VerbNet

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Outline

- Recap

- Levin's Verb Classes

- VerbNet

- PropBank

Recap

- ## Fillmore – Cases

  - useful generalizations, fewer sense distinctions,

- ## Jackendoff – Lexical Conceptual Structure

  - Thematic roles are defined by the predicates they are arguments to

- ## Dowty – Proto-typical Agents and Patients

  - A bag of "agentive" entailments

- ## Levin – Verb classes based on syntax

  - syntactic behavior is a reflection of the underlying semantics

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A Preliminary Classification of English Verbs, *Beth Levin*

- Based on diathesis alternations

- The range of syntactic variations for a class of verbs is a reflection of the underlying semantics

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Levin classes (3100 verbs)

- 47 top level classes, 193 second and third level

- Based on pairs of syntactic frames.
  John broke the jar. / Jars break easily. / The jar broke.
  *John cut the bread. / Bread cuts easily. / *The bread cut.*
  *John hit the wall.   / *Walls hit easily. / *The wall hit.*

- Reflect underlying semantic components
  contact, directed motion,
  exertion of force, change of state

- Synonyms, syntactic patterns (*conative*), relations
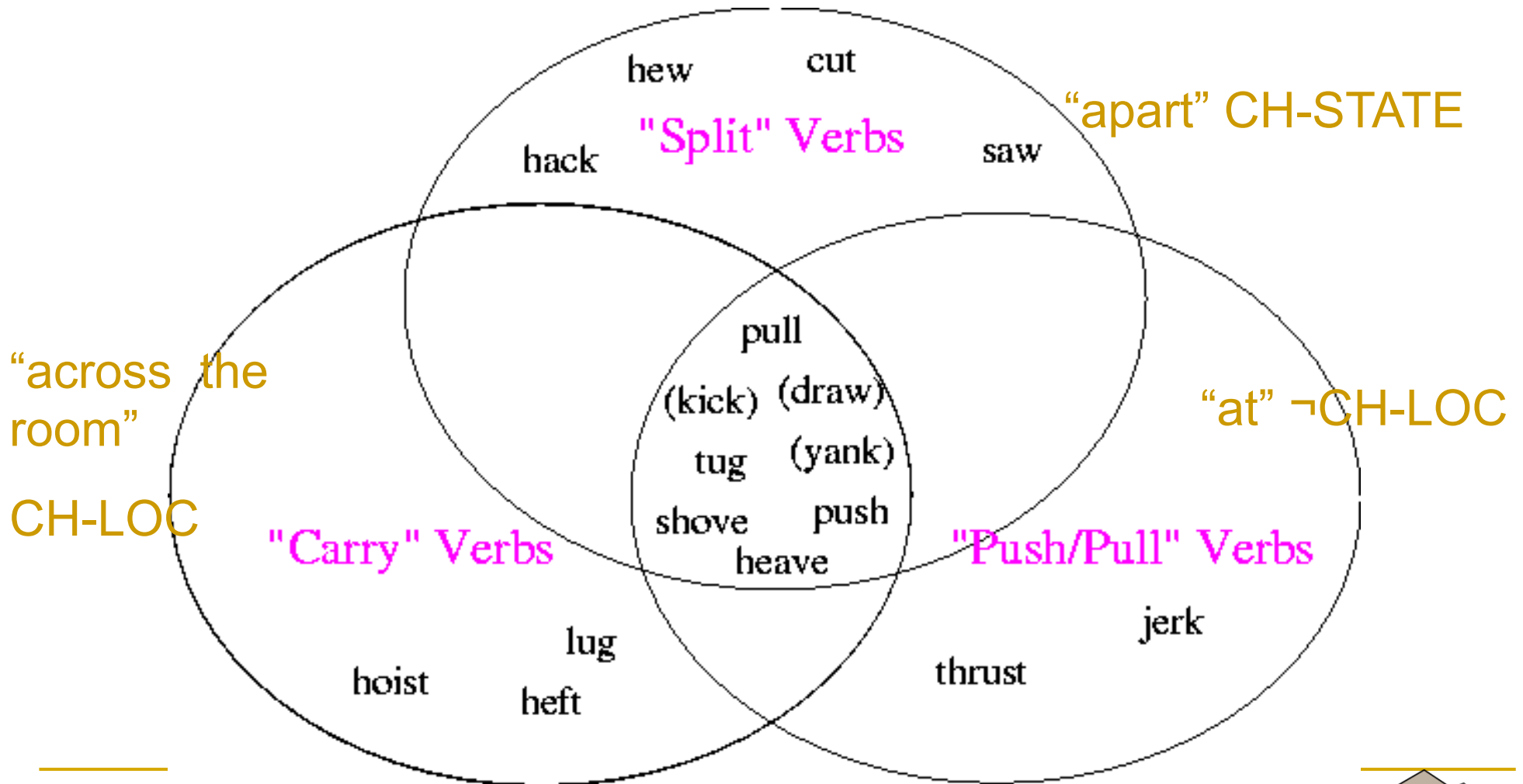
Break Levin class -   *Change-of-state*
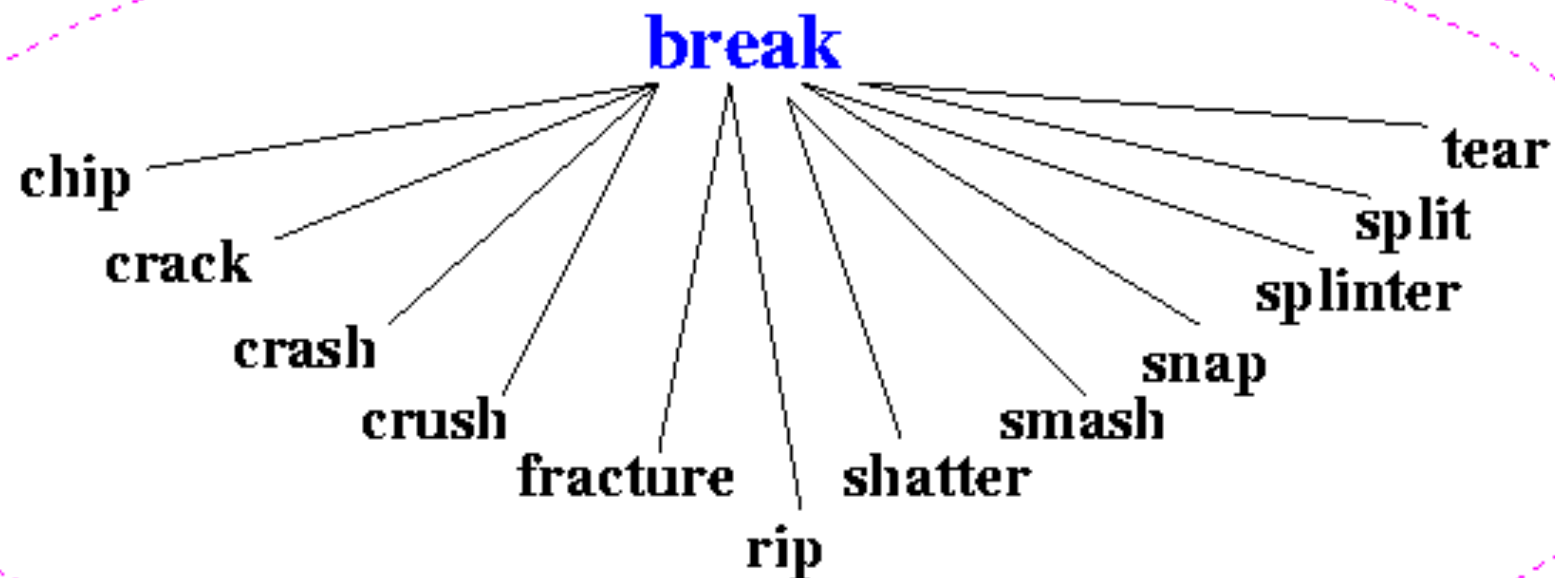
Confusions in Levin classes?

