURCE) PREP(E, THEME, LOCATION)

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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

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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)

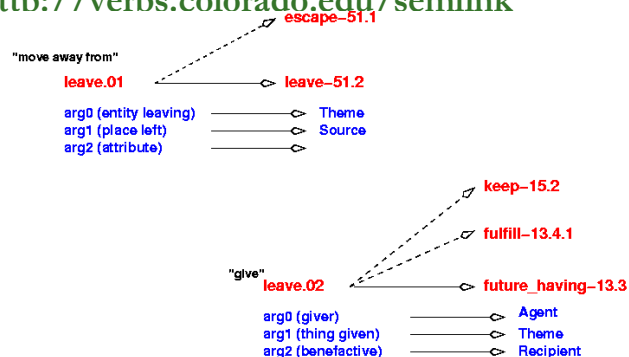
Frameset id =	Sense =	VerbNet class =
<i>ship.01</i>	<i>ship</i>	<i>Send -11.1</i>
Arg0	Sender	Agent/Sender*
Arg1	Package	Theme
Arg2	Recipient	Destination/ *Goal OR Recipient
Arg3	Source	Source

\*FrameNet Labels<sup>42</sup>

Baker, Fillmore, & Lowe, *COLING/ACL-98*  
Fillmore & Baker, *WordNetWKSHP, 2001*



## Mapping from PB to VerbNet <http://verbs.colorado.edu/semlink>



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## 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.

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## Introducing FrameNet

### Thanks to Chuck Fillmore and Collin

**Baker** 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.*

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## 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).

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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.

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## 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)

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- 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 ,...;*

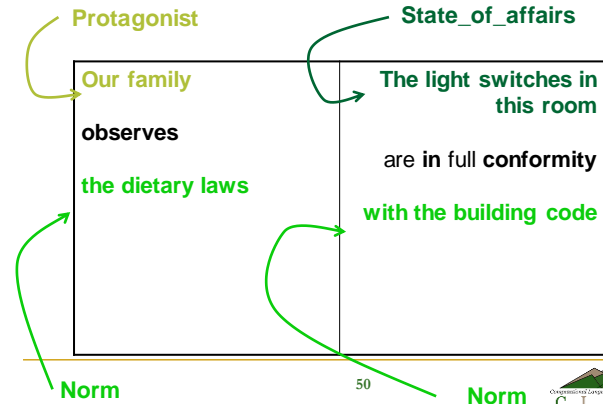
N - *breach, disobedience, transgression, violation,...;*

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

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## Tagging Compliance sentences



- 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*.

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## 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.

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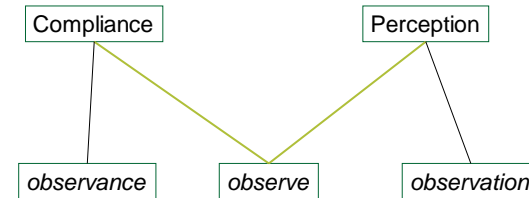
## LUs and V-N relationships

- 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.

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## words, frames, lexical units

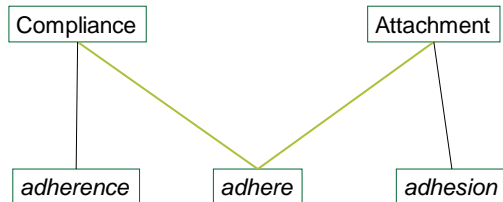


2 lexical units sharing same form:  
Compliance.*observe*,  
Perception.*observe*

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## words, frames, lexical units

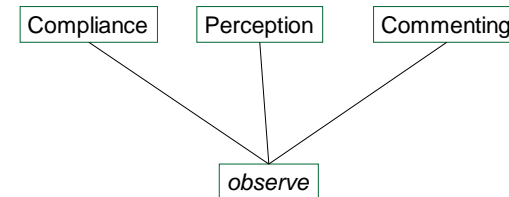


2 lexical units sharing the same form:  
Compliance.*adhere*,  
Attachment.*adhere*

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## The study of polysemy concerns membership in different frames



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## 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+Ving. *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.*

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## 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*.

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