- Not semantically homogenous
  - *{**braid**, clip, file, powder, pluck, etc...}*

- Multiple class listings
  - homonymy or polysemy?

- Alternation contradictions?
  - *Carry* verbs disallow the Conative, but include
  - *{push,pull,shove,kick,draw,yank,tug}*
  - also in *Push/pull* class, does take the Conative

Intersective Levin Classes

"apart" CH-STATE

"Split" Verbs

hew   cut
hack   saw

"across the room"

CH-LOC

pull
(kick) (draw)
tug (yank)
shove push
heave

"at" ¬CH-LOC

"Carry" Verbs

"Push/Pull" Verbs

lug
hoist   heft

jerk
thrust

Dang, Kipper & Palmer, ACL98

Regular Sense Extensions

John pushed the chair.   **+force, +contact**

John pushed the chairs apart. **+ch-state**

John pushed the chairs across the room. **+ch-loc**

John pushed at the chair.   **-ch-loc**

The train whistled into the station. **+ch-loc**

The truck roared past the weigh station. **+ch-loc**

AMTA98,ACL98,TAG98

Intersective Levin Classes

- More syntactically and semantically coherent
  - sets of syntactic patterns
  - explicit semantic components
  - relations between senses

⟹ VERBNET

www.cis.upenn.edu/verbnet

VerbNet: Overview

- Purpose of VN is to classify English verbs based on semantic and syntactic regularities (Levin,1993)

- Classification used for numerous NLP tasks, primarily semantic role labeling (Schuler, 2002; Shi and Mihalcea, 2005, Yi, et. al., 2007))

- In each verb class, thematic roles are used to link syntactic alternations to semantic predicates, which can serve as foundation for further inferences

NP V NP THAT S	
EXAMPLE	"I promised him that he would arrive in time."
SYNTAX	AGENT V RECIPIENT TOPIC <+THAT_COMP>
SEMANTICS	TRANSFER_INFO(DURING(E), AGENT, RECIPIENT, TOPIC) CAUSE(AGENT, E)

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VerbNet – based on Levin, B.,93

- ## Class entries: *Kipper, et. al., LRE08*

  - 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), ON groupings, PB frame files, FrameNet frames,

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The Unified Verb Index

- http://verbs.colorado.edu/verb-index/

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VerbNet: An in-depth example

- *"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?

Hacking and *Notching*

- Same thematic roles: Agent, Patient, Instrument
- Some shared syntactic frames, e.g. Basic Transitive (Agent V Patient)
- *Hack: cut-21.1*

    cause(Agent, E)

    manner(during(E), Motion, Agent)

    contact(during(E), ?Instrument, Patient)

    degradation_material_integrity(result(E), Patient)

Hacking and *Notching*

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

Also Temporal Characteristics

- Needed for distinguishing between *Verbs of Assuming a Position* and *Verbs of Spatial Configuration*

- Semantic predicates are associated with an event variable, e, and often have an additional argument:
  - START(e) – in force at the START of the event
  - END(e) – in force at the END of the event
  - DURING(e) – in force DURING the related time period for the entire event

VerbNet: *send-11.1* (Members: 11, Frames: 5)
includes "*ship*"

- ## Roles
  - Agent [+animate | +organization]
  - Theme [+concrete]
  - Source [+location]
  - Destination [+animate | [+location & -region]]

- ## Syntactic Frame:NP V NP PP.destination
  - ❏   example   "*Nora sent the book to London*."
  - ❏   syntax   Agent V Theme {to} Destination
  - ❏   semantics   motion(during(E), Theme)
    location(end(E), Theme, Destination)
    cause(Agent, E)

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VerbNet can also provide inferences

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

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VerbNet – *cover, fill-9.8 class*

- **Members:** fill, …, cover,…, staff, ….

- **Thematic Roles:** Agent
  Theme
  Destination

- **Syntactic 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)

Recovering Implicit Arguments
[Palmer, et. al., 1986, Gerber & Chai, 2010]

[$_{Arg0}$ *The two companies*] [$_{REL1}$ *produce*] [$_{Arg1}$ *market pulp, containerboard and white paper*]. *The goods could be manufactured closer to customers, saving* [$_{REL2}$ **shipping**] *costs.*

- *Used VerbNet for subcategorization frames*

Implicit arguments

- SYNTAX   Agent V Theme {to} Destination

[AGENT] shipped [THEME] to [DESTINATION]

- SEMANTICS
  - CAUSE(AGENT,E)
  - MOTION(DURING(E), THEME),
  - LOCATION(END(E), THEME, DESTINATION),

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Implicit arguments instantiated using coreference

- *[AGENT] shipped [THEME] to [DESTINATION]*
- *[Companies] shipped [goods] to [customers].*

- SEMANTICS
  - CAUSE(Companies, E)
  - MOTION(DURING(E), goods),
  - LOCATION(END(E), goods, customers),

  Can annotate, semi-automatically!

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Limitations to VerbNet as a sense inventory

- Concrete criteria for sense distinctions
  - Distinct semantic roles, but very fine-grained; leads to sparse data problems
  - Distinct frames
  - Distinct entailments

- But….
- Limited coverage of lemmas
- For each lemma, limited coverage of senses

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Goal of PropBank

- Supply consistent, simple, general purpose labeling of semantic roles

- Provide consistent argument labels across different syntactic realizations

- Support the training of automatic semantic role labelers

- Semantic representation can support…

Training data supporting…

- Machine translation
- Text editing
- Text summary / evaluation
- Question and answering

The Problem

- Levin (1993) and others have demonstrated promising relationship between syntax and semantics

- Same verb with same subcategorization can assign different semantic roles

- How can we take advantage of clear relationships and empirically study how and why syntactic alternations take place?

VerbNet and Real Data

- VerbNet is based on linguistic theory –

  how useful is it?

- How well does it correspond to syntactic variations found in naturally occurring text?

- Use PropBank to investigate these issues

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What is PropBank?

- Semantic information over the syntactically parsed (i.e. treebanked) text

- Semantic information -> predicate argument structure of a verb or a relation

- Unlike VerbNet, the predicate argument structure is specific to the verb or relation in question

- Seeks to

    1. provide consistent argument labels across different syntactic realizations of the same verb

    2. assign general functional tags to all modifiers or adjuncts to the verb

"1. PB seeks to provide consistent argument labels across different syntactic realizations"
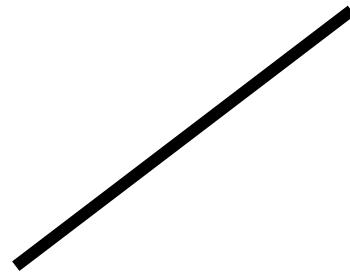
Jin broke the projector.

Syntax: NP$_{SUB}$ V   NP$_{OBJ}$

Thematic Roles: AGENT   REL   PATIENT

Thematic Roles: PATIENT   REL

Syntax: NP$_{SUB}$ V

The projector broke.

Why numbered arguments?

- Avoids lack of consensus concerning a specific set of semantic role labels

- Numbers correspond to labels that are verb-specific

- Arg0 and Arg1 correspond to Dowty's (1991) proto-agent and proto-patient

- Args 2-5 are highly variable

"1. PB seeks to provide consistent argument labels across different syntactic realizations"

- Uuuuuusually…

  - Arg0 = agent

  - Arg1 = patient

  - Arg2 = benefactive / instrument / attribute / end state

  - Arg3 = start point / benefactive / instrument / attribute

  - Arg4 = end point

These correspond to VN Thematic Roles

"2. PB seeks to assign functional tags to all modifiers or adjuncts to the verb"

- Variety of ArgM's:
  - TMP - when? *yesterday, 5pm on Saturday, recently*
  - LOC - where? *in the living room, on the newspaper*
  - DIR - where to/from? *down, from Antartica*
  - MNR - how? *quickly, with much enthusiasm*
  - PRP/CAU -why? *because … , so that …*
  - REC - himself, themselves, each other
  - GOL - end point of motion, transfer verbs? *To the floor, to Judy*
  - ADV - hodge-podge, miscellaneous, "nothing-fits!"
  - PRD - this argument refers to or modifies another: *…ate the meat raw*

Different verb senses…

- Have different subcategorization frames
- PropBank assigns coarse-grained senses to verbs
- PropBank "framesets," lexical resource
- New senses, or "rolesets" are added only when the syntax and semantics of a usage are distinct
- Annotators use "frame files" to assign appropriate numbered arg structure

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Propbank: sense distinctions?

- *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

WordNet: - call, 28 senses, 9 groups

WN5, WN16, WN12

Loud cry

WN15   WN26

Bird or animal cry

WN3   WN19

WN1   WN22

Label

WN4   WN 7 WN8 WN9

Request

WN20   WN25

Call a loan/bond

WN18   WN27

Challenge
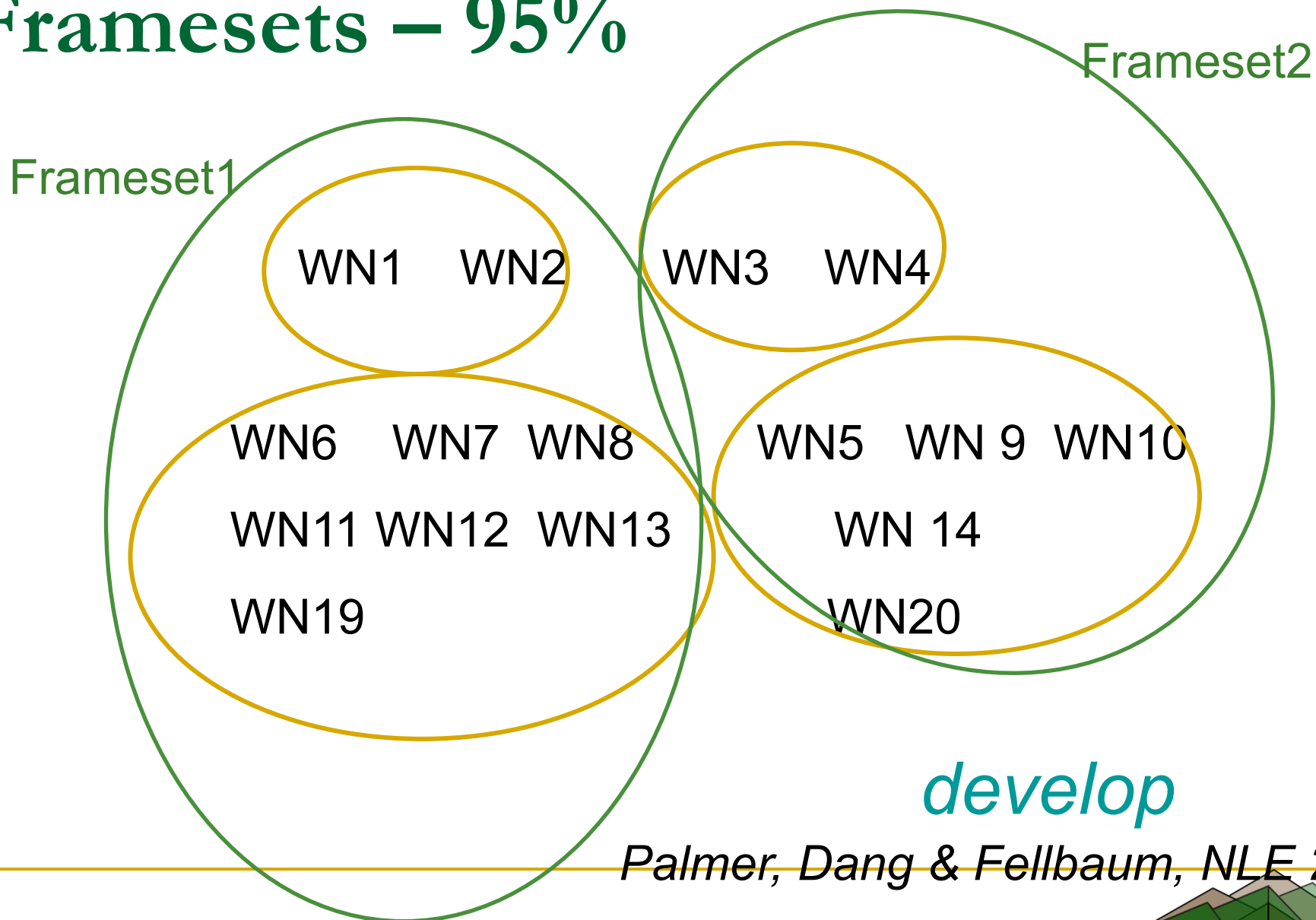
WN6   WN23

Visit

WN2 WN 13

Phone/radio WN28

WN17 , WN 11 WN24,

WN10, WN14, WN21,

Bid

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WordNet: - call, 28 senses, 9 groups, add PB

WN5, WN16, WN12
Loud cry

WN15   WN26
Bird or animal cry

WN3   WN19
WN1   WN22
Label

WN4   WN 7 WN8 WN9
Request

WN18   WN27
Challenge

WN20   WN25
Call a loan/bond

WN2 WN 13
Phone/radio WN28

WN6   WN23
Visit

WN17 , WN 11
WN24,

WN10, WN14, WN21,
Bid

Overlap between Groups and Framesets – 95%

Frameset1

Frameset2

WN1   WN2   WN3   WN4

WN6   WN7 WN8

WN11 WN12 WN13

WN19

WN5   WN 9 WN10

WN 14

WN20

develop

Palmer, Dang & Fellbaum, NLE 2004

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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
Dligach & Palmer, ACL-11, - 88%

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SEMLINK

- Extended VerbNet: 5,391 senses (91% PB)

- Type-type mapping PB/VN, VN/FN

- Semi-automatic mapping of WSJ PropBank instances to VerbNet classes and thematic roles, hand-corrected. (now FrameNet also)

- VerbNet class tagging as automatic WSD

  Brown, Dligach, Palmer, IWCS 2011

- Run SRL, map Arg2 to VerbNet roles, Brown performance improves *Yi, Loper, Palmer, NAACL07*

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

Frameset id = *leave.02*	Sense = *give*	VerbNet class = *future-having 13.3*
Arg0	Giver	Agent/Donor*
Arg1	Thing given	Theme
Arg2	Benefactive	Recipient

*FrameNet Label

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

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Mapping from PB to VerbNet
verbs.colorado.edu/~semlink
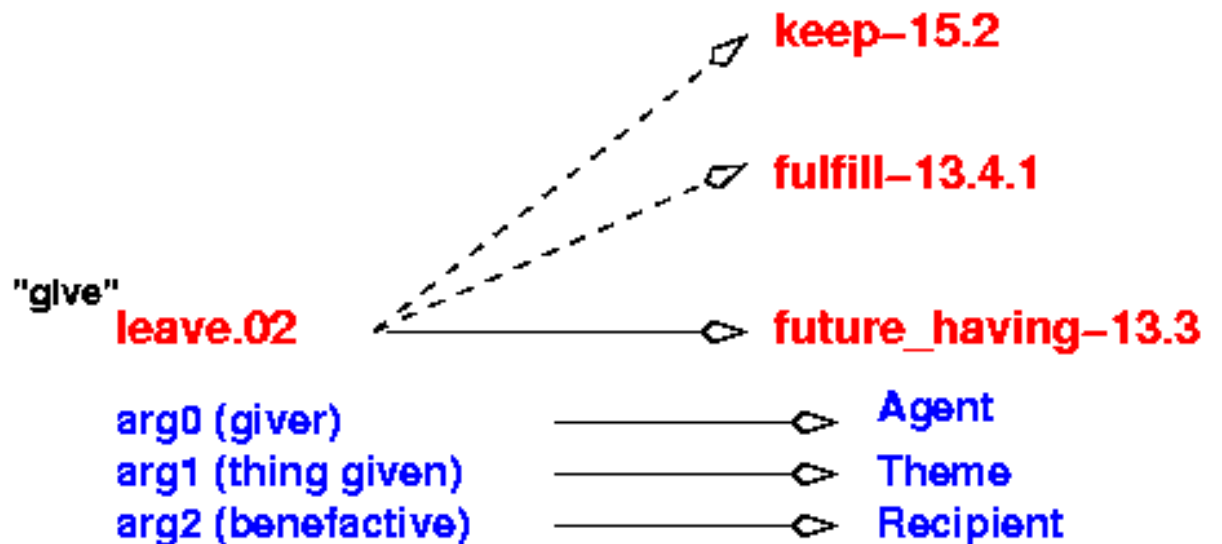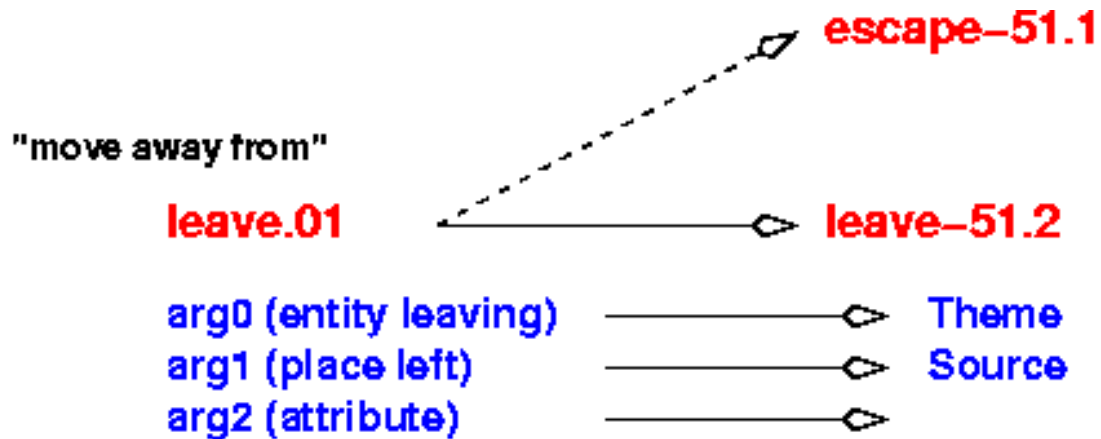
"move away from"

leave.01 → escape–51.1

leave.01 → leave–51.2

arg0 (entity leaving) → Theme
arg1 (place left) → Source
arg2 (attribute) →

keep–15.2

fulfill–13.4.1

"give"
leave.02 → future_having–13.3

arg0 (giver) → Agent
arg1 (thing given) → Theme
arg2 (benefactive) → Recipient

Generative Lexicon - VerbNet

- ## GL: use(Agent, Entity, Purpose)

  - ☐ use, sense 1: apply or employ something for a purpose (the most general sense)
    - *Use 105*

  - ☐ use, sense 2: consume or ingest, usually habitually
    - *Eat 39.1-3*

  - ☐ use, sense 3: expend a quantity (e.g., use up something, use something up)
    - *Consume 66*

Generative Lexicon - VerbNet

- ## GL: use(Agent, Entity, Purpose)

  - ❑ use, sense 1: apply or employ something for a purpose (the most general sense)
    - *Use 105* *http://verbs.colorado.edu/vn3.2.4-test-uvi/vn/use-105.1.php*
  - ❑ use, sense 2: consume or ingest, usually habitually
    - *Eat 39.1-3* *http://verbs.colorado.edu/vn3.2.4-test-uvi/vn/eat-39.1.php*
  - ❑ use, sense 3: expend a quantity (e.g., use up something, use something up)
    - *Consume 66* *http://verbs.colorado.edu/vn3.2.4-test-uvi/vn/consume-66.php*

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Additional Entailments

- ## Sense 1 is the most general

- ## Senses 2 and 3 provide additional specific entailments

  - Sense 2: Entity is ingested by an animate being, who then undergoes a change of state

  - Sense 3: in the process of using the Entity, it is depleted